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USER-ORIENTED METHODOLOGIES AND TECHNIQUES FOR DEEP ENERGY RENOVATION IN SOCIAL HOUSING

The Add-ons' strategy based on multiple variables

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INTRODUCTION

More than 70% of the European existing building has been built between the ‘50s and the ‘70s, in total absence of any specific regulation regarding buildings performances and energy consumptions/savings. The construction has been based on prefabrication systems that allowed short construction times and reduced overall costs but resulted in poor quality buildings that are now in **urgent need of renovation**. This need is accompanied by the urgency of defining trans-national integrated strategies since the existing contingent impediments to a systematic renovation of the housing stock are slowing the renovation process not only at the regional and national scale but throughout all Europe. Specific and case-based solutions have proved to be highly ineffective in terms of replicability and impact when looking at the large numbers. European Member States are working together to define common strategies and approaches that could determine a concrete common solution for the most substantial energy-related challenge that Europe shall tackle in the coming decade: the Energy Renovation of Existing Buildings.

Currently, the **major existing barriers** have been defined as social, economical and technical whereas the complementary barriers are legislative, normative, financial, structural and logistic. The main objective of the research presented in this volume consists in the validation of an **integrated design methodology** based upon the creation of additional volume on existing buildings (Add-Ons) intended as roof-top or aside extensions, enclosures, parasites or façade transformation. The **Add-Ons** are intended as the core and main instrument of an innovative strategy that has been proven able to overcome the actual barriers, increase the feasibility of energy renovation in the residential field and ultimately foster the building renovation market. The practice of extending, transforming and translating existing buildings through additions is all but new in Architecture History but it has not been studied as systematic and programmatic plan and tool to act on existing building, balance the up front costs, reduce the energy consumptions and finally turn the renovation process in a virtuous circle from an economical, technical and social point of view.

Energy, safety and quality requirements change constantly due to new society patterns and emergencies. Buildings that stand as dogma and claim to be able to answer to their function in a rigid and static manner through out the decades have indeed soon lost the capability of serving their users. Thus, the more reliable solution to the problem of Housing Renovation is to empower and increase the degree of flexibility of the built environment in order to guarantee **adaptability**, which has been recognised as substantial characteristics for a sustainable renovation. By turning the existing buildings in adaptable ones, the renovation gains an extra value: it becomes a practice able to assure a long-term perspective, allowing and forecasting future transformations without the need of redefining the original building. Turning the renovations by means of adaptable and flexible systems - such as the Add-Ons - delivers to the next generations' buildings that are able to change. This approach proves that we have finally come to an awareness that those who built before us lacked: buildings need to be fitting transformations, at all the scales at all the levels in order to last.

The proposed approach is characterised by a triple nature and is based upon the possibility of counterbalancing and combining the social, economical and technical aspects generally related to Energy Renovation in Housing. The **main objective of the research** consists in the validation of an integrated design method based up the Add-Ons, that could support planners and stakeholder in fostering the renovation practice, by overcoming:

1. The main social barriers through a new inter-active participative method that aims at developing user-centred design proposal
2. The main economical barriers by reducing the pay-back time of the interventions and by increasing the investors thus the appeal of the renovation market
3. The main existing technical and construction barriers through prefabricated elements upon which the architectural and structural project is based

The research goal is to reach a comprehensive ideal of sustainability, where technology and society priorities meet, in the search for a new construction type both tool and trigger in the Energy Renovation of Existing Buildings. I am referring to the Add-On type, as technological component, economical leverage and social benefit, able to combine the past architectural practice and the future visions and needs related to Energy Efficient buildings, thus overcoming the existing barriers still slowing down the turn around of the renovation practice in a common practice.

Standardized interventions are not the effective and sustainable solutions that we are looking for, pre-made receipts are generally addressed towards one main issue (plants, renovation of windows, insulation…) resulting in very expensive interventions, hardly repayable, with little impact on collateral and related aspects. Several design experiments have been conducted on a wide range of residential building typologies in order to underline a vast repertoire of possible technological and architectural solutions for the envelope re-design of existing housing buildings. The intent of applying the Add-Ons Strategy to different design case studies of Residential buildings' is to investigate and validate a modular and adaptive approach - considering roof extensions/elevations, envelope renovation through densification strategies and facade redesign - that could directly express the internal programmatic need for transformation and contextually respond to the structural and energetic emergency of the existing building. In fact, based upon the Add-Ons, this work has set up an inter-active **design process** able to increment the social participation and offer user-driven solution to the envelope transformation, consistently reduce the existing pay back times of the investments by add new dwelling unit that can also rebalance the social mix within the neighbourhood and, ideally, increase the quality of the existing building and its real estate value.

The **research methodology** reflects the inter-disciplinary approach of the research itself and consists of different and combined research methods - experimental, case-study related and comparative - as function of the different research objectives:

1. The experimental methodology guided the collection and study of the sociological data, used to define the user-driven aspects of the design method proposed. A social questionnaire and survey has been conducted to collect the necessary data stock to formulate the design hypothesis
2. The case-study methodology allowed the application of the user-centred analyses directly in the chosen design case study and the evaluation of the possible technological and formal transformations through volumetric additions. Through the case studies it has been possible to simulate and validate the proposed design process and show its potential when applied to different buildings and contexts
3. The comparative methodology allowed the differential analysis and comparison of case-study experiments, to develop a set of prefabricated solutions that could be replicable

and industrially produced, proving the high potential of the design method proposed. Through the comparative analysis the different building type and contexts have been analysed and the open variables have been determined.

The three different case studies chosen for the research were used to test and simulate the potential, in terms of architectural, energetic and social improvement, of the existing retrofitting action based on the addition of fixed prefabricated structures used as *supports* for the Add-Ons.

The main result of the research is the creation of a new Architecture Technology type, the Add-On type, able to implement, in its multiple configurations, a high degree of adaptability, flexibility and transformability in the renovation practice. The benefits in economical terms have shown the consistent innovation and potential of the proposal. Moreover, through the abacus of prefabricated façade elements presented in the form of an inter-active catalogue of possible transformation and modules, it has been possible to include in the proposed design process a user-oriented character, fundamental when dealing with Housing Renovation, to overcome procedural and social barriers. The inhabitants regain the central role in the design process and act as director in the choice and discern phases; they support and claim the renovation rather than oppose to it. The architect's role stands in the position of the consultant that controls the application of the set of rules defined to control the variability and openness of the system. The result is the implementation of a punctual densification policy that has been proven capable of fostering the investments in deep renovation of the existing built environment throughout Europe.

The research hypothesis is based on the assumption that an empowering synergy can be created between the old and the new, not only in structural, functional and architectural terms but also in economical and social terms. From an economical and financial point of view the Add-Ons strategy has proven the great potential behind the punctual densification of the existing built system. The extra costs of the type of interventions proposed are justified in comparison to the standard energy retrofitting operations since the payback of larger scale interventions together with the direct benefit for real estate investors, have a very positive effect on the technical and economic feasibility of the energy retrofitting interventions. On the other hand, the possibility of re-appropriating to Architecture its social connotation and the direct connection with the final users makes the proposed strategy an innovative and powerful path towards a sustainable redefinition of European suburbs

Within the Architecture Technology ambit, this research takes the distance from the over-imposed strategy and the standardized solutions resulting in isolated actions that have proven to be inefficient and not effective that are partly effective and not efficient considering the entire life-cycle of the building. Technology takes distance from the definition of products and solutions that still are missing a real field of application to move towards the search for **procedural innovation**.. The existing relationship, based upon a cause-effect connection, between the existing buildings and society is the starting point for the redefinition of the built environment, the existing evidence of the failures and lacking wholes of the buildings. Flexibility, adaptability and constant transformation are the key to develop a metabolistic transformation of the rigid Housing building that we inherited from the past century of Architecture. Considering the dynamism of our society, the research re-interprets the energy renovation common practice in an operative inter-active and creative perspective that considers possible transformations, re-configurations and multiple design solutions as central prerequisites, seeking not the right solution but rather the right path.

PART 1

CHAPTER 1_ STATE OF THE ART: ENERGY RETROFIT AND ENERGY RENOVATION IN RESIDENTIAL BUILDINGS

1.1 Field of application: Mass Housing in Europe between 1950 and 1980

" Architects have consistently built, throughout the 1950s, 1960s and into the 1970s, forms seeded in the first flush of the modern movement, a parallel cultural phenomenon to the first brave successes of socialist ideals. [...]
By tradition, modern buildings are releasant, not at all overpowering or threatening.
Yet it could be that this very quality does not provide the necessary protective framework for lost human animals."

Alison Smithson, 'The violent consumer, or waiting for the goodies', Architectural design 1974, n°5

A number of quite drastic measures have been undertaken to answer the great post-war housing shortage. In the main, these measures concerned a thorough going standardisation of plans and building elements, as well as the setting up of a central organisation for the distribution of building material and labour and the creation of a building industry more and more connected to the machine logic. This happened identically even if with different technologies and industries involved, between the two wars and after 1945. The social housing stock has been conceived everywhere in Europe according to the modernist idea of the minimal residential unit. This solution has been then applied - with few considerations on the context - all over Europe, generating social housing complexes that are now facing very similar problems: small dwellings, mono-functional districts, concentration of weak minorities and immigrants, low quality of public spaces, dull blocks in a dull environment. This monotony of endless rows of identical houses acts as an *assault to the identity* of the inhabitant.

Fig. 1 Example of Housing districts built after the Second World War, throughout Europe. From top left to bottom right: Bijlmermeer, Amsterdam (source: Uitbreiding van Almere in het IJmeer / Markermeer, maak er geen tweede Bijlmer van, 2007); Sarcelles Locheres, Paris (source: www.aginmodernism.files.wordpress.com); Sant'Ambrogio, Milano (source: www.audis.it); Grosssiedelungen, Berin (souce: http://www.stadtentwicklung.berlin.de); Alton West, London (source: RIBA, Royal Institute of British Architecture); Alt-Erlaa, Vienna (source: Coronare Modestus Faust, spfaust.wordpress.com)

The system applied is without any doubt the most effective and has proven through out the decades its functional potential, rapidity and capacity of serving the purpose of providing a shelter for everyone. It was not only a problem related to the post-war reconstruction but also an emergency caused by internal migration. In Italy, for example, the extent of the migration from the South to the North was consistent as well as the return of a large number of citizens from the colonies and the migration from the countryside to the cities in France and Spain. These internal waves resulted in a consistent request for Housing which became a 'national issues' for many countries. The legislation answered to the need through several special measures (*Fanfani Plan, Gescal, Casa Plan*, etc). The object of those actions was to combine the interests of developers and the construction companies to generate cheap and fast dwellings that could be rented or, mostly in Italy, sold to the inhabitants or allocated upon social conditions. In Eastern Europe countries the situation was similar: the organisation of socialist states after the defeat of the axis powers, centralisation of planning and powers according to the soviet model lead to the idea that Housing, as a social good, is a good of collective consumption and the Institutions had to provide for their construction, favouring multi-family homes organised in large settlements. A huge number of peasants moved to urban areas, synonymous of technical and economical progress, transforming into working class. Owning a house allowed the individual's position on the ladder of social stratification in the country to be highlighted. Architects and

Urban planners tried to find universal solutions to the housing emergency, reinterpreting the principles of the Modern Movements and its results from the experiences carried between the two wars. The aim was to define one model that could be the best fitting to the actual needs of the human kind and repeat it identical in series, fast and cheap, to answer to the great request.

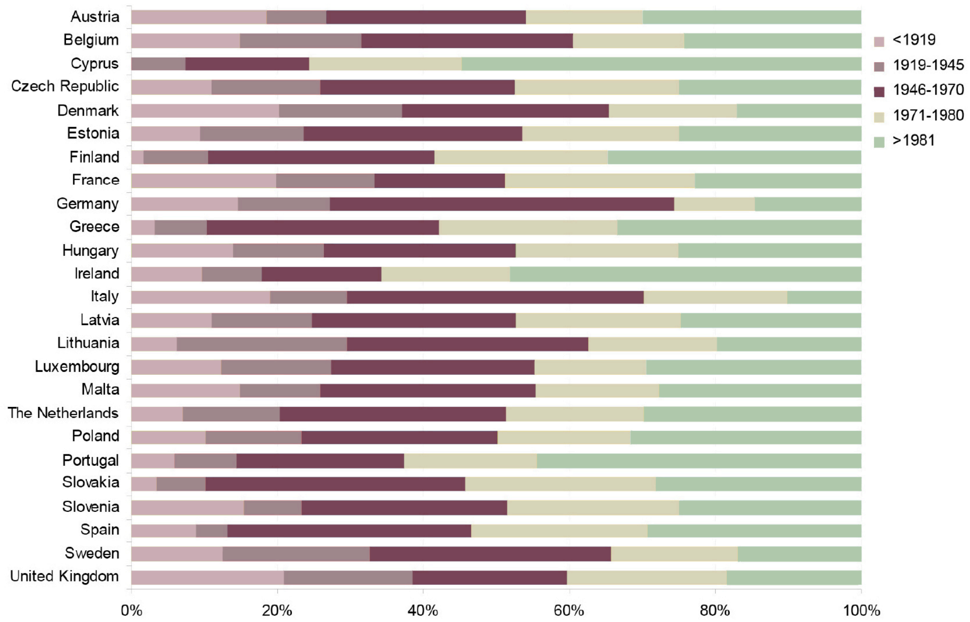

Fig. 2 Age distribution of Housing Stock. Source: Boverket &MMR, 2005.

As showed in Fig. 2, the percentage of buildings constructed in the thirty years that followed the end of the Second World War represents the highest percentage of the European housing stock, accounting for almost 30%[1] of the total European building stock. The increase in the Housing production created a vast and fairly uniform patrimony of buildings that nowadays constitutes the greatest challenge for the European Union in terms of Energy reduction. It is moreover significant to underline - in an analysis of the existing building stock that is in need for renovation in Europe - that an awareness regarding Energy consumptions related to buildings' performances arose only after the energy and oil crises, in the 1970s: thus it becomes clear that these buildings, originally built to answer to the Housing shortage, turned into being Europe's

[1] Knaack U., Bilow, M., Konstantinou T., Lieverse, B., Reimagining Housing, Imagine 06, nai10 publisher, Rotterdam, 2012

priority regarding its Energy savings agenda. In fact, almost two third of the buildings that make up the European real estate assets have been designed in total absence of specific regulations and with very few considerations on energy efficiency. This results in **buildings which are responsible for over the 40 % of the total European energy consumption**, of which residential use represents two third of the total building sector's consumption, namely 27%[2] of the overall European energy consumption. This data is worrying but surely not surprising when taking a closer look to the buildings. A high percentage of the elements that compose the façade (windows, partitioning, walls) are lacking even basic insulation, thermal bridges are geometrical, linear and spread throughout the entire window frames. Moreover, these buildings suffer of a long list of physical problems not related to the building envelope but rather related to the structure and the internal finishing. Plant systems and installations are often obsolete. In other words, many of the parts that compose the building have reached the end of their life-cycle and need to be replaced or receive maintenance. Moreover the social condition of the community that nowadays inhabits these buildings is composed by disadvantage groups (elderly people, immigrants, low-income population) in need of special consideration when intervening through renovation in their living environment. Considering the above described scenarios, renovation and restoration will consequently cover the 80% of the construction market in the coming five years[3] but yet the current renewal rate of the building stock. Three quarters of the buildings standing today, including the residential stock, are expected to remain in use in 2050[4]. So far, only about 1,2% of Europe's existing buildings are renovated every year[5]. Given the size and the high number of buildings – about 200 millions units, eleven million only in Italy - that can be grouped in this analysis, it is clear that a punctual and local strategy for renovation cannot be effective. For these reasons, this portion of the existing European Housing stock has been chose as research sample to study and test an integrated design strategy that could result in a systematic process of renewal throughout Europe.

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[2] Calculation made upon the total floor area of the european building stock and residential portion

[3] Grasso, A.., 5 minuti di recupero, Teaspoon, Montaggio Claudio Esposito Sound design, available at https://www.youtube.com/watch?v=h0egwgTr1D8

[4] COM (2012) Consultation Paper: "Financial Support for Energy Efficiency in Buildings"

[5] The demolition rates is about 0.1% per year and highly energy efficient new-build reach 1% additions/yr. JWG: Towards assisting EU Member States on developing long term strategies for mobilising investment in building energy renovation (EU EED Article 4), Joint Working Group of CA EED, CA EPBD and CA RES, November 2013 (http://www.ca-eed.eu/reports/art-4-guidance-document/eed-article-4-assistance-document).

In order to identify efficient solutions, it is indispensable to start looking at the common problems that those buildings are facing; the aim is to look at the European existing stock, understand the similarities and difficulties and the common weaknesses. In order to define the research field of the design-related research here presented, it is important, as a starting point, to investigate the benchmark and the characteristic of the buildings' sample which has been built after the Second World War and continued to be constructed with almost the same techniques and methods throughout Europe for over thirty years. In the following pages a brief introduction to the building typology of the period analysed is given, together with a general categorisation of the most common construction techniques.

A qualitative analysis on the common emergencies and weaknesses of the buildings considered is hereby provided to present a comprehensive overview of the European building stock built from the '50s till the late '80s throughout Europe, in a fairly homogeneous and systematic manner. Especially in the first two decades a new idealism was born and new forms of dwelling were introduced in response to increasing dissatisfaction with common standardised dwelling forms and models. These were the result of CIAM discussions about the Habitat theme, focused on dwelling in the city. The new motto was populism. It generated two idealistic movements: on the one side the Team X approach, defined as critical regionalism[6] by Frampton, which recognized both historical notion and urban culture, thus expressing mass housing in cultural terms and bringing a philosophical meaning to it; on the other hand the SAR method, advocated by the Foundation of Architectural Research, with open society as its guiding principle, which aimed at developing mass housing conditions that had no relation with architectural conventions, thus enabling resident participation and helping residents set their own targets within a social framework.

The experiments that young architects and planners presented to answer to the (re)construction emergency, were firstly tested in the Northern Africa (Morocco, Algeria, Tunisia) and soon after

[6] Frampton, K., Towards a Critical Regionalism: Six Points for an Architecture of Resistance, in The Anti-Aesthetic. Essays on Postmodern Culture Bay Press, Seattle, 1983.

implemented in the European cities. These architectural housing experiments, developed on the either towards *the invention of new urban patterns*, that guarantee life in the city a domain of its own, or towards *the creation of new exceptional housing typologies* for collective living. In the first case the neighbourhood is generated by the replication of one identical urban block, used as a pattern: streets are divided in primary and secondary and the traffic system is integrated within the overall structure, no consideration nor priority has been preserved for pedestrian, since car traffic still represented then a minor factor. Many examples of these housing typology can be found in countries like France, The Netherlands and Germany where the housing shortage was more severe. In the second case, generally, high rise or scaled up line buildings are grouped together and shape into exceptional urban and architectural experiment, new typologies arose based upon functionalism and optimisation of space. The first model was largely applied in countries where the emergency was severe and a solid infrastructure net could support the production and distribution of prefabricated elements that rapidly built up entire new cities, mainly in the North and Middle European countries, such as The Netherlands and Germany. Large plots were destined entirely for the construction of new urban settlements, satellite cities without functional mixture, uniquely dedicated to housing and which eventually turned into cities-dormitories. The second model often generated interesting buildings whose quality was merely as architectural and urban gesture, it is the case of broadly discussed interventions still nowadays like the Corviale in Rome or Toulouis Le Mirail in Toulouis. The gigantic scale and the monumentality of these experiments indeed could not provide citizens with sufficient living standards, today especially at the ground floor level, where green areas and open spaces were mainly blocked by the mass of those imposing architectures. Little those buildings could perform as good answer to the function of housing and even less they can today considering the society mutation and the actual condition of the buildings at current times.

In both cases, anyway, the modern dwelling was conceived a mass-product a merely residential-unit, where workers were to live as goods, allocated in a cell[7]. The dwellings were produced upon merely functionalist principles, the common believe was that of the possibility of

[7] Allocate in English, allocare in Italian is a verb derived from latin and originally recalls the act of allocating goods in an industrial chain. La Cecla F., Contro l'Architettura, Bollati Borighieri: Turin 2008.

defining the right unit, able to fit everyone's needs and necessities upon statistical suppositions in accordance with a rational usage of space. What I am referring to, is the dwelling as a product of 'machine' thinking, which has exchanged residing and living for a simple entering and exiting the front door. The dwelling has come to function more like a stopover on a restless journey. So architects, together with housing associations, shouldered the world's misery; they designed new dwellings and new urban expansions. Tafuri concludes that the government adopted the personal manifesto instead[8]; personal initiatives were replaced by planned control of Mass Housing (MH). The dwelling was reduced to the function of a consumer article and the dweller to consumer, upon the conviction that it was possible to translate man's requirements into architectural designs. It does not surprise that the MH approach has proven to be wrong in its own assumptions since individual human actions forms themselves part of the housing brief. Housing represents after all one of the central expressions of human civilisation: to build dwelling is *par excellence* a civilised activity. MH deprived man of the most primitive relationship, the relationship that linked humans to the activity of building their own protective environments and defining their own needs, the *natural relationship*[9]. By over imposing pre-made solutions conceived as universal, Housing has been deprived of its original human nature, of the possibility of customisation and personalisation that has characterised the human shelter since its origins.

The result was the creation of a large number of white and grey sub-urban compounds that pretended to be autonomous cities but were indeed inhabited only during the sleeping hours, too rigid and too static to offer the opportunity to the buildings to change and evolve according to the users necessities and – looking at a broader temporal horizon – to the society mutations. The difference among those neighbours, throughout Europe and still today, stands only in the aggregation of the different dwelling-cells therefore in the urban configuration of the agglomerates, either grouped in low-density building blocks or in monstrous MH complexes.

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[8] Tafuri, M., Progetto e utopia: Architettura e sviluppo capitalistico. Bari, Laterza, 1973. English title Architecture and Utopia. Design and Capitalist Development. Translated by Barbara Luigia La Penta. Cambridge, MA: MIT Press, 1976.

[9] Habraken, J., Supports: an alternative to mass housing, p.18-20, Urban International Press, UK, edited by Jonathan Teicher, 1999

The problem of Energy renovation of existing residential buildings has therefore a long list of common aspects that make it possible to define a European state of the art and possibly also to identify a common strategy that could represent a solution for the majority of those buildings, at least all those that have generic characters, typical of the time they were built. The following part of this chapter offers an overview of the most common construction types and typology of the buildings upon which the proposed strategy could be applied. Moreover the current ownership regime schemes and differences are illustrated since different process and approaches have to be applied in different property contexts throughout Europe. Lastly the housing quality of the future that is considered as the goal to achieve for those buildings through renovation is explained to set the target of the research.

1.1.1 Construction types

Trying to provide an overview of the existing relationship between history developments and the main housing construction types in the last century, a time-line has been produced and summed up in Fig.3. It is evident that there has been through the decades a cause-effect relationship between housing construction methods and the historical background but still the diagram does not aim at providing a complete overview but rather grouping together the most common construction types, based on literature review and field observation, and the reasons that brought them into use. The outcome is an analysis of the buildings' typology based upon the historical events that determined them; the time span for the different category is not strict but indicative to illustrate the main passages in terms of technological and industrial changes in the building and construction sector.[10]

[10] Knaack U., Hildebrand, L., Konstantinou T., Wieland, H., Reimagining Housing, Imagine 07, nai10 publisher, Rotterdam, 2012

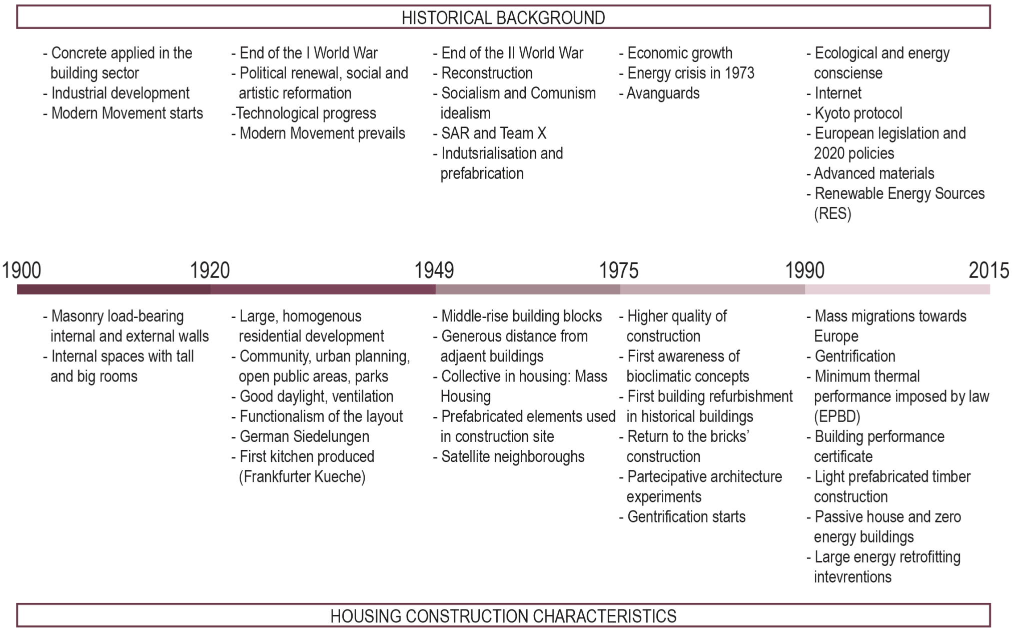

Fig. 3 Relationship time-line between historical/archtectural events and housing construction characteristics

It is evident that the geographical as well as the historical background of the specific regions within the European Member State determined different material usage and technologies. While the large and homogenous residential developments that spread in Europe after the first World War were the physical evidence of the predominant role played by the Modern Movement. Yet the material used for construction were tightly bonded with the regional and geographical location and contexts, infrastructures and the industrial sector were not sufficiently develop to support diffusion of unified construction techniques and methods.

The most used construction technique in this period was masonry: the external load bearing walls carry their own load, the load of the roof and that of the in-between floors with the relative loads. Normally, the roof and the other construction elements WERE made of timber. The thickness of the masonry walls depends on the number of storeys of the building and it was also common to find decreasing thicknesses of the walls at the upper floors, in these cases a minimum thickness was defined for the upper floor and then increased by half a brick for every additional storey. Also the density of the bricks could change according to the location in the construction in the high of the buildings in order to decrease the overall load of the wall itself in

the higher parts of the building. Secondary and internal load bearing walls were distributed between the dwelling units, this forced a regular sub-division of the internal layout and suggested the repetitive and regular distribution of the openings on the front facades.
Another common construction techniques is based on load-bearing cavity walls, unlikely the normal masonry this construction technique presents an intermediate air cavity within the walls. It presents a performance improvement when compared to the normal massive masonry wall, since the air cavity decreases the heat transmission value of the wall and reduces the risk of moistening acting also as insulation. Additional advantages are related to the savings in material and the rapidity of construction. On the other hand it is also important to mention that the static performances and resistance of the cavity wall is less than the normal masonry wall, although bonders or tiles of galvanised steel are generally inserted in the masonry to connect the two layers. In both the above-mentioned techniques, based on load bearing masonry, the solid bricks were soon replaced by perforated clay bricks and lightweight masonry units, which allowed larger formats at the same weight per unit, resulting in a faster and cheaper technique. High strength bricks are generally used in the outer masonry layer for better weather protection. Floors slabs and roofs were built mainly with timber joist and only later, during the fifties, they were replaced by precast concrete floor slabs.
A more advanced construction technique is the confined masonry: a reinforced concrete frame building with masonry walls that are generally used in as infill and specified by architects as partitions in such a way that they do not contribute to the vertical gravity load-bearing capacity of the structure. This type of construction allows a larger number of building configurations, the irregularity provides space for controlling lighting and ventilation and suits architectural requirements. However, this also results in irregular geometry of lateral load resisting elements, which may generate additional torsional stresses during earthquakes. Since openings are created in partition walls, these openings do not have a significant bearing on the structural performance. Compared to the normal masonry, this construction type presents normally the disadvantage of having numerous linear thermal bridges along the structure frame. Even in those cases where a cavity wall or an insulated one is used as infill, the structure is often exposed and the building performances of the overall envelope not up to normal standards even considering the beneficial contribution given by the thermal mass of the walls.

After the Second World War traditional building methods as well as regional materials and techniques became less important as developers and the public authorities in charge of the reconstruction looked for rapid and economical construction solutions to fulfil the huge demand in the minimum timeframe. Yet load-bearing masonry was still a construction technology in use but it consisted almost universally of fired clay bricks. It was not unusual to find bricks produced by the recycle of material from the ruins of the bombing period. The real revolution in the reconstruction period was given by the transition from those load bearing construction systems towards prefabricated construction methods that allowed the pre-fabrication of many building components off-site or directly on the construction site but in series, speeding up the entire construction process and significantly reducing the construction times. Precast concrete elements were preferred both for enclosure walls and for floor slabs allowing to construct buildings from five up to ten floors. With the introduction of precast (prefabricated) concrete constructions the majority of structural components were standardized and produced in plants in a location away from the building, and then transported to the site for assembly. This construction technique was largely used in the republics of the former Soviet Union and Eastern European countries, but after the Second World War, considering the great reduction in time and cost that precast concrete structures allow, was largely applied to the Mass Housing production through out all the countries in Europe. This system allows in fact both the division and specialization of the human workforce and the use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products. Depending on the load-bearing systems, precast systems can be divided into the following categories:

- Large-panel systems (single or double, with/without internal air/insulated cavity): multi-story structures composed of large wall and floor concrete panels connected in the vertical and horizontal directions so that the wall panels enclose appropriate spaces for the rooms within a building. In some cases a layer of insulation had been inserted between the two leaves of concrete panels, such buildings present more difficulties during the energy renovation phase because the inner insulation is often damaged by moisture. The removal of this layer becomes essential although complicated, to ensure an improvement in the performance of the envelope.

- Frame systems: the main structure is a skeleton concrete structure consisting of linear elements or spatial beam-column sub-assemblages, however, considering the difficulties associated with forming, handling, and erecting spatial elements, linear simple elements are generally preferred. Masonry (confined masonry) or precast panels (Single or with cavity) can be use for external infill walls.
- Slab-column systems: this system relies on shear walls to sustain lateral load effects, whereas the slab-column structure carries mainly gravity loads. Precast columns are normally minimum two storeys high while precast concrete floor slabs are lifted from the ground up to the final height. The connections are made through steel bars (dowels) that are welded to the dowels of the adjacent components; transverse reinforcement bars are installed in place. The connections are then filled with concrete that is poured on site[11].

It was only after 1973, after the broke out of the energetic crisis that housing started to be connected to bioclimatic concepts and the search for an efficient relationship between buildings and environment. Also in those years, the first experiments in the field of participative design started: the role of the inhabitant was brought at the centre of the design process as already claimed by few during the fifties. However, the procedural limits of the participative experiments as well as the lack of instruments lead to a partial failure of these experiences. Only today with the new digital tools and the possibilities offered by the internet it is possible to re-interpret and re-consider an inter-actions with the users which became almost crucial in the housing field. This becomes even more clear when considering the emergencies that our age is facing: mass migrations fluxes towards Europe, increasing social mixture, need for integration schemes, new housing emergency and mostly the need of renovate a large building stock that is the heritage of all those decades described above.

[11] Greene, M. and Brzev, S. (2003) . The Web-based World Housing Encyclopedia: Housing Construction Types from Earthquake-Prone Areas of the World. Proceedings of the U.S.-Japan Workshop

In order to define a common European strategy that could represent an integrated methodology to tackle Energy Renovation of existing buildings, the proposed technology shall be flexible and modular enough to adapt itself to the various and heterogeneous buildings type. The short overview above provided of the possible construction techniques that could be encounter when approaching existing buildings provides the list of reference construction types to which the proposed system shall be applied. The goal is thus to define, through one unique system, to the multiple possible scenarios that characterise the research application field above described.

1.1.2 Housing typologies

"… the problem of housing typology has been solved seeking for a solution that could have general validity: the search was not addressed towards the definition of a standard, but rather rational conditions for the living"

Aldo Rossi

Housing can be categorized according to size, function, circulation and neighbour into the following general types: single-family houses, terraced-tow houses, multi-family houses and apartment buildings. Each type's specific characteristic affects and dictates the refurbishment strategy in terms of decision-making and process, as well as user-involvement potential and methodologies applied. The population growth and the housing emergency that took place in the second half of the 20th century was accompanied by a process of rapid urbanization, which also left traces in housing typologies. The relatively homogeneous ratio of variety that characterised the tradition of the European housing typology until 1945 has then rapidly narrowed down to the solely apartment block typology which became as common housing representation, either in the line or in the tower form.

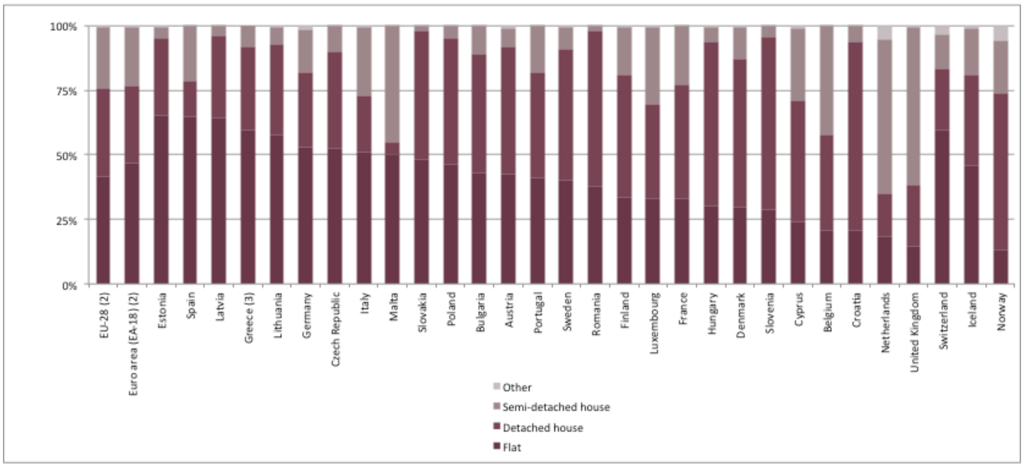

Fig. 4 Distribution of population by dwelling type, (Ireland not available). Datas in % of population. Source: Eurostat 2014

The apartment typology is therefore the major representative of the collective housing movement above illustrated: as shown by Fig. 4, in 2013, 41.1 % of the EU-28 population lived in flats, just over one third (34.0 %) in detached houses and 24.1 % in semi-detached houses[12]. Migration movements and the rapid increase in population density in the cities lead to the redefinition of the *living in community.*

The common dream consisted of neat, ordered and clean buildings, equipped for the first time with services, appliances and installations directly in the apartments. Running water, electricity and functional arrangements, emblematically represented by the Frankfurter kitchen. The identification of high-density Housing models such as towers and building blocks with the concept of MH was soon questioned directly by the exponents of the Modern Movement who started reconsidering the advantages of living entirely at ground level. This moved some of the early representatives the to investigate low-rise dwelling forms like those on which the garden-city idea was based upon. Walter Gropius criticized indeed these theories, claiming that they were unsuitable for Mass Housing, since the single-storey form meant “the negation and dissolution of the city”. Countering this argument, Ludwig Hilbersheimer contended that

[12] Eurostat 2013

everyone must be allowed to choose the type of dwelling he or she preferred[13]. Low-rise housing with gardens were considered better for families with children, whereas couples without children, or single persons tend to prefer living in high-rise structures with communal facilities. He therefore called for mixed housing developments with high- and low-rise structures[14] combined together to offer a social and typological mix within the same urban settlement. The mixed housing scheme was largely used throughout Europe generating various patterns and unifying high and low rise building an different social levels bringing together middle and low classes. It has been proven to be a winning scheme both from a social and an urban perspective, until it lasted; until the social dynamics did not change and the original inhabitants moved out of their homes, until when the fragile balance was then broken and chance or chaos took over.

Collective or mass housing draws its name origin from the way in which the building is accessed, namely by a *common path* and *common entrance* serving multiple units. It is defined by quantity and the form follows the spatial aggregation of the different units, it acquires its spatial quality through grouping. This type of buildings house large numbers of people with varying degrees of housing quality. All the buildings that could be grouped under the definition of Mass Housing, with very little exceptions, are drawn together by the characteristic of uniformity. No other form and typology of housing results in series of identical dwellings. These units are closely grouped, according to rules of horizontal or vertical assemblage, generating spaces with public, semi-public or private character in which certain social practices of housing unfold. The ratio that guides the aggregation of the units it is based upon the primary needs of lighting and ventilation, the internal layout is then repeated identically as uniform solution throughout the horizontal (in case of line buildings) or vertical (in case of tower buildings) development direction of the building. The same methodology is then applied at the urban scale.

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[13] Schittich, C., Low-rise Housing Typology, Detail online, Magazine 3/2010 http://www.detail-online.com/architecture/topics/low-rise-housing-typology-010980.html
[14] Low rise dwelling typology, detail-online

The proposal is that of seeking for an increase in the original density of those compounds and re-interpret the original dwelling typology in an open and flexible manner. What we learned from the past is the impossibility of pre-defining a right typology or distribution scheme that could fit and serve the needs of the users through out the decades. The original Housing typologies need to be renovated and reinterpreted according to an open perspective, empowering them with the ideal capability of being flexible enough to turn themselves from a low density to a high density model and vice-versa according to the needs. Building blocks, towers and garden city buildings are no more than rigid schemes, a base, a blank sheet, upon which the renovation and transformation project shall define and draw the rules for the definition of a new housing typology allowing changes, additions and subtractions of volumes, through Add-Ons. The addition is typologically conceived as unit module that can be used and combine to re-invent the original and increase the adaptability of the existing building, at the present but also in an evolutionary vision that will allow substitution, removal and additions of parts in the future.

1.1.3 Ownership regime

Besides studying the reference buildings by their construction type and architectural typology it is necessary to understand the different stakeholders. Non-technical barriers are the first and most under-estimated limits to the Energy Renovation of the existing building stock. Stakeholders intended as owners, tenants, investors and housing associations are expected to have a great influence on renovation decision-making[15] process and, in many cases, on building operation. The ownership status of the dwelling is extremely important in the renovation practice since it effects directly the authorisation and the feasibility of the proposed intervention. A direct involvement of the inhabitants and the owners' participation in the project is therefore fundamental to propose effective initiatives that could be supported and pass the bureaucratic permission phase.

[15] Thomsen, A. & F. Meijer, Sustainable housing transformation; quality and improvement strategies of the ageing private housing stock in the Netherlands, ENHR congress Rotterdam, June 2007

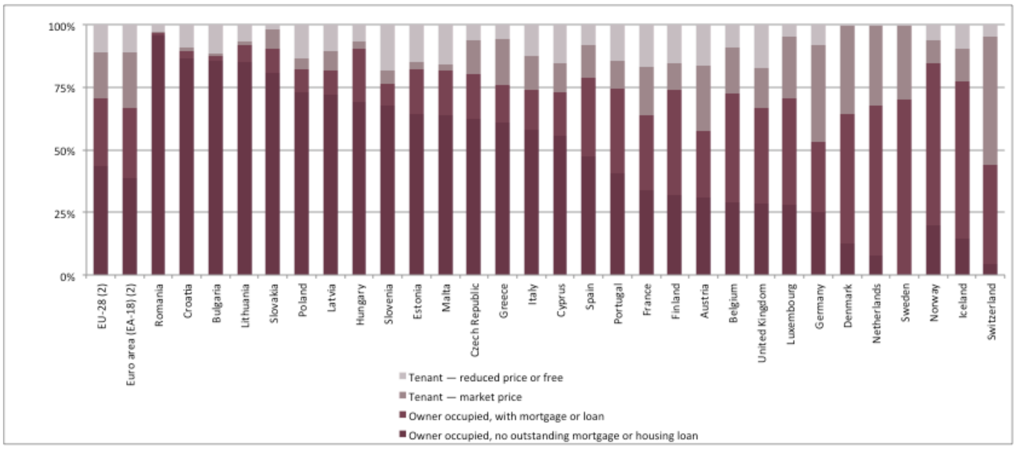

Fig. 5 Distribution of population by ownership and tenant regimes, (Ireland not available). Datas in % of population. Source: Eurostat 2014

If the urban, social and architectural characteristics of these districts can be described within the European borders as a common phenomena not the same can be said regarding policies, property regimes and conceptions. In fact, residential areas in many cases also house different stakeholders, multiple property regimes and different social mixture. A first division is made between owner-occupied (with and without a mortgage/loan), and tenant (with reduced price as social housing or with market price). The highest percentage, within the EU member states, is the owner-occupied regime as shown in Fig. 5, ranging between a minimum of 60% in Austria up to a maximum in Romania of 95%. This is a favourable condition when considering refurbishment since the owner and resident coincide, representing also the major beneficiary of the intervention. In these cases the negotiation phase is generally simpler since it is easier to get in contact with the owners, they are well aware of the disadvantages and actual problems of the apartment and, sometimes, they are also willing to invest or contribute to the renovation costs because they see the benefits on their own property.

On contrary, in situations where the resident and the owner do not coincide, in owner-tenant relationship, the investment and approval circumstances are more complicated. It is in fact harder to receive authorisations, permissions, or financial support from those who are renting an apartment and would not directly benefit from the intervention. Moreover it is often complicated to collect the original owner who might live in another city of even another country, who might have inherited the dwelling and not have much interest in it and ultimately might express a vote against the renovation in the negotiation phase for a broad number of reasons connect to the lack of interest in the property since someone else is currently living in it.

Even more intricate are those cases where in the same building multiple owner-tenant relationship coexist. In several countries like Italy or Spain or Germany, during the years of the regimes, governments were building entire residential compounds: low-cost but relatively high-quality buildings that were then sold for favourable prices or given by right to the exponents of the majoritarian party. Thus often part of those Social Housing Building returned to the public organisation appointed organ such as Housing Associations and partly remained to the original inhabitants and owners. In these mixed regime cases, in the event of a vote or negotiation to support a renovation intervention it is the majority that decides towards the approval or rejection of the motion. The count in Italy is made by property, this means that the Housing Association vote counts only for one since it is representing the interests of one property, no matter how many dwelling units are under the control of the Housing Association, which ends up having very little power at the negotiation table. The single owner has then much more relative power and it is easy to understand that the authorisation for intervention is often hard to be obtained since the consensus shall be (almost)[16] unanimous in order to be able to proceed to the refurbishment. It is therefore fundamental to activate a step-by-step program that includes the inhabitants and the stakeholder in the process from the very beginning, communicating and informing on the potential disadvantages or benefits and engaging an open dialogue on the design level. The standardised participative methods are no longer able to face the current condition of the inhabitants: the experiments for example carried by De Carlo in the Villaggio Matteotti were facilitated by the relatively good social condition of the residents, coming from the same background. The disadvantaged socio-economic condition of the population that today inhabits these districts complicates the procedures; the situation, registered also a further worsening. The effects on homelessness and poverty seem to be worse since 2011 and the

[16] The procedure and required percentages depend on the different countries and regional regulation. The aim of the arguement is to illustrate the often underextimated importance of gaining a broad consensus and participation from the owners and inhabitants and the complexity of doing so in a programatic way considering the vast number of possible ownership regimes.

impact of the crisis and the austerity measures seem to have a strong time lag effect.[17] This is often reflected in rent/mortgage arrears, increases in evictions, homelessness, growth in waiting lists for social housing, demand for homeless services and increased indebtedness in relation to key utilities such as heat and water.[18] Other condition often registered is the definitive decision from the families to avoid usage of water or electricity to reduce the consumption and bills. This leads also to a difficult situation evaluating the economic pay back of the energy renovation intervention since then the benefit of the action would have a reduced impact compared to the current situation. Within the population at risk of poverty (in other words, people living in households where equalised disposable income per person was below 60 % of the national median), the overcrowding rate in the EU-28 was 30.2 % in 2013, some 12.9 percentage points above the rate for the whole population. In addition to overcrowding, some other aspects of housing deprivation — such as the lack of a bath or a toilet, a leaking roof in the dwelling, or a dwelling considered as being too dark — are taken into account to build a more complete indicator of housing quality. The severe housing deprivation rate is defined as the proportion of persons living in a dwelling which is considered as being overcrowded, while having at the same time at least one of these aforementioned housing deprivation measures. Across the EU-28 as a whole, 5.2 % of the population suffered from severe housing deprivation in 2013. Moreover in the recent years, considering also the increased immigration rates, the inhabitants' mixture and social composition has consistently changed arising integration and language problems. Thus, social housing is currently faced with a double challenge: on the one hand it is called upon to respond to increasing housing needs and emergencies which are not satisfied by the market while on the other hand the resources which have so far been used to finance the sector are decreasing, and in some cases they have undergone a dramatic cut over the past year.

Procedural and bureaucratic slow down of the renovation, significant at a first rational analysis, becomes more sever when analysing in specific the current state of the inhabitants and the historically and economically critical moment that Europe is currently facing. Low-middle income

[17] FEANTSA (2011)
[18] See CECODHAS Housing Europe Observatory (2012)

families and individuals with low education levels compose the typical social group populating collective housing building. The rate of elderly and immigrant inhabitants is generally high and these groups have often troubles in creating a cohesive community since there are different if not opposite interests, traditions, habits, cultures and religions. In other words, considering the not ideal composition of population, which share those compounds, fights and discussions happen on a regular base. The little minority represented by young couples or singles – that after the crisis started to increasingly enter the social housing group – is not able to act as mediator favouring possible integration and the creation of harmonised communities like those that initially inhabited those compounds. Those buildings which were hosting the ideal of the reconstruction, the machine era and the living together utopia are now the representation of a far different reality of segregation and poverty becoming the physical evidence of the missed opportunity, in Europe, to undertake effective integration policies. The refurbishing and empowering of these housing sector is more than a challenge, is already now a priority for Europe.

1.1.4 The Housing quality for the future

Considering the common background that has brought to life these compounds and their generally uniform architectural and urban layout it is possible to underline common strategies and goals among the different state members. Even if the actual state is more and more the different and regional obstacles, Matthew Carmona[19] outlined a number of general criteria which can be considered vital to leverage urban and architectural quality in residential developments, studying how a specific form of design guidance such as design coding, can help streamline the process of analysing such quality to define a common scheme that is fundamental to develop crossed analysis and comparisons between different social housing district. The 20 key points listed above outline a possible reference framework for quality in housing design, ranging from the relationship of buildings to urban space to the interior aspect

[19] Carmona, M. Housing design quality: through policy, guidance and review. Taylor & Francis, ISBN 9780419256502 01/2001, Abingdon, 2001.

of individual residential units as presented in the roadmap report of Housing for Europe 2007-2013. These key factors are tightly interdependent, providing in fact a complex “quality mesh” where no one aspect can actually be present in absence of several others. Functional and environmental factors, being mostly related to measurable, statistical indicators, tend to be more objective; aesthetic and psychological factors, which are connected to the cultural sphere, demand a far greater adaptation to context. Clearly enough, it is difficult to imagine how a field so deeply influenced by cultural factors such as housing can be schematized in 20 – or for that matter 100 – single points. What is considered good in Greece may be abhorred in Germany and vice versa.

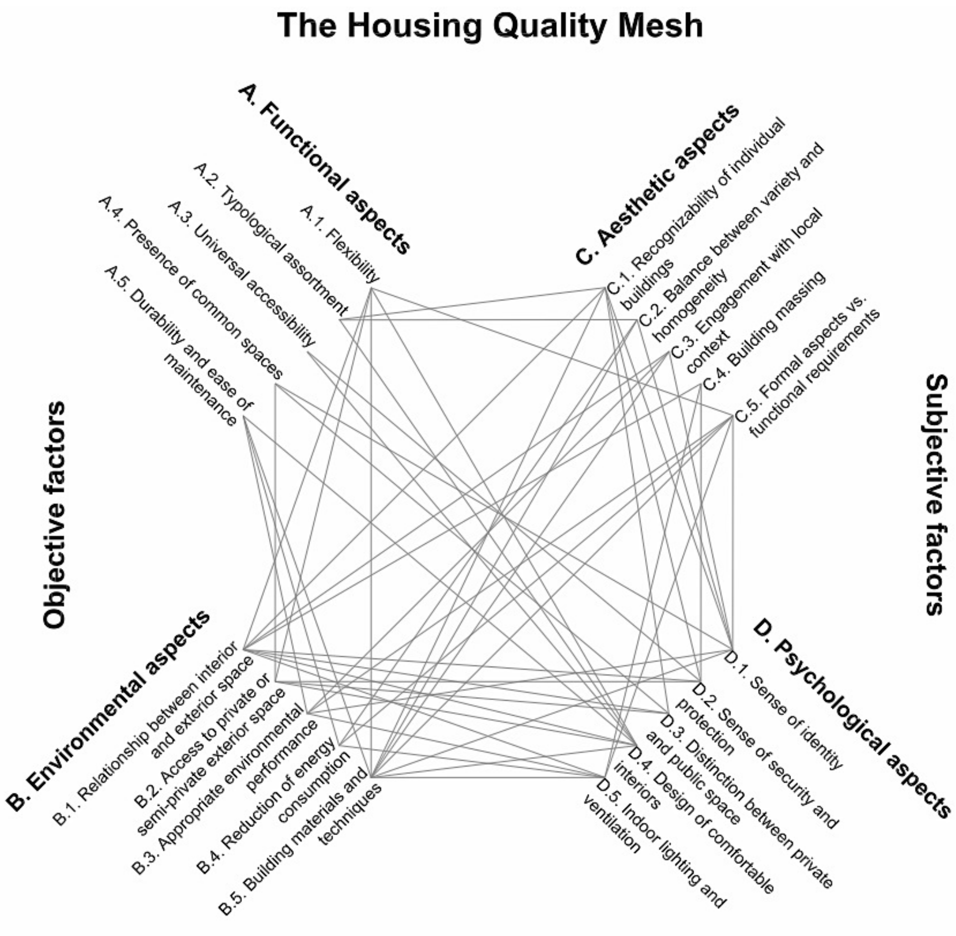

Fig. 6 Carmona’s Quality Mesh, a roadmap for the definition of quality in residential areas, Source: Clemente C., F. De Matteis, Housing for Europe. Strategies for Quality in Urban space, excellence in design , performance in building. Urbact Pubblication, Tipografia del genio civile, Roma, 2010.

Assuming that is possible to define a universal idea of quality and a right path towards it is as utopic as the theories upon which Modernism has based the construction of identical building blocks throughout Europe. The core of this type of analysis is not an “arithmetical mean” of all positive aspects of housing quality, since it is clear that in the past but even more nowadays what could determine a positive effect in Denmark might contribute negatively in Spain: contrary, the criteria illustrated in the quality mesh should each be considered as a starting discussion point open for a local and case-specific interpretation, open for further implementation and to be used as an in-fieri open-source of principles. What it is suggested is an open and flexible process for Housing and Energy Renovation that could be adapted to the specifics of each context and thus be complete of all the possible path and solutions rather than determine a fixed solution with the illusion that will fit at best in all the scenarios.

Looking at the Fig.6 it is possible to have an overview of the main factors that play a key role in the decision and evaluation process when having to define the convenience of the renovation rather than demolition option. The factors grouped as ‘subjective’ factors on the right side of the mesh are not part of a general cost and benefit analysis since it is not possible to quantify and estimate them in economical terms. Objective factors, contrary, are the key parameters upon which Europe is defining targets and policies toward the 2020 deadline for Energy Reduction. However to achieve a log-term sustainable upgrade of the European Housing Stock, actions can no longer merely look at the physical and functional requirements. Psychological and aesthetic requirements play an comparable and crucial role but yet those aspects are underestimated and rarely included in the evaluation regarding the effectiveness of one or one another solution. A proper scheme or evaluation procedure to compare and estimate those requirements in the Housing Renovation intervention is still missing.

Renovation interventions result in an increased quality and value, at different levels and involving multiple aspects, most of which can hardly by quantified but still have a consistent impact in the long term and upon the social, ecological, infrastructural and urban systems. It is thus suggested to look at the Housing Quality Upgrade by two sides: on the one hand considering the subjective factors and a non-financial perspective understanding and evaluating its possible implications and positive results not in economical terms and on the other hand redefining the boundaries of the economical aspects themselves. Comparing the Energy

Renovation of existing buildings to a table game with a set of rules, we can surely state that those rules have been so far based only upon an economical and environmental logic and in the past ten years this game has seen no winner. Time has come to look at the rules, questioning them and introducing the psychological and aesthetic perspective to provide an omni-comprehensive set of rules. Then maybe we can win the match and foster the Renovation on a broad European scale.

1.2 Current Energy Renovation techniques and market

Generally, through standard and specific Energy Renovation interventions in Europe, it is possible to reach modest improvements – usually in the range of 20% to 30% of the overall prior energy consumptions of the buildings. Up until 2010, those improvements have been considered sufficient measures to answer to the Energy reduction imperative. However, if the energy and climate goals for Europe 2050 are to be achieved[20], we are starting to realise that a different approach is needed: we have no choice but to dramatically upscale our performance target and aim at interventions that are far more effective in terms of energy reduction. The implementation of single measures, such as application of an insulation layer, the replacement of windows, the improvement of operation and maintenance services, the lighting upgrades or the creation of roof space insulation constitutes only to a first basic reduction, no longer sufficient. A global and effective plan is required to reach a higher and more ambitious goal. The combination of single measures (which can be termed as *standard renovation*) involves the simultaneous, balanced and studied implementation of several individual energy-saving measures. The right approach starts by looking at the buildings energy performances as the combined result of two distinguished but inter-dependent factors: the envelope and the plant systems. Mono-directional interventions that do not consider Energy Renovation as a practice that unifies actions upon both the systems will result ineffective and return partial achievements.

The term Deep Renovation (DR) or **Deep Energy Renovation (DER)** refers to those energy renovations that instead of focusing on standard renovation measures capture the full economic Energy Efficiency potential of improvements by combining in one integrated strategy several necessary measures, acting upon the building envelope and installation system. By renovating deeply, using state-of-the-art technologies in a combined an integrated manner, it is possible to

[20] Reduction of the annual global CO2 emissions to 25 % below business-as-usual projections in 2020 and 50% below projections by 2030 compared to 2005 levels

reduce the energy consumption of existing buildings by more than 75%, doubling and more the normal practice of energy renovation that generally do not reach the 30% in reduction. According to the definition provided by the Global Building Performance Network (GBPN), the primary energy consumption after Deep Renovation, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting, shall be less than 60 $kWh/m^2/yr$.[21] However, this is only one of the numerous definitions circulating around Europe as the level of achievable savings will vary depending on climate conditions and, in particular, depending on the energy performance of the building prior to renovation. There is yet no common definition of DR established, neither at a regional or international level. The target reduction in consumptions varies between the regions. However, experts from Europe found that renovation as a term is most commonly used whereas experts from the US found that the term retrofit is the term usually used. Therefore, the definition relating to a deep renovation aimed for the deepest reductions of all the terms, these improvements mainly concern the buildings envelope. The definition of a retrofit focuses mainly on the building's mechanical systems.[22]

In 2010, 70% of energy consumption in the world's buildings came from the residential sector and 30% from service buildings. These proportions are expected to stay the same until 2050. Residential heating represents the largest share of consumption therefore Energy Renovation should become the main object of the efforts to increase the energy savings rate. Yet, surprisingly only 1,4 % of European existing buildings are renovated each year[23], and yet the overwhelming majority of these renovations do not lead reach the Deep Renovation standards but are instead limited to standard renovation, thus reducing the consumptions of 20-30% compared to the prior-intervention condition. Taking the Italian building stock as example, the buildings in need of Renovation account for around 11 millions which, coherently with the European average renovation rate, means that every year we renovate only 154.000 buildings. The numbers become more significant when compared with the cubature of new buildings

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[21] Shnapp, S., R. Sitjà, J. Laustsen, What is Deep Renovation, Technical Report, Global Building Performance Network, GBPN, February 2013
[22] Shnapp, S., R. Sitjà, J. Laustsen, What is Deep Renovation, Technical Report, Global Building Performance Network, p. 6, GBPN, February 2013
[23] BPIE, 2011

constructed each year, 50.000 buildings; the ratio between building renovations and new constructions is 3:1 and should double itself by 2050. Three policy scenarios have been developed by the GBPN to assess and compare the mitigation potential (see Fig.7) on the long term, looking as 2050 as the target:

- The **Deep efficiency** scenario combines today's state-of-the-art, know-how and technologies which become standard policies; the assumption is that by 2020 the majority of newly built and renovation buildings will have reached high standards (30-75% reduction in consumptions). Renovation rate shall rise from 1,4 % to 3 %.
- The **Moderate efficiency** scenario illustrates the development of energy use under recent (i.e. business-as-usual) policy trends; buildings will follow the current regional building codes. 30% savings will be reached through renovations and the energy renovation rate shall increase from 1,4% to 2,1%;
- The **Frozen efficiency** scenario is based on the case of no new policy or market developments. It shows consequent increase new buildings' consumptions due to the reduced level of compliance to the existing regional building codes. Energy renovation target remains around 10% of energy reduction. Energy renovation rate remains 1,4%.

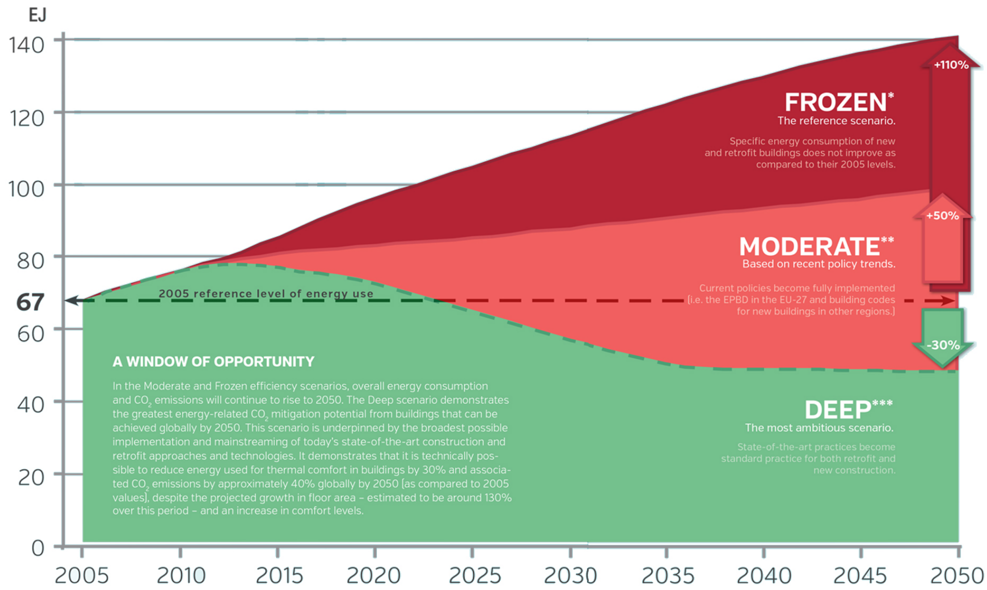

Fig. 7 The graphic above illustrates the three scenarios (Frozen, Moderate and Deep) of the future of energy consumptions and GHG emissions of the building sector. Source: GBPN ,The Deep Path for Closing the Emissions Gap in the Building Sector , Global Builings Perfrmance network (ed.), Paris 2013.

Rather than a forecast, those three scenarios provide insights on how savings potential can be best captured. If no action is taken to improve energy efficiency in the buildings sector, energy demand is expected to rise by 50% by 2050, when the global population is expected to have grown by 2.5 billion people. This increase would be driven by rapid growth in the number of households, the floor area of residential and services buildings, ownership rates for existing electricity-consuming devices and demand for new products.[24] The Deep and the Moderate efficiency scenarios both require changes to today's policy strategies, with the Deep efficiency scenario requiring a much more ambitious approach than is currently the norm. To define the right path to follow the Deep Renovation scenario, a self-sufficient market has to be established by the use of financial incentives linked to total efficiency improvements. Financial incentives should only be offered for improvements that reduce energy consumption by at least 50%, looking at the yearly target of minimum 60 kWh/m^2 as reference or alternatively defining a parametric equation to set the right minimum levels of performances. Sliding scales that favour reductions of 75% to 80% should be the primary goal of financial incentives; an upgrade of those incentives shall be considered in case of interventions that foreseen the integration of additional, non-economical benefits, thus attracting greater investments, enlarging the stakeholder group and activating a virtuous circle around Europe.

Then the author would like to rise a question directly related to the idea of Deep Renovation: is in fact DR the right goal? Or rather DR does not represent the ambitious and revolutionary vision that Europe needs to reach the 2050 with a renovated and efficient building stock? This research presents a strategy able to go beyond Deep Renovation and foster, through the Add-Ons strategy, a ratio of Energy Renovation equal to 8-10% of the existing buildings, looking at trigger a systematic and programmatic revision of the entire European building stock. In order to overcome the existing limits and barriers to renovation it is crucial to first overcome the economical and financial limits, evaluate the non-economical benefits and the social aspects so far underestimated and ultimately increase the investors' confidence showing the real potential of Energy Renovation.

[24] International Energy Agency (IEA), Transition to Sustainable Buildings: Strategies and Opportunities to 2050, OECD/IEA, Paris, 2013.

1.2.1 Deep Energy Renovation strategies

Analysing the building as an organism, the envelope represents the most significant interactive element, being the layer between the interior and the exterior, the means through which Architecture shows and manifests itself to the City, playing as major ecosystem. Professor U. Knaack compares the envelope function to those of the *skin* for the human body: the function of thermo-regulation and reaction to weather variation through regulation of heat emission. Considering its in-between character and location of data sensing, communication and responsive performance and display, it represents the most logical portion of the building to look at for improving the interaction between the building and the external environment.

The quality and functionality of the building envelope determines the heat losses of the buildings and also, inversely, its solar gains. Therefore, when refurbishing an existing building, the envelope is generally the key element among all the different building components. This is due to the fact that interventions focused on the façade can alone reduce up to 45-50% the overall energy consumptions of the buildings. This is due to original technical mistakes but also, largely, because the façade components have mostly already reached the end of their life cycle. Considering the buildings constructed after the Second World War, the structural life span is 60 years but the envelope elements have a reduced life cycle, no longer than 30 years. Up until few years ago, but still today, the most common technical approach to the refurbishment of the envelope has been based upon the principle “the thicker the insulation, the lower the energy demand”.

This results often in a reduction of the heating demand in the winter period but results also in higher cooling demands or higher interior temperatures not only in summer but in the mid seasons as well. An additional weakness of the existing building upon which it is possible to act in the renovation phase is the poor air tightness of the existing envelopes, but the idea of reducing the infiltration of outside air requires the a constant and exclusive mechanical ventilation system in addition to the occupant’s behaviour is far from having an awareness of the correct usage of those type of systems. Another pathology often found in these buildings are the thermal bridges, which still mostly remain even after refurbishment due to a lack of expertise and attention from the technical side in the phase of insulation or installation of the new windows. The plant system and building services represent the other big residual deficit factor.

Integrated actions, in order to be effective and at the same time contain the costs, should consider both the envelope and the plant system as the two sides of the same problem. The envelope is constituted by opaque components (the exterior walls, basement ceiling, roof, balconies, loggias) and transparent components (windows, doors). The possible asset upgrades include a wide range of actions: upgrade of mechanical or electrical systems, restoration of deteriorated building envelopes, repair of structural damage, renovations to reduce service-ability problems, changes to satisfy government mandates, repair of original construction, and corrections to previous renovation errors. In spite of challenges due to being more difficult and requiring less qualified workers than new construction, maintenance and refurbishment activities are implemented by owners to maintain or raise the value of a building, thus decreasing its wear and obsolescence. As for what concerns the plant and installation systems renovation actions can be grouped in invasive or non-invasive interventions. It is possible to partly replace the plant with new centralised heat-pump systems and use the existing services without requiring interventions within the apartments or it is possible to design and replace the entire plant and distribution system, increasing the efficiency but also the disturbance for the inhabitants. New and highly innovative plug-n-play systems are based upon the technological innovation of creating integrated systems directly in the new façade panels that act as technological component, improving together envelope and plants. Through this systems it is possible to apply the new façade or installation element and directly connected to the existing equipment combining efficiency with a minimum-intervention policy that avoids major reconstruction works in the dwellings.

The following part intends to provide an overview of the current and most common strategies used in the refurbishment practice for DR and the consequent primary methods of intervention on the envelope. Insulation strategies need to be suited case-by-case and the performance requirements being sought. Issues related to insulation values, thermal bridging, disruption to the occupants, aesthetics of the outside of the property and loss of space from the inside of the property, impact on the decision making phase to determine the most appropriate strategy for a given project. The Bartlett Energy Institute (UCL-Energy) has defined the following four main Deep Renovation and Deep Retrofitting strategies[25]:

- The whole-house approach (also known as whole-house systems approach) faces the building as an energy system is composed by interdependent parts. The approach considers the interaction between the occupant, the building site, the outdoor climate, and other elements or components or factors that are part of the building or influence it. In this approach the features and performance of each component are strongly affected by the rest, and energy performance is considered a result of the whole system. The calculation is therefore conducted through complicated parametric equations that consider the differential and per cent contribution of each variable.
- The "fabric first" approach prioritises the improvements connected to the thermal properties of the building envelope through the use of high levels of thermal insulation and airtightness. Insulation materials and thicknesses play a key role in this strategy. A range of measures is then employed to increase the efficiency of various systems (e.g. heating and hot water, lighting and electrical appliances). System re-sizing may be desirable as a consequence of reduced energy demand, but oversizing (e.g. of heat distribution systems) can significantly improve the overall performance. Finally, renewables are installed to meet the required CO_2 and energy reduction levels. It is fairly well accepted that this is the most effective strategy for retrofit.
- The Passivhaus strategy is a German-developed standard (which can be considered as a high-specification "fabric first" approach with an enhanced Quality Assurance element). The Passivhaus approach significantly reduces the carbon footprint and results in ultra-low-energy buildings, requiring little energy for space heating or cooling. The Passivhaus standard for central Europe sets a series of specific requirements that determine as well the Passivhaus label: 1. The building must be designed to have an annual heating demand, as calculated with the Passivhaus Planning Package, of no more than 15 kWh/m^2 per year for heating and/or cooling energy, or be designed with a

[25] Retrofit strategies. Key Findings: Retrofit project team perspectives. Analysis of a selection of Retrofit for the Future projects, Institute for Sustainability, 2012 www.instituteforsustainability.org.uk

peak heat load of 10 W/m^2. 2. The total primary energy consumption (source energy for heating, hot water and electricity) must not be more than 120 kWh/m^2 per year. 3. The air permeability of the building must not exceed 0.6 air changes per hour at 50 Pa. It is an ambitious target for a new building and it becomes complicated and even more ambitious to reach when dealing with existing buildings with low budgets.

- The "insulate then generate" philosophy, which is very similar to the "fabric first" approach, first aims at reducing the energy demand from passive design strategies (building fabric, thermal mass and airtightness, ventilation and heat recovery), and then tries to meet the remaining demand through the use of micro-generation technologies such as bio-mass systems, solar collectors systems, micro-wind turbines etc.

KfW, a development bank owned by the German government, has run the best-known and most effective retrofit programme of the past decades: in a period of time of 20 years it renovated a significant portion of buildings in the former East Germany (61%), for an overall cost of EUR 61 billion (KFW, 2013a). To qualify for the deep retrofit grants - that resulted in energy consumption approximately 45% less than in a benchmark building - renovation plans had to base efficiency measures on holistic overall performance and include significant envelope and heating equipment improvements.(see chapter 6 for more information about the KfW subsidies scheme)[26]

As illustrated through the above explained strategies, the first step towards renovation is to reduce energy demand by retrofitting building envelope to higher standards; the second step is to install energy efficient equipment while the last step is to establish on-site low and zero carbon energy supply technologies with smart grid connections.[27] The intervention on the envelope is therefore the starting and most effective action of the entire process. Mistakes, errors and wrong estimations in this face affect and invalidate all the process.

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[26] IEA, International Energy Agency, Technology roadmap, energy efficient building envelopes, OECD/IEA, 2013

[27] Xinga, Y., Hewittb, N., Griffiths, P., Zero carbon buildings refurbishment—A Hierarchical pathway, Renewable and Sustainable Energy Reviews 15 (2011) 3230

Most commonly, in order to reduce heat losses, the application of an extra insulation layer is applied on the existing solid wall. Various type of panels, tiles or normal plaster boards are then added as cladding. The *external insulation* is to prefer to the internal insulation because of the reduced loss of space, the minimum disruption and the reduction of condensation risks. It is also proven to be more effective in terms of final performances of the envelope, especially in hot climates, and easies future eventual maintenance works. The *internal insulation* is however applied in those circumstances where it is prohibited to change the front of the building because of heritage protection restriction. For those buildings that present a cavity wall construction, also *in-between insulation* is an effective and fast solution. The most common insulation materials are mineral wool, expanded polystyrene bead (EPS Bead) or urea formaldehyde foam (UF foam); the important aspect is the resistency to water capillary penetration. The same insulating techniques are applied for the coating of the roof and basement elements of the envelope. When choosing the insulation material it is important to underline the positive effect of thermal mass as property of the insulation: especially in warm climate, the coating strategy for the roof elements should rely on insulation materials able to significantly increase the mass of the roof. On the other side, for cost and efficiency reasons, the strategy for the insulation of the façade generally tends to prefer the minimum thickness possible, although also for the vertical elements, the mass of the wall plays an important role. The type and thickness of insulation varies considerably according to building type. Many new and innovative insulating materials are appearing on the market and offer a wide range of upgrading features (multiple-layer insulation, aerogel, TIS transparent insulation material, GFPs gas filled panels, VIPs vacuum insulation panels)[28] but they are rarely applied in the renovation of housing complexes because of economical reasons.

The second technical aspect that is taken care of in Energy Renovation is the improvement airtightness of the building. Normal air movements in and out of buildings – infiltration and exfiltration – are known as air leakages and are usually measured using air changes per hour (ACH). ACH is a coefficient calculated as equal to the fraction of the volume of air in a structure

[28] Ibid, p.3232

that is exchanged with the outside at a specified pressure difference in one hour (e.g. an ACH of five would correspond to a flow rate that equals five times the volume of the building leaking in one hour)[29]. The control of the ACH of the building reduces significantly the energy losses by ventilation of the envelope. Draught proofing of all the envelope components (roof, walls, floors, windows, doors), by sealing the major heat losses points, is one of the most effective energy efficiency measures. Buildings should be sealed as tightly as possible, but if there is no ventilation, air quality can deteriorate and combustion gases can accumulate, leading to safety concerns. Thus, air leakage rates are often specified with consideration of mechanical ventilation for fresh air[30].

Improving the building envelope and reducing the heat loss by improving the tightness of the façade components is the first step but yet the achievable reductions are not enough to reach the necessary levels of 60% minimum reduction compared to the prior-intervention status. Normally, designers and planners act then on the plant and installation increasing significantly the costs and the disturbance for the inhabitants. A balanced option from an energetic point of view is represented by the volumetric additions. Through Add-Ons it is in fact possible to create a buffer zone between the existing façade and the new or refurbished one that acts as thermo-controlled zone, improving the performances of the building as a whole. In particular, those apartments and dwellings located at the ground floor (or first floor in case of pilotis) and at the last floors are generally the apartments that consume most. By adding extra volume on the rooftop, on the side and around the building, the Add-On act as a volumetric insulation layer that acts efficiently on those units that are most energy consuming. Preliminary Energy simulations performed by the research team of the Department of Architecture of the University of Bologna of several case study and buildings have demonstrated that enclosing the existing building structure with solar extra spaces, room extensions or extra units may provide energy reduction up to the 75% in cold winter season while reducing solar gains and increase natural ventilation

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[29] Technology Roadmap: Energy efficient building envelopes, OECD/IEA International Energy Agency, IEA Publications, 2013
[30] Lstiburek, J. W., Duct Dynasty, Building Science, Sommerville, 2013

rates, thus achieving about 35% energy consumption.[31] The final output of using a volumetric layer as energy reduction strategy offers the possibility of a revision of the envelope components, a wider range of flexible and adaptable variants. The renovation of the building will include a step-by-step framework of possible solutions: from a simple insulation layer, up to the entire re-design of the envelope including volumetric addition and shape transformation.

1.2.2 Deep Energy Renovation market

Within the field of technology and innovation, much has been done in the past decade in the search of solutions and products that could serve the Energy Renovation market. Unfortunately, the same cannot be said in regards to the economical and financial fields. A large number of solutions for envelope and plant upgrade and transformations on existing buildings have been developed, and yet there is a clear investment gap and financial schemes lack in the Energy Renovation market, in particular when looking at the residential sector. Due to this fact, Europe faces an over skilled industrial and technical sector that is missing a concrete field of application despite the emergency that t housing and energy consumptions are generating.

In fact, research studies implemented the University of Bologna have been focussing on quantifying different variants in retrofitting actions of existing housing and showed that it is possible to reach an average yearly Energy Performance (EP) around 35-70 to kWh/m^2, by insulation of opaque surfaces and replacement of existing windows, what could be defined a standard Energy Renovation Intervention. The cost-benefit assessments (see chapter 1.3 for specifics) show excessive payback times (up to 35-45 years without incentives)[32]. This is due to the fact that high investments are required up-front and characterised by a high degree of risk with potential limited return on investments (economic and financial gap).

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[31] Simulations have been performed from northern climate to Mediterranean area reaching NZEB performances with traditional thermal insulation coating combined with controlled mechanical ventilation (VMC). Many references in literature and findings also confirm that energy reduction potential. Among the latest: K. Hilliaho, E. Mäkitalo, J. Lahdensivu "Energy saving potential of glazed space: Sensitivity analysis" Energy and Buildings, 99 (2015) 87-97.

[32] Paybacks vary from 10-15 years (standard operations) to 30-40 years (for major renovations) without considering the possible contribution of feed-in tariffs/tax reductions/incentives, and from 8 to 25 years considering incentives.

In the Mediterranean countries, this gap is even exacerbated, being associated with a strong and generalised lack of confidence by final users and owners and by weaker market conditions. In fact, the harder economic crisis that these areas are experiencing and the lack of confidence on the perceived sense of safety in the majority of existing buildings are both major barriers when approaching the subject on building retrofit. At the EU level it is necessary to implement a viable programme with widespread appeal and market uptake to motivate investors and building owners to renovate buildings that are not currently scheduled for renovation. Energy Renovation is often delayed because of the large capital cost, and because of a long list of factors so a key policy goal should be to establish technical and performance benchmarking that can establish a business case for deep energy renovation earlier rather than later.

The European Commission has brought together a large number of key players from the finance sector to deliberate on the subject of financing energy efficiency. The goal is to set some clear recommendations to policy makers about what needs to be done to ensure a flood of financing flows into energy efficiency measures in several sectors, including the buildings sector. It moreover lists the approaches and instruments to Stimulate Energy Efficiency Investments in Buildings, both in the financial and in the strategic perspective. Several new specific key aspects have been brought up in the last discussions especially considering the residential sector such as the Behavioural Economics, meaning **the recognition that decision makers are not always economically rational.** As such, decisions about undertaking energy efficiency investments will depend on other factors in addition to the economic ones, such as how effective marketing material is; peer pressure what neighbours, friends and family do; perception of other value components accruing from efficiency refurbishments – such as comfort, health benefits, modernization of properties among others.[33] Also the Individual Homeowner Repayment Capacity (partially or through governmental support) and the On-bill financing mechanism are key figures.

[33] The Energy Efficiency Financial Institutions Group ("EEFIG"), Report Energy Efficiency – the first fuel for the EU Economy. How to drive new finance for energy efficiency investments, 2015

The lack of demand for energy efficiency investments is a critical aspect of the Energy Renovation market, preventing the greater allocation of resources from financial institutions towards this sector. The EEFIG (Energy Efficiency Financial Institution Group) discussed, identified 25 drivers the **demand side** for energy efficiency investment for buildings refurbishment. Those drivers were then evaluated and ranked (1-25, top ranks are coloured with greater intensity) for each different segment of the buildings market and the summery of the results are shown in Fig.8[34]

Buildings Sector	Commer-cial	Public	Public Rental	Owner Occupied	Private Rental	Average Rank
Standardization	6	3	1	11	2	4.6
Clear Business Case	1	7	9	9	4	6
Effective enforcement of regulation	4	6	6	8	6	6
Awareness at Key Decision Maker Level & Leadership	2	2	2	12	13	6.2
Buildings Regulation, Certification and Energy Performance Certificates	5	4	3	13	11	7.2
Tailored Financial Product availability	18	11	7	5	3	8.8
Transaction costs / simplicity	10	16	12	2	5	9
Regulation which impacts on timing and scope of renovation	7	8	4	15	14	9.6
Regulatory Stability	3	9	10	19	9	10
Facilitation/ Technical Assistance	22	5	8	10	15	12
Fiscal Support	14	25	22	4	1	13.2
Body of Evidence (including Social Benefits and Costs)	13	13	11	16	17	14
(Individual/ Owner) Payment Capacity	23	22	18	1	8	14.4
Awareness of appropriate timing for energy efficiency measures within the traditional building cycle	16	15	13	18	10	14.4
Awareness. Communication & Marketing	20	20	24	6	7	15.4
Measurement, Reporting & Verification (MRV) and Quality Assurance	9	10	15	22	21	15.4
"Green Premium" / Brown Discount	8	23	23	14	12	16
Rules on public authority accounting, procurement and reporting	25	1	5	25	25	16.2
Price of energy	11	19	21	7	24	16.4
Mandatory Energy Audits	15	14	17	21	19	17.2
Availability of Data	12	17	19	20	20	17.6
Definition and common understanding of the value of energy cost savings	17	18	16	17	23	18.2
Human Capacity	19	12	14	24	22	18.2
Behavioral Economics (personal priorities)	24	24	25	3	16	18.4
Communication between market actors	21	21	20	23	18	20.6

Fig. 8 EEFIG ranking of key drivers affecting demand for energy efficiency investment by market segment. Source: EEFIG report on Energy Efficiency – the first fuel for the EU Economy. How to drive new finance for energy efficiency investments, p. 16

[34] Energy Efficiency Financial Institution Group (EEFIG), Energy Efficiency – the first fuel for the EU Economy. How to drive new finance for energy efficiency investments, p. 16, 2015. Available for download at: http://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report%20EEFIG%20v%209.1%2024022015%20clean%20FINAL%20sent.pdf

The evaluation underlines the critical gab between the owner occupied residential sectors and the others market sectors. However, a strong regulatory framework with effective enforcement of regulation is the only demand driver, which EEFIG sees as a truly “cross-cutting” priority across all buildings segments.[35] Standardisation and Clear Business Case are key financial drivers both in the demand and in the supply side of the financial analysis of investments for Energy Renovation.

This depends substantially by the existence of successful proven pilot cases and the availability of efficient and standardised technology that can be applied on a large number of buildings and scenarios. Concerning the private residential sector, the demand side is depending mostly upon the personal economic possibility of the individuals. A suggestion could be develop incentives tailored policies and financial products. In order to unlock investments requests in the residential factor, the market should be able to count on simple, flexible, tailored and low-interest rate financial instruments, customised to different incomes levels that keeps into account the large spectrum of economic and non-economic benefits for householders and tenants. Awareness at key decision makers level is another significant driver. When dealing with multi property buildings this collides with the creation of a common awareness of the potential benefits of the intervention, the creation of a community that might also have the same economical interest in the eventuality of the creation of a stock-group that could be acting as cooperative, made by the single inhabitants, and playing the role of an Energy Service Company. Cooperative among inhabitants and buying groups are simple forms of associations that might result and facilitate the demand also in the public-private rental sector or mixed regimes cases. The group discussed and identified also 23 drivers ranked 1-23 in terms of its survey score for each building segment; top ranks are coloured with greater intensity) affecting the **supply side** of finance for energy efficiency investments in building Renovation. Fig.9 provides a summary of the results[36]

[35] Ibid, p. 16
[36] Ibid, p. 18

Buildings Sector	Commer-cial	Public	Public Rental	Owner Occupied	Private Rental	Average Rank
Standardization	6	3	1	11	2	4.6
Clear Business Case	1	7	9	9	4	6
Effective enforcement of regulation	4	6	6	8	6	6
Awareness at Key Decision Maker Level & Leadership	2	2	2	12	13	6.2
Buildings Regulation, Certification and Energy Performance Certificates	5	4	3	13	11	7.2
Tailored Financial Product availability	18	11	7	5	3	8.8
Transaction costs / simplicity	10	16	12	2	5	9
Regulation which impacts on timing and scope of renovation	7	8	4	15	14	9.6
Regulatory Stability	3	9	10	19	9	10
Facilitation/ Technical Assistance	22	5	8	10	15	12
Fiscal Support	14	25	22	4	1	13.2
Body of Evidence (including Social Benefits and Costs)	13	13	11	16	17	14
(Individual/ Owner) Payment Capacity	23	22	18	1	8	14.4
Awareness of appropriate timing for energy efficiency measures within the traditional building cycle	16	15	13	18	10	14.4
Awareness. Communication & Marketing	20	20	24	6	7	15.4
Measurement, Reporting & Verification (MRV) and Quality Assurance	9	10	15	22	21	15.4
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Mandatory Energy Audits	15	14	17	21	19	17.2
Availability of Data	12	17	19	20	20	17.6
Definition and common understanding of the value of energy cost savings	17	18	16	17	23	18.2
Human Capacity	19	12	14	24	22	18.2
Behavioral Economics (personal priorities)	24	24	25	3	16	18.4
Communication between market actors	21	21	20	23	18	20.6

Fig. 9 EEFIG ranking of key drivers affecting demand for energy efficiency investment by market segment. Source: EEFIG report on Energy Efficiency – the first fuel for the EU Economy. How to drive new finance for energy efficiency investments, p. 16

The key drivers on the supply side are Standardisation and Regulatory Stability. In addition to these “cross-cutting” drivers, important elements are the Reduced transaction costs and Simplicity of the repayment systems, referring to on-bill repayment that have been proved to be the most secure repayment for investment or financial institutions. Moreover the possibility of measuring, reporting, verification and quality assurance represent factors that increase the investors confidence for all the market sectors analysed. It is clear that the pay-back time of the investment and the investment rate are also crucial to foster the supply side. For what concerns the multi-property cases or the rental situations, which are the most complicated, an important factor consists in the possibility of signing binding contract and strategies to increase the stakeholder and key decision makers awareness and support in the action, thus reducing the risks.

To help justify deep renovation policies, both from the demand and from the supply side, decision makers need to consider the multiple benefits to the broader economy that these policies have been shown to deliver, including public health benefits, job creation and tax revenue, in addition to conventional energy considerations. Building owners can be encouraged to take into account non-energy benefits such as personal health and well-being improvements, increased occupant productivity, added market value and demonstrated greater capital return on investment. The goal is to establish a business climate that places greater value on high-performance buildings that can provide a beneficial return on investment for owner-occupied buildings and greater leasing revenue for leased spaces.[37]

[37] IEA, International energy Agency, Technology roadmap, energy efficient building envelopes, OECD/IEA, 2013

1.3 **Needs and emergencies: the existing barriers to energy renovation**

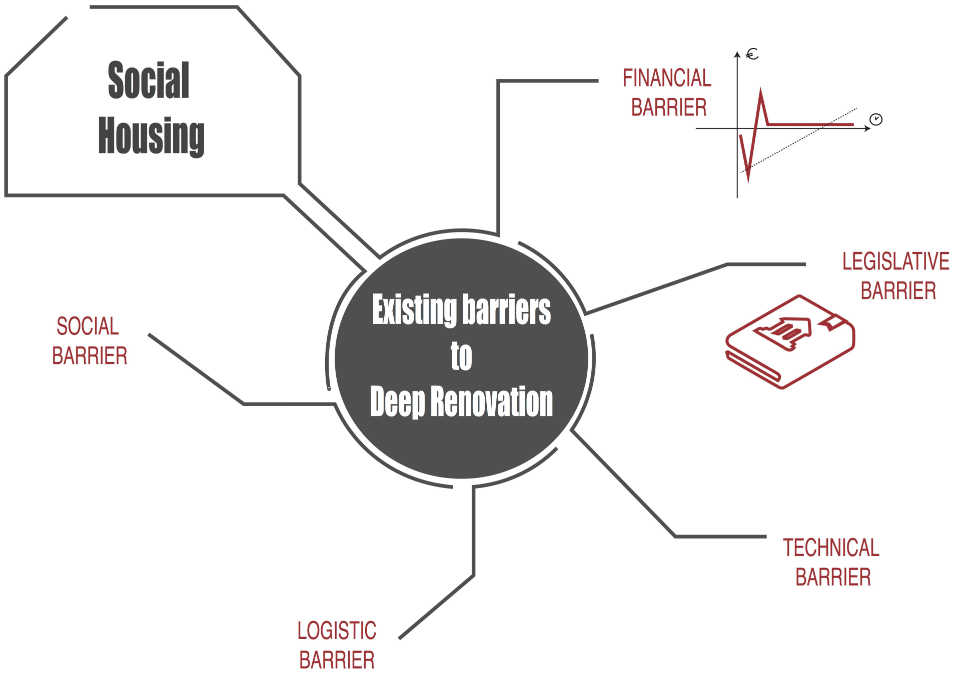

Fig. 10 The actual barriers to the implementation of Deep energy Renovation for the residential building stock in Europe

Key gaps have been identified as main barriers to the development of new cutting edge solutions and approaches that foster Deep energy Renovation of existing buildings, with a primary focus on the residential field. As data and surveys show, yet there is a significant slow-down in the renovation of existing building process throughout Europe: the renovation rate is not mirroring the fast developments achieved in innovation and policies that resulted from the past decades of efforts from the European Community.

Which are reasons that could justify such a low rate in deep renovation, 1,4% as above mentioned, despite all the efforts that have been driven towards this subject?

1.3.1 Legislative barriers

The delay of European member States and Regions in developing common policies and regulations for building energy renovation as foreseen by article 4 of the EED 29/2012/EU is the second main barrier to building renovation. Not only common definitions, procedures, regulations and precise targets are missing but also common legislation and incentive plan. The existing different policies and incentive scheme, often insufficient or inadequate, are not yet subject of a defined and prescriptive set of norms that could eventually guide and instruct Member States to a turn-around in Energy Renovation. The lack of common regulation makes it more complicated to also develop comparative analysis and evaluate possible applicable demonstrative cases at a European level. The fragmented legislative framework has to be guided through several, specific and practical policies. Based upon clear and common indicators, targets and measures.

There is the need to ensure that the processes and standards for Energy Performance Certificates, energy regulations and their enforcement is strengthened and improved as a matter of priority; it is time for a strong regulatory stability in the EU. The Fraunhofer ISI report[38] identifies the impact that putting an overall binding energy efficiency target for 2030 first steer national energy efficiency action plans and renovation roadmaps and second would significantly impact on greenhouse gas emissions and on the share of renewables in the EU. CO2 emissions would be reduced by more than 50% and that the share of renewables would rise to 35% - both significantly higher than the proposal adopted by the European Commission and the Member States for 2030. Without a carbon-based hierarchy to rank types of energy savings, energy efficiency programs are not well aligned with community-wide carbon reduction goals.[39]

1.3.2 Technical barrier

[38] Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI), Analysis of a European Reference Target System for 2030, Report to the Coalition for Energy Savings, 2015.
[39] Quigley, E. V., E. Willmott, Breaking Down Barriers to Deep Energy Efficiency in King County, published online, 2015, http://climatesolutions.org/sites/default/files/uploads/pdf/2015_09-14_energyefficiency_briefing_paper.pdf

A large number of innovative technical and integrated solutions have been developed in the last years to comply to different (and sometimes conflicting) building standards requirements but still little has been done for a concrete introduction of those product on the market. The limited budgets of these interventions and the various typology of the buildings in need for renovation makes it difficult to find the right, effective, cheap and universal solution that stakeholders are looking for. The existing prefabricated or standardised solutions are not able to comply to new and different building standards requirements -energy saving, safety/seismic risk. Standardisation, in its old mean cannot answer to the vast set of needs and requirements of Energy Renovation. Digitally controlled prefabrication could represent the key to tackle the current technological limits and approach the great typological and structural variety of the problem. The shift in methodology should consider the yet unexplored application of CNC - Computer Numerical Control - machines to the market and products for energy renovation meaning that a computer converts the design by Computer Aided Design software (CAD), into numbers that are communicated to the machine that guides the production. This would allow to develop flexible products that could vary, adapt and be tailored according to the specificity of each building and case study without having to develop specific technologies for each of them.

1.3.3 Social barriers

Another significant and often under-estimated barrier is connected to the social aspects related to building renovations. First of all different property regimes and often mixed situations combining owners and tenants complicate consistently the negotiation discussions. It is indeed crucial to achieve the overall consensus of the inhabitants: procedural and social conflicts generate bureaucratic issues that are problematic and often block the intervention. The available technologies are often fairly invasive creating disturbance and noise, plus it is not rare that the works require a temporary relocation of the inhabitants during the renovation. Without active and efficient policies to engage the inhabitants, reduce the disturbances and facilitate the collection of consensus among the people living inside the building, it is impossible to conclude the renovation revolution that we are looking at. Moreover, considering the possible contributions of an overall European binding agreement of 40% of CO2 reduction by 2030, the implementation of a sectorial target for buildings would deliver all of the **multiple benefits** that come with increased energy efficiency. It would mean the creation of 2 million new, local, direct jobs by 2020 (bringing over 6 million new jobs in the overall economy), a boost of nearly €40bn to public finances in 2020, an annual GDP growth of 0.7% and measurable improvements in health and productivity in the general population.[40]

1.3.4 Logistic barriers

By logistic the author refers to all those crosscutting barriers that affect the broad variety of fields that are involved in the energy renovation due to the current lack of standardisation of the policies, methods technologies and systems. The logistic of the renovation project is still left to chance and is a case-related issue that should instead be controlled and regulated by specific procedures that support planners, authorities, investors and inhabitants in all the phases avoiding and reducing the risks and difficulties that are now characterising projects on existing buildings.

1.3.5 Economical and financial barriers

The most consistent barrier to deep renovation is however related to the costs: renovating a building in general and even more when it comes to a consistent intervention, is an investment that requires very high up-front costs. This is probably the most fitting answer to the question on why still so little investments are directed towards Energy Renovation. Cost and benefit analysis demonstrate that those investments are characterised by long pay-back times and low investments rate. This has generated a wide spread lack of confidence from potential investors. Moreover, banks and financial institutions are reluctant in supporting initiatives that generally have such great risks and little guarantees. The deep renovation market has poor craft, both on the demand and from the supply side.

[40] Adrian Joyce, EuroACE Presentation, Practical Approaches to the Building Renovation Challenge, Bruxelles, 9th December 2015.

STANDARD RENOVATION		
	INTERVENTIONS	€/m2
ENERGY REQUIREMENTS	External thermal insulation + finishing systems	70
	Windows replacement	300
	HVAC and water heating system improvements/replacements	80
	Related demolitions and reconstructions	30
	Scaffoldings and safety installations	30
	TOTAL ENERGY RENOVATION COSTS	**510**
	Maintenance and replacements (25 years cycle, heating/cooling running costs not included)	135
	INTERVENTIONS	€/m2
SAFETY REQUIREMENTS	New reinforced concrete structures (e. g. shear walls) + foundations	250
	Demolitions and reconstructions related to new structures (e.g. floor replacement)	30
	TOTAL STRUCTURAL SAFETY COSTS	**290**
	Maintenance and replacements (25 years cycle)	5
	INTERVENTIONS	€/m2
USER REQUIREMENTS	Inhabitants relocation	100
	TOTAL INHABITANTS COSTS	**100**
	TOTAL RENOVATION COSTS (with structural safety)	**900**
	LIFE CYCLE COSTS (after 25 years, excluding energy running costs)	990
	EXPECTED REAL ESTATE VALUE AFTER INTERVENTION	+15%

Tab. 1 Break-down costs of energy and structural renovation. User requirements have also been considered as well as a qualitative analysis of the life cycle costs for a period of 25 years. The following assumptions have been made:

- COSTS PER SQUARE METRE– (referred to the Mediterranean area) The cost per square metre (€/m2) of each intervention is referred to the Usable Floor Area (UFA) of each housing unit. Some costs are initially calculated according to the façade area, then referred to UFA, considering an average ratio between façade area and UFA equal to 0.5.
- WINDOWS AND OPENINGS– The ratio between transparent surfaces and UFA in existing buildings is equal to 0,125 (1/8). Their area is then calculated dividing UFA by 8. New buildings meet same day-lighting requirements, possibly increasing transparent surfaces;
- CONDITIONING SYSTEMS – In traditional deep renovation, “HVAC and water heating systems improvements and replacements” consist of heating and air conditioning generators replacement, partial distribution pipes replacement inside floors and walls, new control systems and metering devices, not necessarily new radiators.
- LIFE CYCLE ASSESSMENT – The 25 years of the analysis period is derived from NIST LCC manual (1995).
- MAINTENANCE AND REPLACEMENT COSTS – During average yearly maintenance costs for external facades are considered 0,05 % (non exposed structures) and 0,26% (exposed structures); (Di Giulio, r., Relationships between building condition assessment and maintenance costs in the evaluation of real estate refurbishment programmes, CIB proceedings W070, 2002). Cost takes into account one replacement of heat/cold generators, and partial pipes replacement. Additional costs in typical renovation are derived for further demolitions in case of repair and replacement.
- INHABITANTS RELOCATION – Moving costs are considered, and potential new flat rent, assuming that people would move in case they will have a significant improvement of performances.

As for the political and governmental side, locally and regionally still little has been done to provide sufficient and stable scarcity funding and split incentive; the possibility of tailored financial scheme is still under discussion at the European level and communitarian regulations are lacking. It is therefore significant to look at the state of the art and the cost and benefit analysis of a standard renovation. In order to do so, a hypothetical standard renovation has been studied and the following chart illustrates a possible break down of the unit costs estimated considering the state of the art. Considering the analysis carried in Italy also structural costs have been listed to meet the structural safety requirements.

The overall investment cost has been accounted for 510 euros/m^2 in case of standard energy renovation intervention including basic HVAC interventions and 900 euros/m^2 in case of standard energy renovation requiring also structural interventions with inhabitants relocation. As for the purpose of defining a standard renovation the structural renovation costs will not be taken into account in the following calculations. Considering the yearly consumptions of an average social housing building, before the energy renovation, a value of c = 200 kWh/m^2 (thermal kWh) has been estimated as average. As demonstrative, a building with a Usable Floor Area of 2.000 m^2 has been used for calculations. The total cost of the investment can be calculated as:

$$I_i=i*S \qquad (f)$$

$$I_i = 510*2.000 = 1.020.000\ €$$

Since standard renovation normally reduce the overall consumptions of 60%, in total, the yearly consumption of the building before and after renovation are

$$C_{before/after}=c*S \qquad (b)$$

Where:

C is the total yearly consumption/Savings of the building in kWh
c is the total yearly consumption/savings of the building in kWh/m^2
S is the total liveable surface of the building in m^2

$$C_{before}=200 \cdot 2000=400.000\ kWh$$

$$C_{after}=80 \cdot 2000=160.000\ kWh$$

In the simulation the building is equipped with gas boilers and will be integrated by a centralised gas heat pump, with COP (Coefficient Of Performance) of 0,8. Thus, the total productivity of the new instalment is 80 %. Due to the losses of the gas boiler the real kWh of yearly consumption, before and after the intervention are:

$$C_{real} = C_{before/after}/COP \qquad (c)$$

$$C_{real,before} = 400.000/0,8=500.000\ kWh$$

$$C_{real,after} = 160.000/0,8=200.000\ kWh$$

In a qualitative evaluation such as the one that is carried here to define the state of the art of energy renovation and its pay-back time, we can state that the overall yearly thermal energy cost, net from inflation rates are:

$$E_y=(C_{real}/g) \cdot e \qquad (d)$$

Where:

Ey is the total yearly thermal energy cost in €/y
Creal are the real consumptions of the buildings, considering the plant losses
g is the productivity of the gas, estimated as 10 kWh/m³
e is the current gas price is 0,950 €/m³

$$E_{y,before}= (500.000/10)*0,950 = 47.500\ €/y$$

$$E_{y,after}= (200.000/10)*0,950 = 19.000\ €/y$$

The price for gas has been accounted as 0,896 €/m^3 taking the Italian market as reference. This means that the housing associations, the municipalities and/or the single housing owners or tenants spend, every year, 47.500 € to heat the apartments; the economic figure is significant.

The environmental figure is not less relevant: according to the European Directive 2003/87/EC[41] every m^3 of natural gas releases in the atmosphere around 1,95 kg CO2; if we consider the total yearly consumption of the building chosen as example and the productivity of the gas g as above defined, we can calculate the total volume of gas saved through the intervention and the consequent Carbon Footprint reduction, expressed in kg of CO2 per year:

$$FP=(C_{before} - C_{after} /10)*1,95 \qquad (e)$$

FP= (40.320 – 12.900)*1,95= 53.496 kg/y = 53,5 ton/y

The benefits and potential of the intervention are considerable, although intervening through a standard renovation represents still a missed chance to produce better investments and higher reductions in terms of energy consumptions and CO2 reductions. To sum up, for the following analysis, the data here listed have been considered:

Gas consumptions		
50.00,00	m^3 per year	Gas consumptions before
20.00,00	m^3 per year	Gas consumptions after
Energy Price		0,950 €/m^3
Energy savings		
300.000,00	kWh per year	Energy savings after intervention
28.500	€ per year	Savings after intervention

NPV and IRR are two very basic metrics of the cost-benefit analysis. The Net Present Value (NPV) is defined as the sum of the present values of the individual cash flows (both incoming and outgoing) of a series of cash flows. The Present Value is defined as the current worth of a future sum of money or stream of cash flows at a certain discount rate.

[41] 30.04.2014 Consolidated version of Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

Discount rate is a rate at which future cash flows are discounted to find present value. It is in other words the interest rate. The IRR (Internal Rate of Return) is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. In general, the IRR method indicates that a project whose IRR is greater than or equal to the firm's cost of capital should be accepted, and a project whose IRR is less than the firm's cost of capital should be rejected. NPV and IRR are based on the same formula:

$$\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

Where:

t: is the time period considered (years)
Ct: is the cash flow (positive or negative) at time t
i: is the interest rate

The following tables shows the actualised cash flows and the overall NPV and IRR keeping into account the initial investment costs and the energy benefits due to the intervention, as above calculated.

The inflation rate for the energy cost has been set to 0,0211[42] and the investment interest rate has been set around 3%.

[42] Data collected from the Istat report for the period 2006-2014

	Initial investment	1.220.000,00	€		
	Savings (non weighted)	28.500,00	€ per year		
	Interest rate	0,0300			
	Energy inflation rate	0,0300			

Year	Incoming Savings	Consumptions	Outgoing Cashflow	NPV	Sum
0	0,00	0,00	-1.220.000,00	-1.220.000,00	-1.220.000,00
1	28.500,00	79.300,00	28.500,00	27.669,90	-1.192.330,10
2	29.355,00	81.679,00	29.355,00	27.669,90	-1.164.660,19
3	30.235,65	84.129,37	30.235,65	27.669,90	-1.136.990,29
4	31.142,72	86.653,25	31.142,72	27.669,90	-1.109.320,39
5	32.077,00	89.252,85	32.077,00	27.669,90	-1.081.650,49
6	33.039,31	91.930,43	33.039,31	27.669,90	-1.053.980,58
7	34.030,49	94.688,35	34.030,49	27.669,90	-1.026.310,68
8	35.051,41	97.529,00	35.051,41	27.669,90	-998.640,78
9	36.102,95	100.454,87	36.102,95	27.669,90	-970.970,87
10	37.186,04	103.468,51	37.186,04	27.669,90	-943.300,97
11	38.301,62	106.572,57	38.301,62	27.669,90	-915.631,07
12	39.450,67	109.769,75	39.450,67	27.669,90	-887.961,17
13	40.634,19	113.062,84	40.634,19	27.669,90	-860.291,26
14	41.853,21	116.454,72	41.853,21	27.669,90	-832.621,36
15	43.108,81	119.948,37	43.108,81	27.669,90	-804.951,46
16	44.402,07	123.546,82	44.402,07	27.669,90	-777.281,55
17	45.734,13	127.253,22	45.734,13	27.669,90	-749.611,65
18	47.106,16	131.070,82	47.106,16	27.669,90	-721.941,75
19	48.519,34	135.002,94	48.519,34	27.669,90	-694.271,84
20	49.974,92	139.053,03	49.974,92	27.669,90	-666.601,94
21	51.474,17	143.224,62	51.474,17	27.669,90	-638.932,04
22	53.018,40	147.521,36	53.018,40	27.669,90	-611.262,14
23	54.608,95	151.947,00	54.608,95	27.669,90	-583.592,23
24	56.247,22	156.505,41	56.247,22	27.669,90	-555.922,33
25	57.934,63	161.200,57	57.934,63	27.669,90	-528.252,43
26	59.672,67	166.036,59	59.672,67	27.669,90	-500.582,52
27	61.462,85	171.017,69	61.462,85	27.669,90	-472.912,62
28	63.306,74	176.148,22	63.306,74	27.669,90	-445.242,72
29	65.205,94	181.432,66	65.205,94	27.669,90	-417.572,82
30	67.162,12	186.875,64	67.162,12	27.669,90	-389.902,91
31	69.176,98	192.481,91	69.176,98	27.669,90	-362.233,01
32	71.252,29	198.256,37	71.252,29	27.669,90	-334.563,11
33	73.389,86	204.204,06	73.389,86	27.669,90	-306.893,20
34	75.591,55	210.330,18	75.591,55	27.669,90	-279.223,30
35	77.859,30	216.640,09	77.859,30	27.669,90	-251.553,40
36	80.195,08	223.139,29	80.195,08	27.669,90	-223.883,50
37	82.600,93	229.833,47	82.600,93	27.669,90	-196.213,59
38	85.078,96	236.728,48	85.078,96	27.669,90	-168.543,69
39	87.631,33	243.830,33	87.631,33	27.669,90	-140.873,79
40	90.260,27	251.145,24	90.260,27	27.669,90	-113.203,88
41	92.968,08	258.679,60	92.968,08	27.669,90	-85.533,98
42	95.757,12	266.439,98	95.757,12	27.669,90	-57.864,08
43	98.629,83	274.433,18	98.629,83	27.669,90	-30.194,17
44	101.588,73	282.666,18	101.588,73	27.669,90	-2.524,27
45	104.636,39	291.146,17	104.636,39	27.669,90	25.145,63
46	107.775,48	299.880,55	107.775,48	27.669,90	52.815,53
47	111.008,75	308.876,97	111.008,75	27.669,90	80.485,44
48	114.339,01	318.143,28	114.339,01	27.669,90	108.155,34
49	117.769,18	327.687,57	117.769,18	27.669,90	135.825,24
50	121.302,25	337.518,20	121.302,25	27.669,90	163.495,15
		NPV	50 years	163.495,15	
		IRR	50 years	0,03520	
		Pay-back time	years	45	
		CO_2 Reduction	kg	61.500,00	

Tab. 2 Cost-benefit analysis carried for standard renovation intervention. The payback time calculated upon the NPV is 45 years and the IRR is 3,52%

	Initial investment		1.220.000,00	€		
	Savings (non weighted)		28.500,00	€ per year		
	Fiscal incentive	0,65	793.000,00	€		
	Incentive rate (10 years plan)		79.300,00	€ per year		
	Interest rate	0,0300				
	Energy inflation rate	0,0300				
	Incoming		Outgoing			
Year	Savings	Incentive 65%	Consumptions	Cashflow	NPV	Sum
0	0,00	0,00	0,00	-1.220.000,00	-1.220.000,00	-1.220.000,00
1	28.500,00	79.300,00	19.000,00	107.800,00	104.660,19	-1.115.339,81
2	29.355,00	79.300,00	19.570,00	108.655,00	102.417,76	-1.012.922,05
3	30.235,65	79.300,00	20.157,10	109.535,65	100.240,64	-912.681,41
4	31.142,72	79.300,00	20.761,81	110.442,72	98.126,93	-814.554,49
5	32.077,00	79.300,00	21.384,67	111.377,00	96.074,78	-718.479,71
6	33.039,31	79.300,00	22.026,21	112.339,31	94.082,40	-624.397,30
7	34.030,49	79.300,00	22.686,99	113.330,49	92.148,06	-532.249,24
8	35.051,41	79.300,00	23.367,60	114.351,41	90.270,06	-441.979,19
9	36.102,95	79.300,00	24.068,63	115.402,95	88.446,75	-353.532,44
10	37.186,04	79.300,00	24.790,69	116.486,04	86.676,55	-266.855,89
11	38.301,62		25.534,41	38.301,62	27.669,90	-239.185,98
12	39.450,67		26.300,44	39.450,67	27.669,90	-211.516,08
13	40.634,19		27.089,46	40.634,19	27.669,90	-183.846,18
14	41.853,21		27.902,14	41.853,21	27.669,90	-156.176,27
15	43.108,81		28.739,20	43.108,81	27.669,90	-128.506,37
16	44.402,07		29.601,38	44.402,07	27.669,90	-100.836,47
17	45.734,13		30.489,42	45.734,13	27.669,90	-73.166,57
18	47.106,16		31.404,11	47.106,16	27.669,90	-45.496,66
19	48.519,34		32.346,23	48.519,34	27.669,90	-17.826,76
20	49.974,92		33.316,62	49.974,92	27.669,90	9.843,14
21	51.474,17		34.316,11	51.474,17	27.669,90	37.513,05
22	53.018,40		35.345,60	53.018,40	27.669,90	65.182,95
23	54.608,95		36.405,96	54.608,95	27.669,90	92.852,85
24	56.247,22		37.498,14	56.247,22	27.669,90	120.522,75
25	57.934,63		38.623,09	57.934,63	27.669,90	148.192,66
26	59.672,67		39.781,78	59.672,67	27.669,90	175.862,56
27	61.462,85		40.975,23	61.462,85	27.669,90	203.532,46
28	63.306,74		42.204,49	63.306,74	27.669,90	231.202,37
29	65.205,94		43.470,63	65.205,94	27.669,90	258.872,27
30	67.162,12		44.774,74	67.162,12	27.669,90	286.542,17
31	69.176,98		46.117,99	69.176,98	27.669,90	314.212,08
32	71.252,29		47.501,53	71.252,29	27.669,90	341.881,98
33	73.389,86		48.926,57	73.389,86	27.669,90	369.551,88
34	75.591,55		50.394,37	75.591,55	27.669,90	397.221,78
35	77.859,30		51.906,20	77.859,30	27.669,90	424.891,69
36	80.195,08		53.463,39	80.195,08	27.669,90	452.561,59
37	82.600,93		55.067,29	82.600,93	27.669,90	480.231,49
38	85.078,96		56.719,31	85.078,96	27.669,90	507.901,40
39	87.631,33		58.420,89	87.631,33	27.669,90	535.571,30
40	90.260,27		60.173,51	90.260,27	27.669,90	563.241,20
41	92.968,08		61.978,72	92.968,08	27.669,90	590.911,10
42	95.757,12		63.838,08	95.757,12	27.669,90	618.581,01
43	98.629,83		65.753,22	98.629,83	27.669,90	646.250,91
44	101.588,73		67.725,82	101.588,73	27.669,90	673.920,81
45	104.636,39		69.757,59	104.636,39	27.669,90	701.590,72
46	107.775,48		71.850,32	107.775,48	27.669,90	729.260,62
47	111.008,75		74.005,83	111.008,75	27.669,90	756.930,52
48	114.339,01		76.226,01	114.339,01	27.669,90	784.600,42
49	117.769,18		78.512,79	117.769,18	27.669,90	812.270,33
50	121.302,25		80.868,17	121.302,25	27.669,90	839.940,23
			NPV	50 years	839.940,23	
			IRR	50 years	0,06579	
			Pay-back time	years	20	
			CO_2 Reduction	kg	61.500,00	

Tab. 3 Cost-benefit analysis carried for standard renovation intervention considering the incentives currently available in Italy that provide the fiscal reduction of 65% of the investment within a period of 10 years. The payback time calculated upon the NPV is of 20 years, the IRR is 6,58%

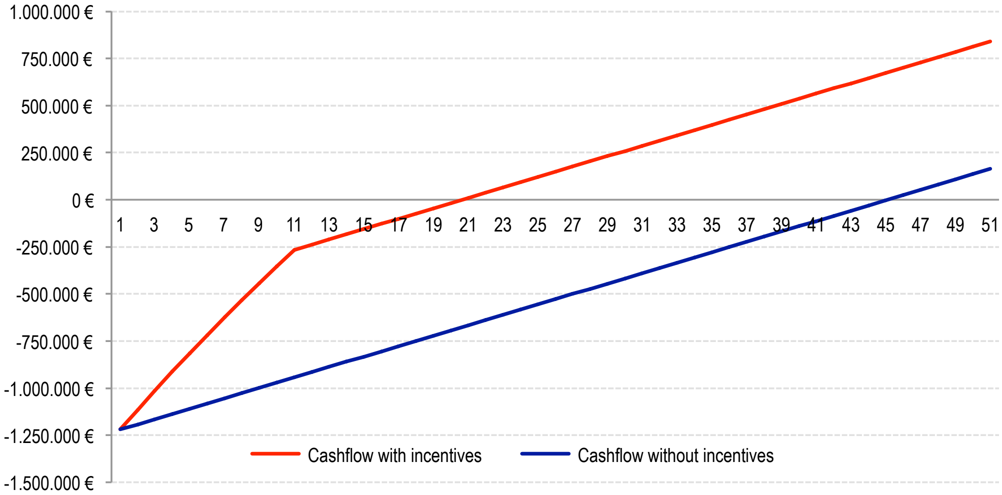

Fig. 11 The graphic shows the comparison between the two cost-benefit analyses carried for standard renovation. Standard renovation investments without incentives (blue in the graphic), can reach a pay-back time of 45 years whereas the pay-back time of standard renovation investments, with incentive - for the Italian legislative framework accounting for 65% of the initial investment within 10 years distributed as fiscal reduction rates - (red in the graphic) is about 20 years

As above demonstrated in both the scenario considered the investment is not competitive and the IRR shows that no financial institution or investor would consider to put money in this type of renovation. First of all the reduced budget have led to a renovation that resulted in a minor reduction of the consumptions, only 60%. This is a missed opportunity and the goal is to look at energy renovation that set the goal to reduce up to 85-90% the current energy consumptions. Moreover, the interest rate of the investment is yet too low when looking at possible investments from private companies or Energy Service COmpanies (ESCOs) which aim at investments of at least 4-5% of interest. The payback time shall be indeed minor than 8 years to become competitive. Even if incentives and financial support is provided, for standard intervention it is not possible to have interesting rates and payback times lower than 15 years. Standard and basic interventions are therefore uneconomical and not effective. As shown the main barrier to face is the economical gap of these interventions. This is valid both for standard and for deep interventions. In the last case higher up-font investment result in a more consistent reduction of the energy consumption but yet the return of the investment is not competitive in the current financial market. New instruments and strategies have to be introduced to radically reduce the pay-back times, increase the Internal Rate of Return and attract investors and funds into the Energy Renovation Field.

CHAPTER 2_ RESEARCH OBJECTIVE: DENSIFICATION AND ADDITION AS STRATEGIES FOR THE DEEP RENOVATION

Deep Energy Renovation for residential buildings is a composite process including significant, articulated, interconnected – and sometime conflicting- sets of requirements; in order to optimize these different requirements, the goal is to capitalize on all existing technological solutions in a win-win perspective that can be achieved only by the mutual collaboration of energy and non-energy related components. Based upon the residual transformation potential of existing building. Given the undeniable costs of deep renovations, energy requirements need also to be explained and made attractive to final users and key decision-makers; Deep renovation has to be interpreted considering the multiple benefits in economic, social and environmental terms.[1]

Thus the focus should shift towards the willingness to pay rather than the mere investment rate of the proposed intervention in the aim of providing an integrate system which may accelerate the uptake of the deep renovation. In fact, the core element of every redevelopment is the increase in value for the client (investor, building owner, and tenant), since "focusing solely on the optimization of energy efficiency is ineffective, and does not meet overall requirements" .[2]

As shown in the previews chapter, several consistent barriers are currently slowing down the revolution to Deep Renovation. First of all, it is imperative to increase the bankability and attractiveness of the Deep Renovation from an economical perspective, creating extra value: this means combining the action upon old buildings with the construction of new living space, extra units and/or buildings that could act as financial guarantee, counter-balance the initial investment and reduce significantly the pay-back times. Moreover social aspects need to be included in the feasibility study in order to reduce the risk of bureaucratic and authorisation

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[1] Adrian Joyce, EuroACE Presentation, Practical Approaches to the Building Renovation Challenge, Bruxelles, 9th December 2015.

[2] IEA ECBCS Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings Retrofit Strategies Design Guide Advanced Retrofit Strategies & 10 Steps to a Prefab Module. Marc 2011

impediments and promote an active participation by inhabitants and owner in the process and design of the renovation. Policies, strategy and technologies are moving fast towards the definition of the 'right path' towards deep renovation whereas tools and methodologies to overcome the social barrier are left behind and it is ultimately the lack of inhabitants and owners consensus that often does not lead to a successful renovation.

The need of generating extra value to balance the significant up-front investment suggests to combine the renovation of existing buildings with the construction of extra units or new 'satellite' buildings in support to the existing ones that could act as guarantee for banks and investors and increase the attractiveness of the renovation intervention. The proposal seeks for a design tools and means to **overcome the economical limits** of the actual energy renovation on residential buildings and, at the same time, offer an occasion to **increase the adaptability** degree of existing building through **an inter-active dialogue with the inhabitants**. Based upon the residual transformation potential of existing building, the strategy offers a combined **socio-economical added value** that could change the current practice in deep-renovation.

2.1 Adaptability through punctual densification: the Add-Ons hypothesis

> *Adaptability is the ability of the system design to be changed to fit altered circumstances, where circumstances include both context of a system's use and its stakeholders' desires.*
>
> *(A. Engel 2006)*

The concept of *adaptability* refers to the capacity of buildings to accommodate substantial changes.[3] Adaptability is broken down into three aspects: Flexibility, Convertibility, and Expandability.[4] The possibility of transformation, internally and externally, according to the user's needs, the changed functions or the intention of transforming the existing into something

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[3] Kobayakawa, S., Chae, S., Kano N., Development of an adaptable system for effective utilisation of architectural space, ISAR 2006

[4] Assessing the Adaptability of Buildings. International Energy Agency. Annex 31. Energy-Related Environmental Impact of Buildings. Nov. 2001

new is therefore linked to its degree of adaptability of the building itself. The consequent and related quality is the durability of the building. This approach hides a great potential in architectural terms by offering the possibility of integrating a consistent re-design in the renovation practice but also in economical terms since it opens up the possibility of transforming the existing through the creation of new living space. In fact, increasing the real estate value of the original building after the renovation leads to an Additional surplus that could significantly benefit in the feasibility analysis.

A construction can be divided in structural elements and envelope components whose life cycle is about one third of the forecasted life cycle of the structural elements. It follows that, if the building presents a certain degree of adaptability, the most convenient renovation strategy lies on the potential exchange of the envelope and those components that have already reached the end of their life cycle. This should be done accordingly to the current user's need but also with a high degree of flexibility that ensures the possibility of undertaking future transformations in case of a change in use or users. While traditional construction methods were based on the physical requirements, minimal space units, healthiness, standard values, more and more technology, today, looks at differentiation, not uniformity[5], customisation of the products through mass production rather than standardisation. It means design through quality, durability, maintainability, and the ability to adapt, dismantle, relocate, or recycle.[6] As industry and academic leaders discussed already in the early 1999, during the CERF/CIB Symposium, '*sustainable*' means in fact being able to meet the multiple requirements of society through the life cycle of a building or structure[7]. Adaptation is the means by which sustainability addresses the urging challenges of the contemporary age (not only in the building and construction field) and enters a new era of innovation.[8]

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[5] Preiser, W. F. E., Vischer, J. C. and White, E. T. Design Intervention: Toward a More Humane Architecture, Van Nostrand Reinhold: New York, 1991

[6] Chapman, J. C., What can we learn from marine structures?, in Sommervile, G., The Design Life of Structures, Blackie and Son Ltd, Glasgow, pp. 85-93.,1992

[7] Bernstein, H. M.,Highlights of the CERF/CIB Symposium, Building Research and Information, 27 (6), 437-438, 1999

[8] Hoberman Associates and Adaptive Building Initiative, 2011

The preliminary question is therefore how can we evaluate and calculate the adaptability degree? What are the factors that influence it and how can it be improved? According to several previews research and literature[9], the assessed design features are spatial, structural and services design such as[10]:

- SITE (possibility of expansion, access for pedestrians, access for services),
- SERVICES and lifts (capacity, extra space).
- STRUCTURE (strength of columns/walls, column density/span, floor-to- ceiling height, floor loading, floor structure, removability of partitions),
- HVAC system (plant location, plant size space wise, access for people, access for equipment, ducting access),
- FAÇADE (windows' size, balconies, loggias, ballatoires),
- INTERNAL LAYOUT and design (completeness of brief, flexibility of layout, grouping of functions, average main room size, provisions for disabled),

In order to be able to evaluate the adaptability degree, in relation to the above listed feature, a scale 1 to 5 has been developed:

- 1-2 → Low adaptability – design features are appropriate for minor changes
- 3 → Medium adaptability – design features are appropriate for complex changes
- 4-5 → High adaptability – design features are appropriate for complete changes

The increasing level of possible changes and adaptability potential has been mapped and put into an hexagonal evaluation chart (Fig. 1) according to the above-mentioned scale; for each case study it is then possible to run a qualitative preliminary evaluation of the adaptability degree.

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[9] Langford, MacLeod, Maver, Dimitrijevic, 2002

[10] Dimitrijevic, B., Langford, D., MacLeod, I., Maver, T., An Assessment Tool For The Durability Adaptability And Energy Conservation Of Buildings, 9DBMC-2002, Paper 140, 2002

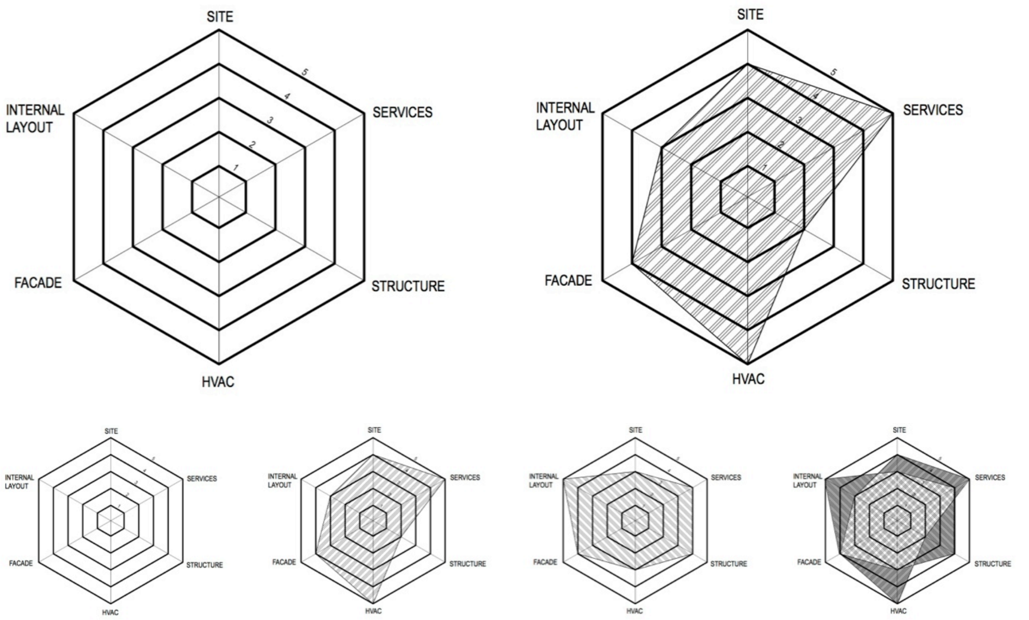

Fig. 1 Adaptability evaluation chart. The above example shows the application of a qualitative evaluation chart to two case study and the comparative analysis between the two, showing the overlapping and differential potential in adaptaibility terms

Comparative analysis are possible by overlaying different evaluation, the in-between represents the differences in adaptability from the compared situation. By intervening on one or more design features, the results would be an increase of the overall adaptability marked. With the scheme presented it is then possible to evaluate also the effectiveness of certain specific measures. The higher the total degree of adaptability obtained by the above illustrated analysis, the more intensive can the adaptation be, according to the following scale:

- Adaptation of building spatial organisation
- Adaptation for people with different physical abilities
- Adaptation for people with different cultural and religious background
- Adaptation of technology and services
- Adaptation of use
- Adaptation in volume

Through this analysis is moreover possible to directly define the features upon which transformation can occur without major interventions and define a preliminary strategy for the renovation. The chart is a useful tool to support decision-making process and determine the most effective strategy.

The residual adaptability potential of the existing building till hear evaluated should correspond to intervention that further increase the adaptability of the building also after the renovation. By intervening on the aspects connected to the adaptability and increasing it, the consequent result is an increase also in the durability of the design features above listed: durability in fact is defined as service life, i.e. actual period during which no unacceptable expenditure on maintenance or repair is required.[11] The approach to durability practised in the building industry usually leads to regulations and discussions about the degree of insulation and the materials that are to be used. Although the value of these aspects is certain, durable building includes facets that have not received much attention so far.[12] Durability is the ability of a building to last in time, despite the change in number or needs of the people that live the building itself. This quality becomes central when looking at residential buildings considering the exchange rate of the inhabitants and the rapidly changing nature of our Society.

How could then design and planners, policy makers and financial players approach the problem of reducing the energy consumptions of existing buildings by increasing their adaptability, thus their durability and at the same time offer a solution to the existing barriers that slow down the Renovation of the existing building stock?

Among all the state of the art strategies in the field of Energy Renovation, rarely it has been taken into account the possibility of intervening through the adaptation of the total volume of the building (e.g. by increasing the number of storeys, transforming the balconies in closed extra-room or adding new space on the side of the building). The relationship between the adaptability quality and the durability quality of an existing building is thus a cause-effect relation: by increasing the adaptability of the construction, its life cycle costs can be reduced of

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[11] Ibidem, p. 4
[12] Vreedenburgh E., Melet E., Rooftop Architecture, building on an elevated surface, NAi Publishers, 2012

150 euros/m2[13] and the real estate value rises of significant figures. The application of construction systems and technologies that incorporate directly the concept of variability among the intrinsic characteristics of the project (for new construction but also and more specifically for energy renovation), it possible to reach modular and adaptable outcomes able to transform according to the various needs that the building has throughout its life-cycle. Such a shift in the approach and perspective of Deep Renovation would guarantee final products and urban compounds with increased efficiency and durability not only at the building scale but also in relation to the Urban, Sociological, Environmental and Economical Systems: the contribution of an integrated action would be therefore an overall benefit in all the spheres involved.

QUALITY / SYSTEM	ADAPTABILITY	DURABILITY
Economical	Capability of answering rapidly to the variable development and evolutions of the market	Extension of the life-cycle of the building and its components
Social	Capability of flexible relations between dwellings and dwellers. Adaptability guarantees an efficient reaction of the dwelling in providing coherent answers to the changed needs of the dwellers	Preservation of the cultural values and empowerment of the community, sense of belongings and durable realities. By increasing the sense of possession of the inhabitants the social quality and value increases.
Environmental	Re-use and re-cycle of the resources involved	Preservation of the resources in a long-lasting perspective
Urban	Possibility of transformation, reuse and development of public/private spaces, adaptation to the increased car traffic and new needs of the community and the society.	Belonging feeling to the community, long lasting and consolidated urban tissues

Tab. 1 Quality-System Matrix showing the interaction between Adaptability/Durability and the different Systems involved in Deep Renovation (economical, social, environmental, urban)

[13] The evaluation considers an equal life span of the building of 25 years, comparing standard renovation with the proposed volumetric Addition renovation

The densification strategy here proposed as innovative approach, not only socially but also economically, could become the key node to overcome the existing barriers to Deep Renovation[14].

The research aims at demonstrating the effectiveness and potential of a renovation strategy based on volumetric Addition, energy plus prefabricated that could be built above, aside or inside the existing building (hereinafter defined Add-ons). By Add-Ons we refer to one (or a set of) extension unit(s) like aside or façade Additions, rooftop extensions or even entire new buildings, whose objective is to assist the existing buildings to deeply and comprehensively renovate them up to nZEB. The suggestion is the implementation of a punctual densification policy, represented by the possibility of increment, transform and re-design the existing building through the Addition and extension of specific parts of the envelope. This *Addition architecture* would result in re-writing the existing architecture, by the means of a progressive stratification and layering of time and needs that is not new in architecture but has not yet been applied in a systematic revision of the energy retrofitting practice. The Addition becomes a mean to increase adaptability and durability, improve the energy performance of the buildings without massively intervining on the existing and creating disturbance to the inhabitants. Moreover the proposed system is based upon a reinterpretation of prefabrication as core production method a mass industrialised perspective thus based upon customisation of the single products on a user-oriented logic. The creation of these new Add-Ons units or even new Assistant Buildings' supporting the old ones as satellite buildings or units, integrated with Renewable Energy Sources, aims at creating a virtous energetic sinergy between the existing and the new (portion of) buildings and reducing the initial investment allocated for the deep renovation.

[14] Studies identifying key categories of hurdles (economic, technical, credibility, social, legislative) in delivering deep buildings' energy renovation are contained in: 1. A guide to developing strategies for building energy renovation: Delivering Article 4 of the EED, BPIE, Published in February 2013 by the BPIE. 2. Studies of financial institutes (e.g. KfW in Germany); 3. The EU multiannual Roadmap for the EeB PPP, led by E2B consortium providing recommendations for building energy renovation. 4. Guidelines for strategies on renovation provided by the concerted actions EPBD, EED and RESD 5. EU projects (FRESH, SURE-FIT, SHELTER, RESHAPE, TRAINREBUILD, iNSPiRe and POWERHOUSE).

2.2 Transformation as design manifesto

"The architects stands there, indeed, to build new methafores"

Manfredo Tafuri

Starting from Derrida's deconstructionism, and continuing with Eisenman's theories[15], the importance of the continuous transformation and evolution - through consecutive development phases - of architecture has been broadly investigated with important theoretical meaning as a gesture in itself significant; this acknowledgement opens up still today to interesting suggestions both from a conceptual and a design perspective regarding the Architecture of the Addition. Assuming transformation as design manifesto relies on the possibility of continuous stratification, which can be declined in new forms of re-interpretation concerning the built environment.

The current normative and political revision of European policies, aiming at controlling the increasing consume of agricultural land and containing the urban sprawl, brought back to the centre of the discussions the idea of Architecture as mean to re-write the City, of building on the existing, as alternative to the pre-made recipes of the *tabula rasa*.[16] The design phase is no longer conceived as an act of art, a stand-alone gesture of the Architect called to interpret the context and society according to his own singular sensitivity; a gesture to impose the vision of one upon the interest of many. The urgent need of acting on the existing buildings by re-writing and re-interpreting their original architectural connotations opens a fascinating terrain for technological and procedural innovation in the field of Housing. Thus, Architecture could take advantage of this opportunity to retrieve its social connotation and explore a new discourse on densification and transformation actions.

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[15] Eisenman, P., "Notes on Conceptual Architecture: Towards a Definition," Casabella, (Nov/Dec, 1971)

The practice of adding, transforming, changing, extending existing buildings in different historical periods it has been exploited throughout Europe in the past centuries. The architecture of the Addition has been limited to occasional manifestos experiments or largely and commonly applied to transform and evolve the dwelling environment in informal settlements, this happened largely in the past and history of European architecture but today *in the so called shanty towns.*[17] All forms of spontaneous settlements, illegal occupations, invasions, and squatter settlements are generally identified as "informal", on contrary the "formal" is then considered as that which is planned through rational processes and under legal institutional frameworks[18]. The informal is synonymous of continuous transformation but also of variety and adaptability, characteristics yet lacking in the majority of the residential neighbourhoods in Europe. In this perspective, it is possible to integrate much of the hidden knowledge, techniques and systems typical of the informal processes in the formal process of reconstructing our suburbs. Extensions, in the sense of creating extra space to complete and transform an existing building, is approached in its intrinsic capacity of representing and translating the reality: this makes of the Addiction a possible bridge between design experimental practice and the self-made practice of the informal Architecture.[19]

Informal architecture represents a natural model from which the experiments in the field of Addition for the existing built environment could take inspiration and derive a great source of information regarding the needs of the inhabitants. It is not a coincidence if the interest in this topic comes together from the fields of Architecture Technology, Design and Urban Planning. The Addition joins and connects the different expertise and technologies, at the different scales, that belong to the large Housing system and together are able to re-generate it starting from a different premise: densification as a mean for change.

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[17] Klanten, R., Feireiss, L., Spacecraft. Fleeting Architecture and Hideouts, Die Gestalten Verlag, Berlin, 2007, see also the chapter Over the top, dedicated to the rooftop construction in urban context.
[18] Hutchison, R. 2010, 'Encyclopedia of Urban Studies', SAGE Publications, California
[19] Marini S., Architettura parassita, strategie di riciclaggio per la città, Architettura Ascoli Piceno, Quodlibet Studio, 2008

The evolutionary interpretation of European historical urban settlements shows that our cities are the result of multi-layered re-interpretations and incremental construction, which underlines the spatial and physical evolution that the urban tissue has experienced through densification, Additions and transformations actions. The buildings that populate our cities are nothing but the result of constant aggregation of one and more elementary cells, in different association/combination typologies and relationships, based upon the inter-action between constructive, spatial and typological systems. The architectural language of the Addition has been broadly investigated in the past and up until today is embedded in our buildings.

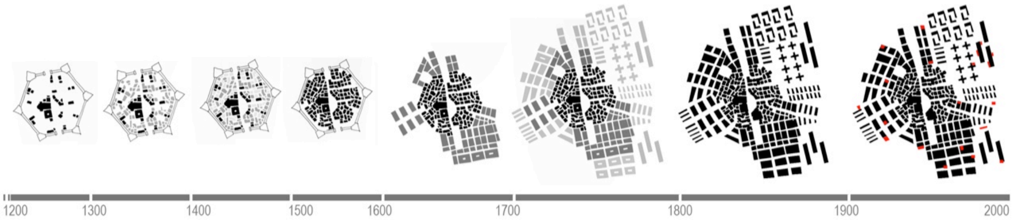

Fig. 2 Urban development, before and after the Industrial revolution. Toady there is an inversion in tendency, punctual densification policies (marked in red in the graph above) are substituting the *diffused city scheme*

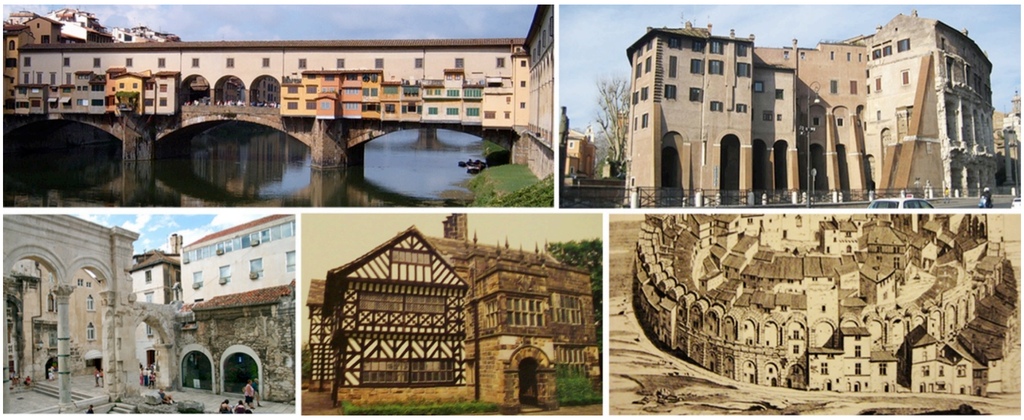

Fig. 3 Examples of consolidation of housing Addition on historical tissue, from top left: Ponte Vecchio, Florence; Teatro Marcello, Rome; Dioclezian Palace, Split; Typical English House from the 16th century with 17th wooden frame Addition; Arles Colosseum historical reconstruction, Arles.

With the first urban settlement, the idea of the city walls has created a border that contained physically the built environment, beyond which the city could not expand. With the population and wellness growth of the cities, a transition in building type became unavoidable: the city typical low construction of the XIII and XIV centuries left space to towers and higher buildings up until the complete saturation of the inner city. During these centuries, the practice of increasing density and punctually acting upon the existing through Addition and transformation was common practice to create new living space without consuming new land. The images grouped in Fig. 3 show a sample of architectural transformation through incremental additive elements. In fact, European cities and their historical centres are often characterised by a history of changes, evolutions and transformations. The city boundaries represented almost an insuperable gateway beyond which the countryside and the agriculture happened, where building as an activity was not permitted. The building pressure was exercised upon the existing and increasingly dense urban tissue, through Additions through a process that could be defined as *urban re-cycling*. The practice of layering and constructing in progressive times has defined and redefined the actual character of the built environment that has survived the destruction of the two world wars, not only considering the residential field and housing typology but through out the entire History of Architecture. The creative reuse of existing buildings, many of them large industrial structures or housing developments, has been a steady work for architects over the same period. The challenge many have helped to set the tone of innovation now so evident in extensions. The design outcome have certainly established the generic style template of contemporary urban evolutionary living. In fact, one thing has not changed through the years and centuries. Regardless of the socio-economic climate, every home-owner was and is at some stage wondering whether they could add value to their property, or make it a better place to live in if it were larger or better organised.[20]

With the upcoming of the industrial revolution the city boundaries disappeared and left space to an uncontrolled urban sprawl. The advent of the industrial revolution and the consequent creation of a rapidly growing infrastructure net opened up the construction industry to the benefits and innovations given by the possibility of transporting goods and machines, offering vast new lands to building developments. The cities spreads open and becomes a diffuse city: when trying to describe regions characterised by diffused (industrial) settlements, urban

[20] Mornement A., Extentions, p.9, Laurence King Pub, London, 2007.

economists has therefore revisited for theoretical and operational purposes the concept (and terminology) of` *industrial districts* [21]. During the industrial revolution, cities started to expand and grow outside the historical walls, streets and rails allowed the construction of great industrial developments and satellite residential compounds where workers could live. The transition in the urban pattern has been represented as a scheme in Fig. 2 and shows the important transformation of the cities between XVI and XVIII century. The tendency of enlarging the city beyond its boundaries became then an established and consolidated practice with the great urban interventions of the 1700 and 1800, centuries of great disembowelment and majestic intervention, that looked at the city as an iconic entity with an important representative function. Transformations were mainly based upon consistent infrastructural works that resulted in large scale demolishment (Parisian boulevards are an iconic and significant example of the practice here described). New construction compounds followed this seek for majestic and spectacular gestures, new development, perspectives and suggestions were aiming at the horizon as their sole spatial limit. Key words for the city became solemnity, greatness, vastness, beyond any boundary and control signing an historical fracture with those punctual and localised densifications and transformations that had for long ruled urban evolution in Europe. More and more the city centre became an historical monument to preserve, no longer able to transform and adapt itself to the new materials, technologies and needs, increasingly threatened by plagues, hygiene emergencies and scares safety.

Another significant transition in the city evolution history finds its roots in the first and second post wars that signed the entire XX century with their consequences on the urban structure and development. The bombing and destruction of many European cities resulted in a consistent housing emergencies calling for a shelter for a large percentage of population. Sanitarian and Hygienic needs became priorities in the decades immediately after the wars, arising the discussion regarding new quality in housing, based upon light and air. Building blocks started then to be equipped with electricity and running water, the iconic simple of this transition

[21] As defined by Goodman & Bamford in 1989. For more information on the topic: Besussi, E., A. Cecchini, E. Rinaldi, The diffused city of the Italian North-East: identification of urban dynamics using cellular automata urban models, Comput., Environ. and Urban Systems, Vol. 22, No. 5, pp. 497±523, Elsevier Science Ltd, 1998

towards a house of comfort is the Frankfurter kitchen. Those are the years of the advent of the Modern Movement, the years of the garden city but also of the city as a machine, where dwellings become as units, cells. Standardisation became the main instrument of the building practice, whose priority was to build for great numbers, fast and efficiently at low cost, housing the masses in the socialist dream of the collective living together. What is the relationship of social science, or whatever alternative scientific discipline is proper to housing, and history? The integration of the two seems to point to a materialist framework, including a Marxist position.[22] Housing developments at great scale grew once again outside the city upon the principles of velocity and control of cost, without any consideration regarding the durability and adaptability that those massive residential compounds had, almost identical through out Europe, without little questioning of what would the next generations inherit from those Mass Housing.

In the '70 and '80 the urban sprawl became regular praxis, the faith in the recovery and the economical growth generated the autonomous urban settlements intended to be cities within the cities. It is only after the 1990 that an increasing awareness in the political and social necessity of reducing the uncontrolled urban sprawl, brought back the discussion upon the city and its development. This unconditioned sprawl, especially during the second half of the twentieth century, has shown its faults and generated a long list of chronic problems of European cities, that we urgently need to face. Beyond the problems connected to the energy consumptions of the existing buildings, t is crucial to impose a turn around in the city development and policies. The tendency should aim at controlling and regulating the agricultural soil occupancy. Already in 1998, Germany set to 30 hectares per day the maximum land that could be turned into construction land. In Italy, still today, over 70 hectares of land are lost in construction per day. Calculations have shown that from 1990 till today Italy has lost in total 2.189.000 hectares of land, a surface comparable with the entire Emilia Romagna region[23]. The Architecture Nota laws approved in 2000 in The Netherland, on the other hand have imposed a rigid control on the new construction in Holland: at least half of the entire new constructions have to be on already

[22] T.A. Markus, Rehumanising the dehumanized, in Rehumanizing Housing, p. Butterworths 1988.
[23] Report on land consumption, 'Il consumo di suolo in Italia', 2014.

urbanised soil, new urban development shall include mix-functions and integrate the transformation and re-use of parts of the city currently not fully exploited.

The 10th International Venice Architecture Biennale, in 2006, "Cities, Architecture and Society" directed by Richard Burdett, drove the attention exactly toward this shift in tendency and focused on the themes and emergencies above illustrated. The city shall look at itself and find new ways of development through densification and consolidation policies based upon of its over-writing and re-writing process. Here an extract from the Convertible City project:[24]

> *The city must be re-generated to mirror its lively and complex society. Demographic developments and social change produce concepts for new ways of living. Older people are moving back into the cities, and thirty- and forty-year-olds no longer migrate to the outskirts as a matter of course. The classical nuclear family is being replaced by lifestyle concepts for single people, lone parents, communes or multiple generations living together. Cities are faced with the task of integrating immigrants and activating the potential to enrich our society culturally. The change from an industrial to a service and information society opens up new possibilities for using the existing infrastructure of cities, their buildings, streets and supply facilities, better and more sustainably.*

Some of the projects presented in the German Pavilion demonstrated and showed, for the first time in a comprehensive and theoretical framework, the possibilities of Architectural Addition as architectural concept to re-define a new relationship between the existing building and the new construction. In this sense, it becomes a new constructive model, able to adapt itself and means to transform a rigid system in a more adaptable one. The system of aggregation among different parts is no longer determined by a common structure but rather by the system of connection and relationship among the parts. Superimposition, shifting and penetration have been presented at the Biennale as possible design actions to extend existing building structures, transform and define them in new possible synergies and interpretations. It is the search for ne identity patterns that happens through "conceptual transformation strategies"[25]. For the first time the Addiction in architecture gained an autonomous space and identity of its own, rather then being confined in the occasional manifestations of informal practice. Transformation becomes a

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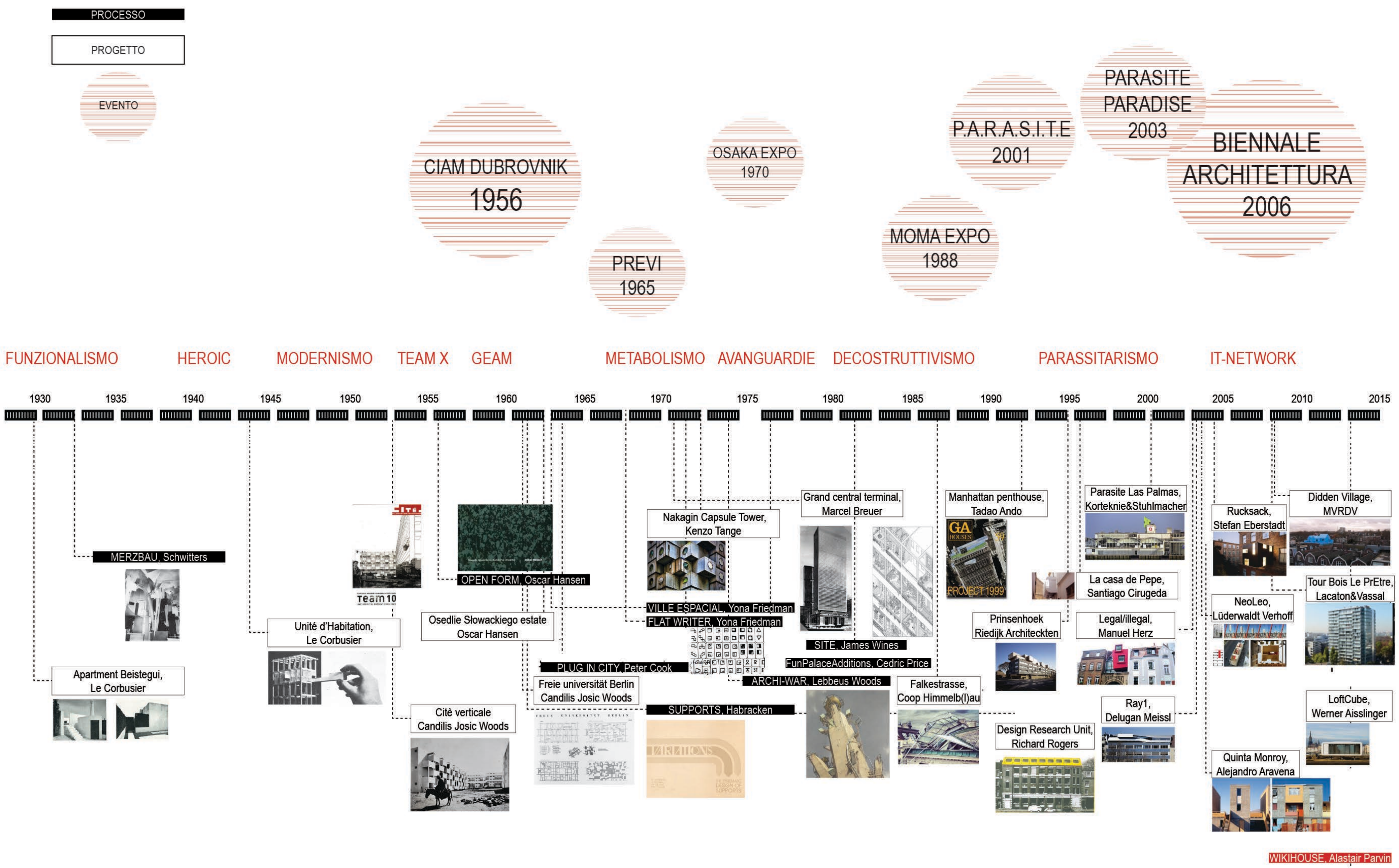
[24] Gruentuch A., Ernst A., Convertible City/Archplus: German Pavillion Venice Biennale (German Edition), 2006
[25] Gruentuch A., A. Ernst, Convertible City/Archplus: German Pavillion Venice Biennale (German Edition), 2006.

design manifesto and declaims its right of redefining a new language and new expressions to re-write the existing building stock.

As formal and theoretical ground to better illustrate the *Architecture of the Addition*, a selection of the twentieth century's most significant precedents has been carried considering the processes and ideological currents that represent significant moments in its definition, the crucial events that characterised the milestones for its development and the key projects that could determine a continuous evolution of the Addition as transformation mean in Architecture. The references for this *excursus* through the most significant events, processes and projects based upon the Addition have been grouped in the thematic time map that follows.

A search for the conceptual and theoretical framework that stands behind the transformation/stratification act has been the central subject of the comparative research conducted on the previous architectural experiences of this kind. It is important to define the framework of the Addition and the typology of the proposed intervention in order to insert the design process here proposed - that will focus exclusively on the existing housing stock - in the broader architectural scenarios. This analysis underlines also the existing contradiction between the eccentric character of these punctual injections, completions or Additions and the rigid status of the current normative/legislative framework. As well shown in the thematic map, the Addition becomes more and more a subject with its own identity in the architecture scenario and claims the right of overcoming the marginal boundaries and be legitimate as a densification and renovation element whose specific function is that of answering to an urgent revision of the building stock and a necessary return to the social connotation of architecture, especially in the housing field.

This collection does not intend to trace a detailed and comprehensive History of the Addition but rather to provide a possible ground for discussion, initiate a discourse regarding the legitimacy of the Addition as architectural paradigm. The thematic map offers a first draft of study to derive common characters and differences that this design model and construction had already shown and presented but that yet have not been studied in an organic and unified manner.



PROCESSO
PROGETTO
EVENTO
CIAM DUBROVNIK 1956
PREVI 1965
OSAKA EXPO 1970
MOMA EXPO 1988
P.A.R.A.S.I.T.E 2001
PARASITE PARADISE 2003
BIENNALE ARCHITETTURA 2006
FUNZIONALISMO
HEROIC
MODERNISMO
TEAM X
GEAM
METABOLISMO
AVANGUARDIE
DECOSTRUTTIVISMO
PARASSITARISMO
IT-NETWORK
1930
1935
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2010
2015
MERZBAU, Schwitters
Apartment Beistegui, Le Corbusier
Unité d'Habitation, Le Corbusier
Team 10
OPEN FORM, Oscar Hansen
Osedlie Słowackiego estate Oscar Hansen
Citè verticale Candilis Josic Woods
PLUG IN CITY, Peter Cook
Freie universität Berlin Candilis Josic Woods
Nakagin Capsule Tower, Kenzo Tange
VILLE ESPACIAL, Yona Friedman
FLAT WRITER, Yona Friedman
ARCHI-WAR, Lebbeus Woods
SUPPORTS, Habracken
Grand central terminal, Marcel Breuer
SITE, James Wines
FunPalaceAdditions, Cedric Price
Falkestrasse, Coop Himmelb(l)au
Manhattan penthouse, Tadao Ando
GA HOUSES
PROJECT 1999
Prinsenhoek Riedijk Architeckten
Design Research Unit, Richard Rogers
Parasite Las Palmas, Korteknie&Stuhlmacher
La casa de Pepe, Santiago Cirugeda
Legal/illegal, Manuel Herz
Ray1, Delugan Meissl
Rucksack, Stefan Eberstadt
NeoLeo, Lüderwaldt Verhoff
Quinta Monroy, Alejandro Aravena
Didden Village, MVRDV
Tour Bois Le PrEtre, Lacaton&Vassal
LoftCube, Werner Aisslinger
WIKIHOUSE, Alastair Parvin

Addition has always been seen as incident, eccentric gesture, unavoidable and politic symbol to rebel to the superimposed structures, as *Parasite Architecture*[26] intended as organism that create a inter-dependent relationship with the existing, thus rejecting the Vitruvian *firmitas* and the eternity of the construction but rather seeking for a dialectical and more articulated relationship between the built environment and the time.[27] This led to a categorisation of the different relationships that could be created between. By the analysis of the previews significant architectural experience and established connections, it has been possible to draft a theory of the Addition and its historical matrixes including typological and theoretical categorisations based upon the different relationships between the Addition and the existent building, between the new and the old, the part and the all, in conceptual, formal and technological terms. The architectonic language of the Addition is in fact dictated by the system of relationships found among the layers[28], this system could be re-interpreted in a contemporary logic to serve the need of energy renovation of residential apartment buildings.

Transformation becomes therefore the new design manifesto[29], approaching the necessary renovation of the existing buildings, the *before-and-after, vorher-nacher, prima-dopo* visualisation becomes the primary tool to show the potential results and evolution of the existing in a modern reinterpretation of the existing. It is not an exception or a design concept but rather a methodological approach and revolution in confronting and facing the new and actual questions upon contemporary architecture, looking at the existing rather than imagining the

[26] The exhibition P.a.r.a.s.i.t.e. (Prototypes for Advances Ready-made Ambiphibious Small scale Individual Temporary Ecological houses and boats) The city of small things was presented in Copenhagen first and later in Rotterdam in 2000 and 2001. Has been constructed upon liveable structures, light and transportable, thought to colonise residual urban locations. Through this exhibition the definition of Parasite architecture entered the literature and started defining those intervention of Addition on existing buildings with the clear intention of creating a statement based upon a new set of rules.

[27] Marini, S., Architettura parassita, strategie di riciclaggio per la città, Architettura Ascoli Piceno, Quodlibet Studio: 2008.

[28] Jacques Derrida and Peter Eisenmann dialogues,

[29] "Transformation als bauliches Manifest" is the title of the on-going (4. February 2016 - 3. April 2016) exhibition at the Weisenhof Siedelungen Museum in Stuttgart, presenting the projects of the french architects Frédéric Druot, Anne Lacaton und Jean- Philipp Vassal.

new. In fact, a higher degree of flexibility and adaptability favours the integration in the renovation of the existing of three central elements of sustainability[30]:

- **Dwelling-User appropriateness** Social developments lead to a change in living habits. The percentage of elderly and single users is increasing, the immigrants family structure is generally different from the typical European family structure upon which the dwellings have been conceived. Demographic and ethnographic change calls for constant reviewing of building design projects which form the basis for future construction. Renovation shall include layout and envelope flexibility to adapt to the changed users and the possible future changes to guarantee a high level of user appropriateness of the building through its extended life cycle.
- **Life cycle upgrade** The operation and construction of a building uses about 45% of the gross energy consumption[31]. Replacement, renovation or refurbishment optimises material and energy use in a building. However, susceptibility to failure increases as technology integration increases. This means that building systems and components have to be easily replaceable. Building transformations and renovations shall be based upon modularity, prefabrication and dry systems that can better integrated the existing material and energy sources in a life-cycle optimisation manner. This guarantees also a sustainable *cradle-to-crane* cycle of the materials and components used (see Chaper 3).
- **Effectiveness rather than Efficiency** Quality and sustainability awareness stands often in contradiction to the all-overriding cost pressure. An adaptable building is a high-quality product. It seems inappropriate to focus exclusively on efficiency (cost). Considering value retention and profitability as an indicator of sustainability, effectiveness not efficiency is the more appropriate scale to judge Additional value. It is not solely a matter of costs and benefits in a merely economic perspective, it is

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[30] Cowee, P., P. Schwehr, Are our buildings “fit” to resist incommensurable evolution?, The Competence Centre for Typology & Foresight Planning in Architecture (CCTP) Lucerne University of Applied Sciences and Arts / Switzerland. Lucerne, 2009. http://www.changingroles09.nl/uploads/File/Final.PlagaroCowee-Schwehr.pdf

[31] Koschenz, M. Pfeiffer A., Potenzial Wohngebäude. Energie und Gebäudetechnik für die 2000-Watt-Gesellschaft, Faktor Verlag, Zürich 2005

fundamental to evaluate the non economical benefits and its consequences in the long term evaluation. This observation involves aspects indirectly connected to the economical perspective of the problem as the possibility of creating jobs and foster the renovation market but also a long list of non-economical factors such as the improved living conditions of the suburban areas, the reduced agricultural land consumption, the upgrade in energy waste of existing buildings.

The design approach based upon transformation and evolution, Addition and re-design allows planners and architects to explore a new area of the profession imagining a connection between the before status and the after status, designing and planning a connection between the two or rather a complete fracture between the two temporal phases, the pre-existence and the renovation: transformation and evolution become the core principle of the renovation that seeks a flexible and adaptable interpretation of Housing. Sustainability in these terms look at renovating the existing building stock by increasing its capability to resist and endure the changes and evolutions that Society and Technology are quickly and continuously undertaking.

2.3 The Addition strategy for Deep Renovation

Addition [/əˈdɪʃ(ə)n/] noun, s. (pl. –s)

Meaning: 1. the act or process of adding or uniting. 2. the process of uniting two or more numbers into one sum, represented by the symbol +. 3. the result of adding. 4. something added. 5. a wing, room, etc., added to a building, or abutting land added to real estate already owned. 6. Chemistry. a reaction in which two or more substances combine to form another compound.
Origin: 1350-1400; Middle English addicio(u) n < Latin additiōn- (stem of additiō), equivalent to addit (us), past participle of addere to add (ad- ad- + di- put + -tus past participle suffix) + -iōn- -ion **Synonyms:** 1. joining. 3, 4. increase, enlargement; increment; accession, 4. supplement; appendix. Addition, accessory, adjunct, attachment mean something joined onto or used with something else. Addition is the general word, carrying no implication of size, importance, or kind, but merely that of being joined to something previously existing: an Addition to an income

2.3.1 Addition as building type

From the analysis of the historical development of the Architecture of Addition conducted in the previous paragraph, it has been possible to draw conclusions regarding the typology of the Addition. The categorisation here provided has been based upon an increasing subversively level of the possible synergies between the pre-existence and the new Addition element(s): starting from a subdued role of the addiction, moving to a reflexive role, up until a subversive one. Analysis the possible In general terms, four different relationships between the Addition and the existing building both from a structural and a formal point of view have been derived.

- **Completing:** the Addition is 'filling' and 'completing' the existing empty spaces, urban voids and left out sections that make the volume 'incomplete'. The Addition does not overcome the boundaries of the original volume and generally the structure of the new and old parts are collaborating or connected. The economics of infill are notorious complex, since often they require expensive and time-consuming remediation works. They are likely to be constrained by planning requirements, which may limit their hight, bulk and marketability. The infill category as addition it is often limited, a small scale and punctual action, steeply constrained but yet highly challenging, offering the most to formal and interaction perspectives and interpretation of the addition as architectural concept.[32]

- **Adding:** the Addition consists in aside or front apposition of extra new elements like extensions of the existing one. The Addition stands outside the original perimeter and exceeds the boundaries of the original volume's projection. The structure of the new and old portions can be independent or partially connected. The main restrictions are related to urban services and potential of the plot. Since through a consistent addition on the side or on the front of the building it is possible to realise consistent increase in Usable living surface the urban load of the area would significantly increase. Car parks and services as urban net shall therefore be able to support the extra load or alternatively be implemented in order to reach an appropriate level to supply the additional inhabitants.
- **Topping**[33] This category is derives from the adding above-mentioned but for its peculiar and significant character has been left as autonomous field. The topping-Addition consists in an extension of the existing building by an increase in high through the construction of extra floors, new volumes or new prefabricated elements on top of the existing one.[34] Depending on the building location and regulation regarding structural safety and in particular seismic safety, the topping of existing buildings requires extra calculations and could become rather complicated due to the fact that the existing structure is subjected to extra loads.
- **Translating** the Addition here happens with no uniform character with the aim of transforming and re-defining the entire envelope and layout of the existing building. The

[32] Mornement A., A. Biles, Infill: new houses for urban sites, p. 10, Laurence King Pub, London. 2009.
[33] The Topping category could be considered a special typology of the Adding category. Considering the special attention given both in the practice and in literature to the rooftop extension, the writer believes it represents a stand-alone category with character of peculiarity.
[34] The categorisation here presented lie outside the distinction made in literature by Vreedenburgh and Melet (2012) between topping and rooftop construction as they are intended in the same manner without inferring a different approach, in formal terms, to the vertical extension of the building. According to these authors, the negative acceptation given to *topping up*, as inappropriate answer to early renovation neighbourhoods built after the II World War, lies mainly in having maintained the original layout of the building, not enhancing the location on the rooftop and addressing to the same target group. The mainly typological characterisation made in this work goes beyond the distinction between rooftop and topping up considering both as vertical extension and disregarding the formal discourse.

possible approach is made by the combination of several transformations – through Addition, subtraction and replacement of the original components - of the existing building aiming at re-defining entirely the original pre-existence. The structure of the existing building is entirely re-defined through the intervention.

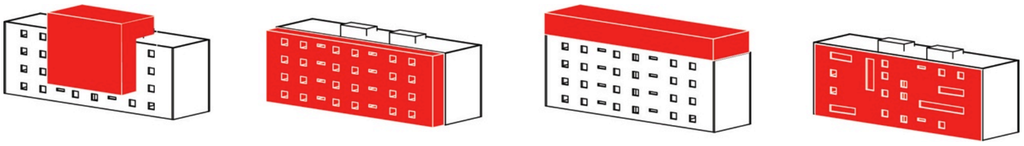

Fig. 4 Different categories of Additions. From left to right Completing, Adding, Topping, Translating

Yet, all the different possible relationships that the transformation through Addition could have according to the above categorisation follow a unified criteria and distinction. It is indeed always the main intention of the project - from a structural and formal point of view – which stands in the type of relationship that the Addition creates with the pre-existence, that defines the overall outcome: whether the Addition creates a fracture and declares its own identity or rather hides behind the pre-existent formal composition and integrates with it. In the first case the Addition represents an act of subversive transformation that underlines the moment and space, the upcoming of a new time for the building, the renovation process that the building has crossed. In the second case the continuity between past and present is emphasised and the continuity between before and after is preserved. The *before-and-after* is not longer a visualisation mean to underline the improvement and differences from the previews status but rather becomes the search from a mirrored image from the time before and the time after the intervention. The goal here is to renovate and add without leaving a trace that is visible but rather necessary and thus adapted to the existing.

Since we cannot predict what is going to happen, the more variety the housing can assume, the better; the more flexible and adaptable the system, the more durable it will be. Thus, the question that stands behind this process is *how can architecture anticipate diversity and* *change?* Is it possible to make this dynamism the core concept that drives the renovation of the existing building stock? It is, in other words, a question upon *thinking the unthinkable*[35], the unpredictability of human behaviour, and in the end, the substantial illusion of planning. The programmatic revision of the renovation practice should by closely connected to the opportunity for Addition and transformation that are aiming at increasing the flexibility of the structure and of the typology of the social housing architecture, probably the most rigid and typologically fixed.

A set of best practices has been chosen to illustrate the possible outcomes and results of using the Addition strategy when renovating existing buildings. As the Best Practice sheets will show, the first strategy is the most largely used, mainly because up until now, the role of the Architect has never been consistently discussed and re-dimensioned. Still, in the presented project cases, the Architecture of the Addition did not come as the answer to a social need but rather as a new way for architects to express their style and vision upon the existing, another act of formalism that our society can no longer afford. It is yet not defined as renovation mean and tool but as sporadic and rare case of experimentation.

Flexibility is a must for any project wanting to attain a long life cycle and subsequently, to attain sustainability especially when looking at Deep Renovation of the existing buildings. In the same way as doctors not only care for a patient’s long life but also for life quality, a building should guarantee high-quality comfort for its users during its life cycle. However, requirements constantly change due to new society patterns. Predicting future needs is an exercise in speculation. The more reliable solution is to enhance flexibility in the building system in order to guarantee adaptability. When the world changes, buildings should change with it.[36] **Defining the Addition as architectural type means therefore understanding and defining the flexibility typology, potential and character of a given system.** Those areas and paths through which flexibility and adaptation can occur represent spaces and potential for the extensions and additions. Thus, by defining the potential and residual flexibility it is possible to

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[35] Price, C., Think the Unthinkable, Exibitionat the Lighthouse, Glasgow, 2011
[36] Plagaro, N. Schwehr, P., Die Typologie der Flexibilität im Hochbau, interact Verlag, Luzern 2008

increase the adaptability degree of the building, according to the different strategies above illustrated: by completing, adding, topping or translating the existing volume. For example, a building whose elevation has discontinuity and is not compact in shape suggests including the addition as completing element, or again where surrounding urban plans allow for higher buildings in comparison to the one building considered, topping interventions would be suggested. Understanding the building and its potential is therefore the first design step to identify the most appropriate Addition strategy to apply when intervening through Deep Renovation. Based on concepts described by the Fraunhofer Institute[37] and supported by typology-based building evaluation[38], the following two main building flexibility types were identified[39]

- Extension Flexibility refers to extension and retrofit possible configurations. This involves analysing and classifying the positioning and structural properties of extensions and retrofit systems and their interaction with the existing building.
- Internal Flexibility defines the internal adaptability of the building: in which degree are modifications within an existing structure possible. What are the risks and time requirements. How does the extension influence the building and the internal layout together with the possible (new) relationships between the inside and the envelope.

Extension and internal flexibility are building characteristics that enable high value stability over the entire (renovation) life cycle[40] and are intrinsically related to the possibility of having an *autonomous* extension or a *parasitic* one. It is evident that the Typology of the Addition is a result of the potential in terms of External and Internal Flexibility of the existing

[37] Fraunhofer-Institut für sichere Informationstechnologie, Forschungsprojekt FlexHaus, 2002.
[38] Fischer, R. Schwehr, P., Typenbasierte Evaluation. Chancen für den ganzheitlichen Wohnungsbau, contribution to 15th Swiss Status-Seminar „Energie und Umweltforschung im Bauwesen“, Zürich 2008
[39] Plagaro, N. Schwehr, P., Die Typologie der Flexibilität im Hochbau, interact Verlag, Luzern 2008
[40] Schwehr, P., Evolutionary algorithms in architecture, O&SB2010 “Open and Sustainable Building” – Chica, Elguezabal, Meno & Amundarain (Eds.)
Labein –TECNALIA, 2010

building. Buildings with *A Priori planned flexibility*[41] have structure, mechanical engineering, joints and space which has been planned to allow future changes.[42] This allows the development of *Parasitic Additions,* intending with parasitic an extension that relies on the existing structure and distribution scheme of the existing building therefore is dependent on the original construction. Even considering the possibility of integrating the extension in the existing building though, the new regulations and law (especially considering the seismic and safety regulations in countries like Italy and Greece) make it generally complicated and expensive to proceed with these type of interventions. When structural flexibility and internal flexibility is not found - as happens in the majority of the apartment blocks that were built during the '50s, '60s and '70s – *Ad Hoc Flexibility* has to be integrated in the renovation phase generating the option of a *Semi-parasitic Addition*, referring to an extension that uses the original distribution and layout scheme of the original building but is independent structurally and mechanically. The third possible interaction consists in creating a totally independent and *Autonomous Addition* (not connected), which is linked to the original building solely by spatial and internal connections. In these cases the new structure has to be completely independent by the original one and do not generate extra loads that could worsen the structural behaviour of the pre-existence. The autonomous addition could also become an entirely new building, connected through a net or a plant system to the original, 'feeding' the old building and supporting the energy renovation in a synergy that not necessary requires a physical connection of the architectural outcome. Tab 2 shows a matrix that illustrates -through pictorial examples- the possible interactions between the addition typological and conceptual configuration (completing, adding, topping and translating) and the inter-dependency of the addition and the original buildings in structural and distributional terms:

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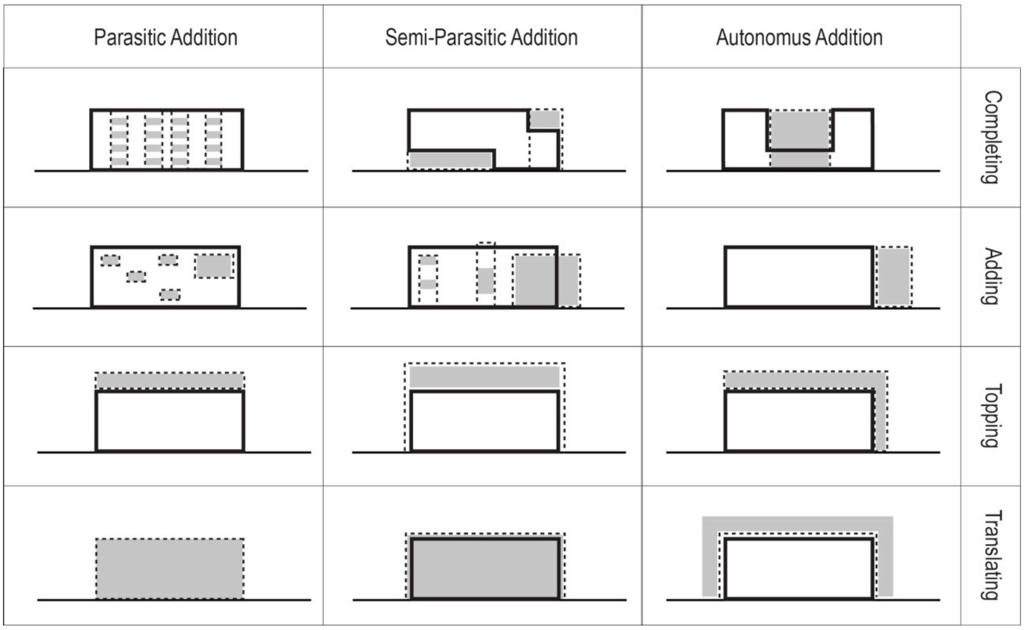
[41] Joyce, Candilis and Wood experiments in Casablanca are a good example of planned flexibility in design, see Cattani, E., Ferrante, A., Mochi, G., Energy retrofitting in urban areas Procedia Engineering International Conference on Green Buildings and Sustainable Cities, Ravenna, Italy, 2011

[42] See as an exampe the Citè Vertical, Hay Mohammedi building planned by Joice, Candilis and Wood – members of the Team X – in Casablanca with the specific intent of leaving the project undefined and opened to future evolution and transformations as actually happened in the past decades. For more information: Cattani, E., A. Ferrante, G. Mochi, Energy retrofitting in urban areas , Procedia Engineering, International Conference on Green Buildings and Sustainable Cities, Ravenna, 2011.



Tab. 2 Typological and structural cathegorisation of the possible relationship between the Addition and the existing building. Transformation through Addition can occur at 4 levels: Completing, Adding, Topping, Translating.

2.3.2 Best practices

Ten best practice in the feel of energy renovation on existing buildings have been selected as best practice showing the potential of volumetric Addition when dealing with existing buildings. Each sheets illustrates the main characteristics of the existing original building, the typology of addition that has been applied, the overall extension surface and the materials/construction technology used. The overview intends to provide a series of completed examples and case studies where this old densification 'strategy' has been used as tool to intervene on renovation projects in the recent years. The majority of the architectural offices that have engaged renovation intervention through Additions and have been grouped in the following study have been contacted and participated in the survey providing additional material and information.

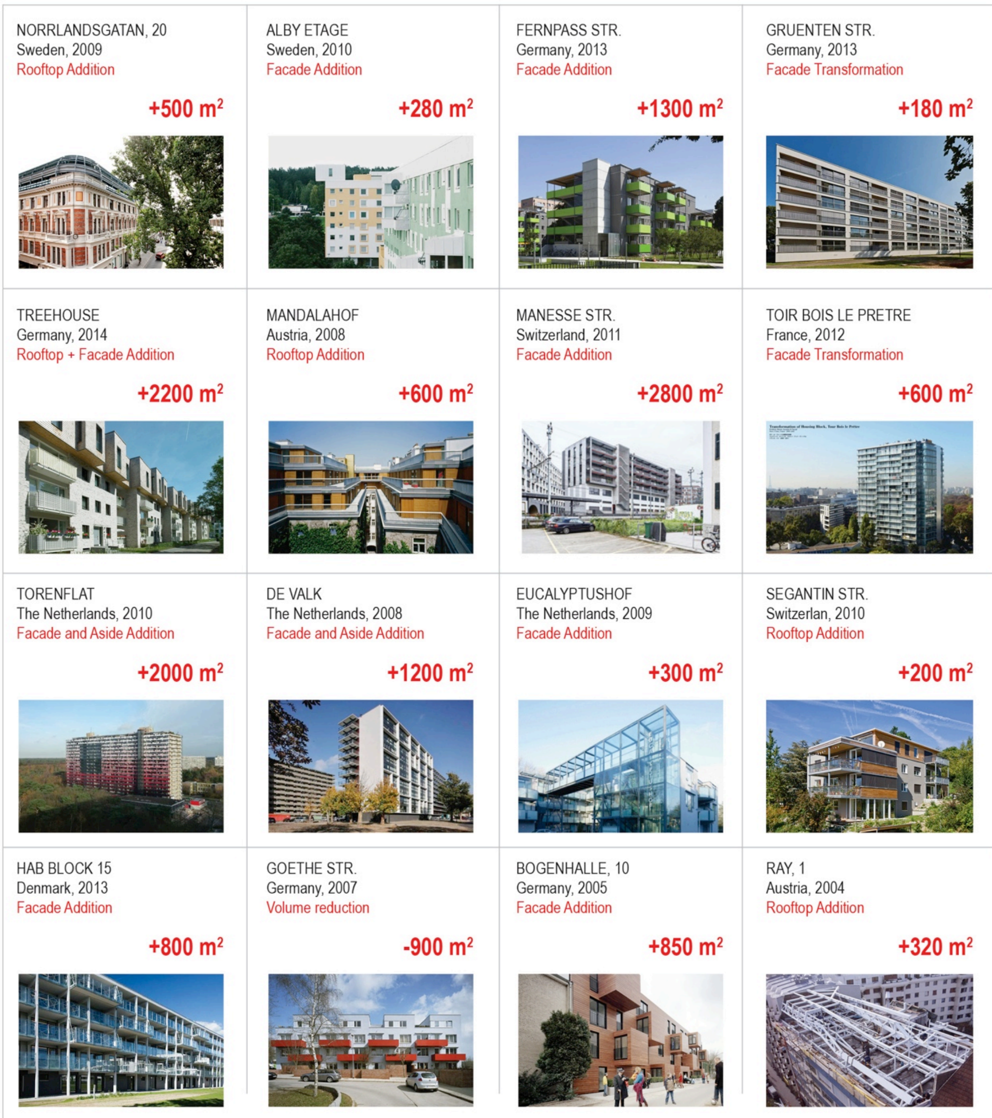


Fig. 5 Overview of the selected best practice. The presented projects are Europe-wide realised renovation projects where the addition (and in one exceptional case the subtraction) of extra living surface has been used as tool and concept for the renovation of existing building (Diverse image sources, quoted directly in the following sheets)

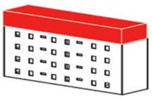
NORRLANDSGATAN, 20

LOCATION
Stockholm, Sweden

BUILDING TYPE
Retail and housing building

YEAR OF CONSTRUCTION
1880

FACADE
Masonry (1880)



ARCHITECT
Koncept AB

YEAR/DURATION
2008 - 2009

ADDITION
500 m^2

CONSTRUCTION SYSTEM
Steel and glass

MATERIAL
Steel

TYPOLOGY

FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING

SOURCES

www.koncept.se
www.worldarchitecturenews.com/project-images/2012/21068/koncept-stockholm-ab/vildmannen-in-stockholm.htmlv

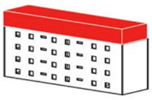
ALBY ETAGE ROOFTOP EXTENSION

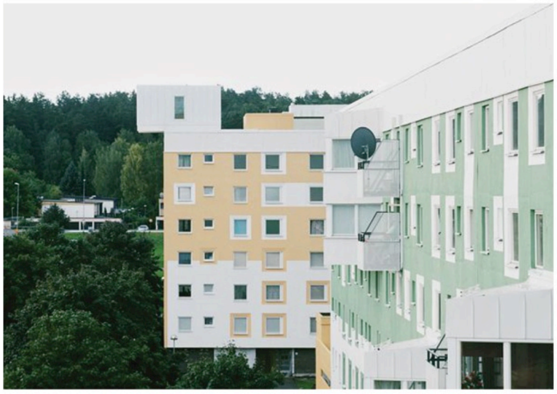
LOCATION
Stockholm, Sweden

BUILDING TYPE
Apartment Building

YEAR OF CONSTRUCTION
1935

FACADE





ARCHITECT
Sandell Sandberg

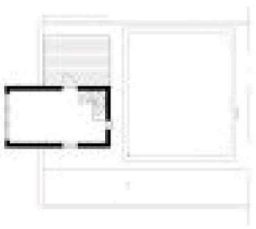
YEAR/DURATION
2010 - 12 months

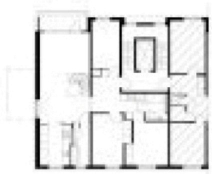
ADDITION
23 m^2 each module

CONSTRUCTION SYSTEM
Prefabricated Modules
Produced by

MATERIAL
Container

TYPOLOGY
FACADE RENOVATION
ROOFTOP
ASIDE
BALCONIES/LOGGIA
NEW BUILDING





SOURCES

http://www.sandellsandberg.se/project/Alby+etage
http://www.fotolog.com/tukholma/24800000000001530/

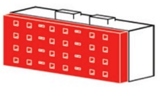
GWG FERNPASSSTRASSE

LOCATION Munich, Germany

BUILDING TYPE Apartment Building

YEAR OF CONSTRUCTION 1958

FACADE Prefabricated Panels



ARCHITECT Hermann Kaufmann
Lichtblau Architekten

YEAR/DURATION 2012 - 2013

ADDITION 1311 m^2

CONSTRUCTION SYSTEM TES Facade System

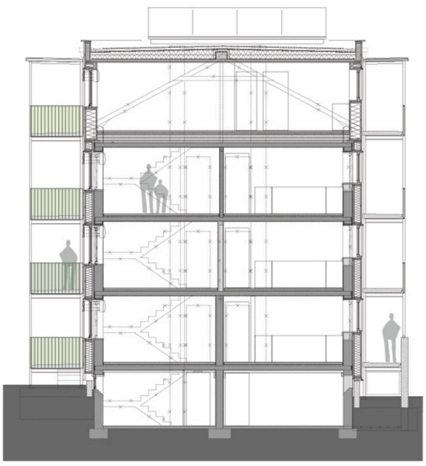
MATERIAL Timber

TYPOLOGY

- FACADE RENOVATION
- ROOFTOP
- ASIDE
- BALCONIES/LOGGIA
- NEW BUILDING

SOURCES

http://www.hermann-kaufmann.at/index.php?pid=2&kid=3&prjnr=07_51&lg=en
http://www.mkp-ing.com/projekte/wohnen-buro-hotel/wohnanlage-gwg-muenchen-sendling-d



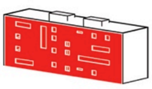
GRUENTENSTRASSE RENOVATION

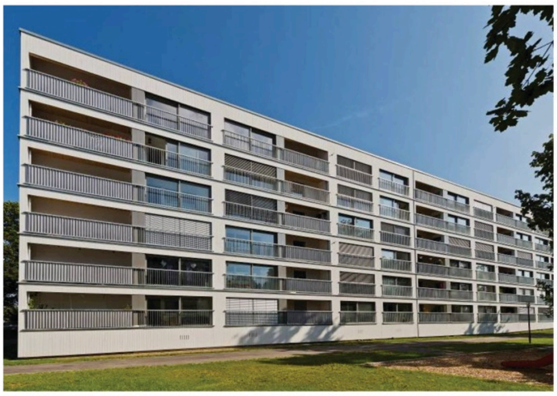
LOCATION Augsburg, Germany

BUILDING TYPE Apartment Building

YEAR OF CONSTRUCTION 1966

FACADE





ARCHITECT Lattkearchitekten

YEAR/DURATION 2012 - 9 months

ADDITION 180 m^2

CONSTRUCTION SYSTEM TES Facade

MATERIAL Timber/Concrete

TYPOLOGY

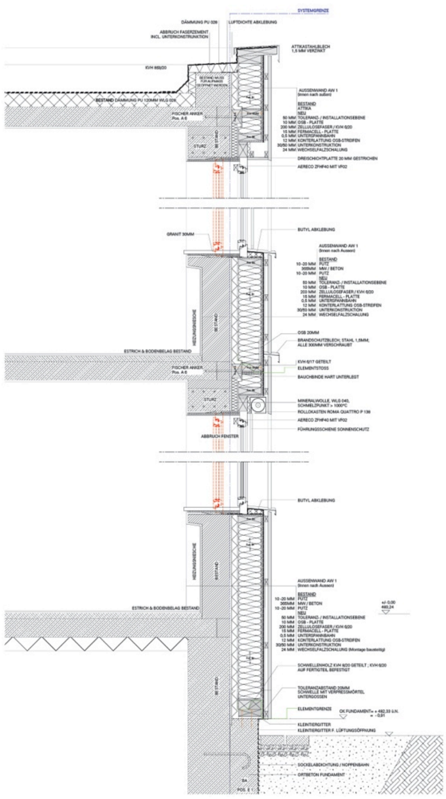
FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING

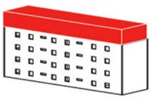


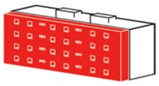
SOURCES

Lattke, F. 2013. TES Energy Façade – proven practice in Implementing Sustainability, Barriers and Chances. Book of Abstracts. Fraunhofer IRB Verlag (2013). ISBN 978-3-8167-8965-9, ISBN 978-3-8167-8966-6.

TREEHOUSES

LOCATION	Hamburg, Germany
BUILDING TYPE	Maisonette Type
YEAR OF CONSTRUCTION	1959
FACADE	





ARCHITECT	Blauraum architects
YEAR/DURATION	2012 - 2014
ADDITION	2200 m^2
CONSTRUCTION SYSTEM	Prefab. wooden panels
MATERIAL	Wood

TYPOLOGY

FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING

SOURCES

http://www.blauraum.eu/architektur/project/5/

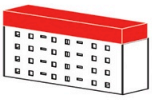
WOHNHEIM MANDALAHOF

LOCATION **Wien, Austria**

BUILDING TYPE Apartment Building

YEAR OF CONSTRUCTION 1968

FACADE Concrete scheleton



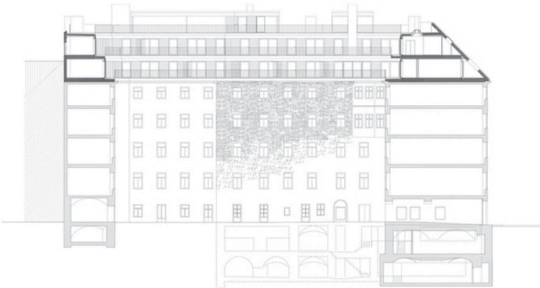
ARCHITECT Adolf Krischanitz

YEAR/DURATION 2003v - 2008

ADDITION 22 Apartments from 22-59 m² each

CONSTRUCTION SYSTEM Prefabricated Modules Produced by

MATERIAL Wood



TYPOLOGY

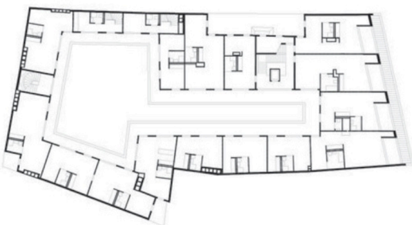
FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING



SOURCES

www.nextroom.at
www.krischanitz.at
www.proholz.at/architektur/detail/mandalahof-in-wien/

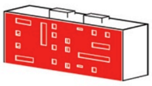
MANESSESTRASSE

LOCATION
Zürich, Switzerland

BUILDING TYPE
Apartment building

YEAR OF CONSTRUCTION
1960

FACADE
Wooden panels



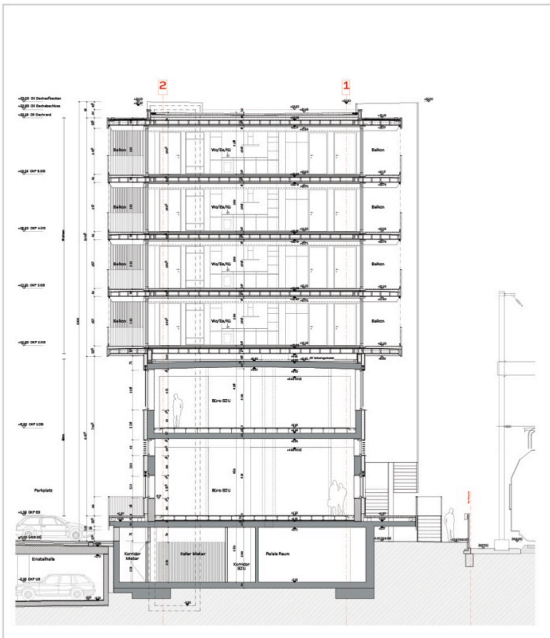
ARCHITECT
Burkhalter Sumi

YEAR/DURATION
2008-2011

ADDITION
2.800 m^2

CONSTRUCTION SYSTEM
Prefabricated wooden panels with insulation

MATERIAL
Wood



TYPOLOGY

FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING

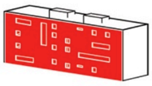
SOURCES

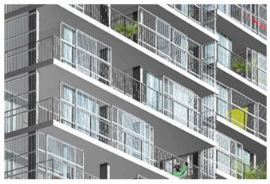
http://www.promolegno.com/materialegno/05/pile-it-up/
http://www.burkhalter-sumi.ch

Photos credit Georg Aerni, Heinz Unger. Project drawings Burkhalter Sumi

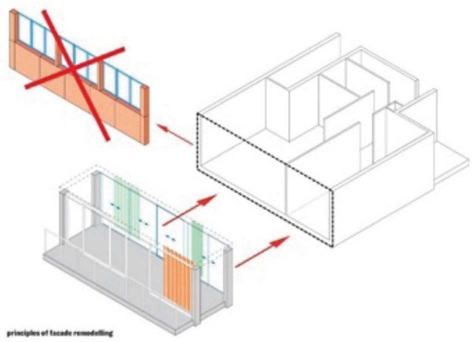
TOUR BOIS LE PRETRE

LOCATION	**Paris, France**
BUILDING TYPE	Apartment Building, Tower
YEAR OF CONSTRUCTION	1962
FACADE	Prefabr. concrete panels





ARCHITECT	Lacaton and Vassal Frédéric Druot
YEAR/DURATION	2011 - 2012
ADDITION	600 m^2 (35,6 m^2 each unit)
CONSTRUCTION SYSTEM	Prefabricated Modules Produced by
MATERIAL	Prefabricated facade panels



TYPOLOGY

$\boxed{\text{FACADE RENOVATION}}$

ROOFTOP

ASIDE

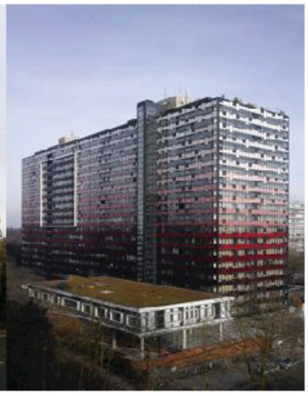
$\boxed{\text{BALCONIES/LOGGIA}}$

NEW BUILDING

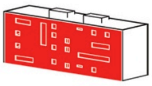
SOURCES

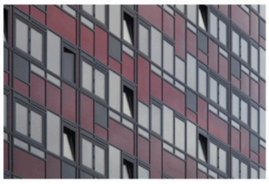
http://www.lacatonvassal.com/?idp=56
https://docomomoiscetnewsletteriv.wordpress.com/article-2/ù http://www.architectural-review.com/buildings/lacaton-and-vassals-revitalisation-of-a-parisian-tower-block/8624097.article

TORENFLAT BINNENGANGEN

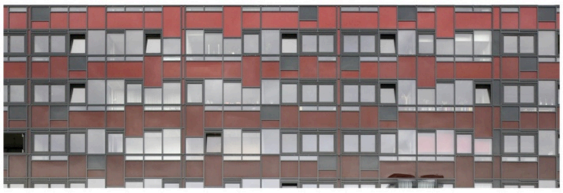



LOCATION	Zeist, The Netherlands
BUILDING TYPE	Apartment building
YEAR OF CONSTRUCTION	1973
FACADE	Concrete Structure






ARCHITECT	Frowijn de Roos architecten
YEAR/DURATION	2007 - 2010
ADDITION	2 0a00 m^2
CONSTRUCTION SYSTEM	Facade Prefab Panels Kremers and Schüco
MATERIAL	Alluminium



TYPOLOGY

FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

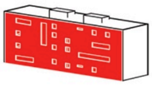
NEW BUILDING

SOURCES

www.frowijnderoos.nl
http://www.dearchitect.nl/projecten
http://www.aluplanet.com/documenti/InfoAl-luminio/Premio_Aluminium_in_Renovation_edizione_2009.pdf

DE VALK

LOCATION	Apeldoorn, The Netherlands
BUILDING TYPE	Apartment Building
YEAR OF CONSTRUCTION	1962
FACADE	Prefabricated facade modules



ARCHITECT	Groosman Partners
YEAR/DURATION	2005 - 2008
ADDITION	1200 m^2
CONSTRUCTION SYSTEM	Prefabricated Modules Solarlux and Normteq
MATERIAL	Concrete

TYPOLOGY

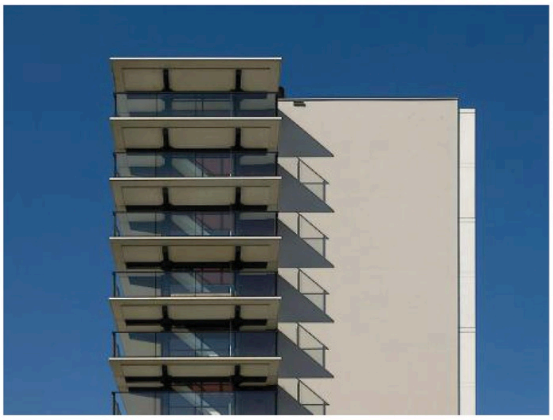
FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING



SOURCES

http://www.archello.com/en/project/de-valk/35693
http://www.groosman.com/project/de-valk/

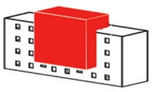
EUCALYPTUSHOF

LOCATION Rotterdam, The Netherlands

BUILDING TYPE Apartment/office building

YEAR OF CONSTRUCTION 1976

FACADE Prefabricated modules



ARCHITECT THE ROOM INDUSTRY

YEAR/DURATION 2007 - 2009

ADDITION 300 m^2

CONSTRUCTION SYSTEM Facade Prefab Panels
BRS-Artdeck system

MATERIAL Steel construction

TYPOLOGY

FACADE RENOVATION

ROOFTOP

ASIDE

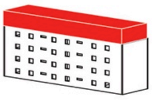
BALCONIES/LOGGIA

NEW BUILDING

SOURCES
http://www.brs.nl/expertise-project.php?-exp=3&proj=1989818&img=2
http://www.aaarchitects.nl/nederlands/projecten/eh/

SEGANTINISTRASSE 200

LOCATION	Zurich-Höngg, Switzerland
BUILDING TYPE	Apartment Building
YEAR OF CONSTRUCTION	1954
FACADE	Masonry



ARCHITECT	Kämpfen für Architektur
YEAR/DURATION	2009 - 6 months
ADDITION	200 m^2
CONSTRUCTION SYSTEM	Prefabricated Wooden Panels produced by AG
MATERIAL	Steel-Wood

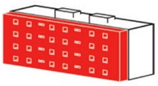
TYPOLOGY

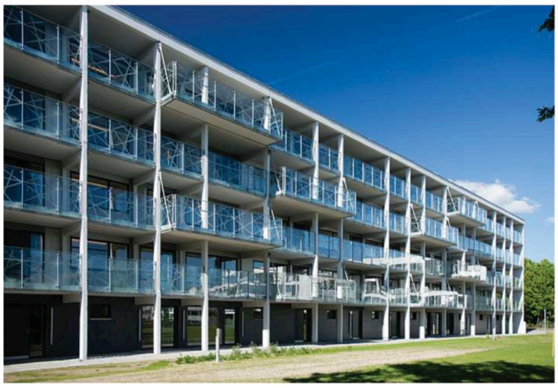
- FACADE RENOVATION
- ROOFTOP
- ASIDE
- BALCONIES/LOGGIA
- NEW BUILDING

SOURCES

http://www.kaempfen.com/
http://www.world-architects.com/en/projects/44464_Apartment_house_renovation_and_extension_Zurich_Hoengg_MINERGIE_P_effectively_a_plus_heating_energy_building

HAB VARBERGPARKEN BLOCK 15





LOCATION	Haderslev, Denmark
BUILDING TYPE	Apartment Building
YEAR OF CONSTRUCTION	1974
FACADE	Prefabricated modules
ARCHITECT	Møller Architects
YEAR/DURATION	2008 - 2013
ADDITION	800 m^2
CONSTRUCTION SYSTEM	Facade Prefab
MATERIAL	Steel construction
TYPOLOGY	FACADE RENOVATION ROOFTOP ASIDE **BALCONIES/LOGGIA** NEW BUILDING
SOURCES	http://www.cfmoller.com/p/-en/varberg-parken-block-15-low-energy-hous-ing-i2466.html

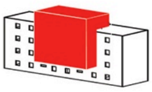
GOETHESTRASSE/ EINSTEINSTRASSE

LOCATION Leinfeld, Germany

BUILDING TYPE Apartment Building

YEAR OF CONSTRUCTION 1957

FACADE Prefab. concrete panels



ARCHITECT Stefan Forster

YEAR/DURATION 2003-2007

ADDITION Reduction of 1/3

CONSTRUCTION SYSTEM original construction

MATERIAL Prefab. concrete panels

TYPOLOGY

FACADE RENOVATION

ROOFTOP

ASIDE

BALCONIES/LOGGIA

NEW BUILDING

SOURCES

http://www.stefan-forster-architekten.de/de/stadtumbau/haus-4-goethestrasse/
PHOTOS: Stefa n Forster Architekten /Jean-Luc Valentin

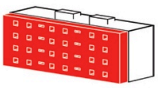
BOGENALLEE 10

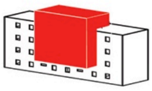
LOCATION Hamburg, Germany

BUILDING TYPE Apartment Building

YEAR OF CONSTRUCTION 1974

FACADE Concrete





ARCHITECT Blauraum Architects

YEAR/DURATION 2004 - 13 months

ADDITION 850 m^2

CONSTRUCTION SYSTEM Facade Prefab

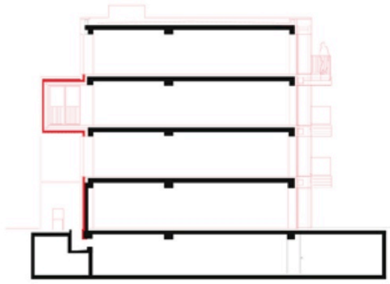
MATERIAL Wood

TYPOLOGY

- FACADE RENOVATION
- ROOFTOP
- ASIDE
- BALCONIES/LOGGIA
- NEW BUILDING

SOURCES

http://www.detail.de/research/forschung-entwicklung/wohnen-statt-arbeiten-umnutzung-innerstaedtischer-buerohaeuser-023933.html
http://www.blauraum.eu/architektur/project/2/
http://www.convertiblecity.de



Photos: blauraum architekten , Christian Schaulin , Giovanni Castelli

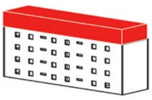
RAY 1

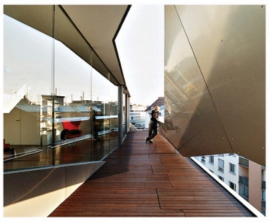
LOCATION: Vienna, Austria

BUILDING TYPE: Office Building

YEAR OF CONSTRUCTION: 1960

FACADE: Prefab. panels, concrete structure





ARCHITECT: Delugan Meissl

YEAR/DURATION: 2003-2004

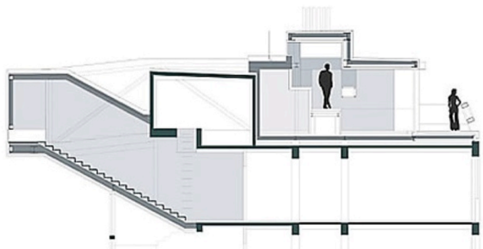
ADDITION: 340 m^2

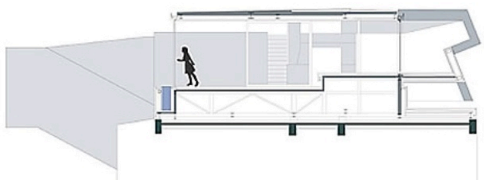
CONSTRUCTION SYSTEM: Steel

MATERIAL: Alucobond

TYPOLOGY

- FACADE RENOVATION
- ROOFTOP
- ASIDE
- BALCONIES/LOGGIA
- NEW BUILDING





SOURCES

http://www.dmaa.at/projekte/detail-page/house-ray1.html

Several of the selected case studies have been invited to take part in the International Workshop organised by the University of Bologna on the 23rd-24th of June 2016, within the framework of the financed European Project Abracadabra, which is based on the research presented in this thesis. Abracadabra (Assistant Buildings' addition to Retrofit, Adopt, Cure And Develop the Actual Buildings up to zeRo energy, Activating a market for deep renovation) aims at demonstrating to the key stakeholders and financial investors the attractiveness of a new renovation strategy based on volumetric Add-ons and Renewables intended as one (or a set of) Assistant Building unit(s) - like aside or façade addictions, rooftop extensions or even an entire new building construction - that "adopt" the existing buildings (the Assisted Buildings) to achieve nearly zero energy. The creation of these new Assistant Buildings' Additions integrated with Renewable Energy Sources aims at reducing the initial investment allocated for the deep renovation of the existing building creating an up-grading synergy between old and new. The ABRA strategy results in the implementation of a punctual densification policy that aims at fostering the investments in deep renovation of the existing built environment throughout Europe. Our aim is to provoke a legislative and market earthquake accelerating the revolution towards nearly Zero Energy in existing buildings.

The conference will be an important occasion to discuss and critically analyse the state of the art of the proposed approach and evaluate its potential in economical, architectural and sociological terms. It will also set the basis for a further evolution of the Addition strategy as a systematic and programmatic approach to renovation.

2.4 Integrated design methodology for Deep Renovation: energy and non-energy related factors

When anything as socially vital as Housing fails to fulfil its primary functions it is a tragedy, but when nearly everybody involved fails to anticipate, understand and explain these failures, it is a farce
Necdet Teymur, 1988

The preview experiences and best practices have provided a formal, structural and procedural overview of the potential of the addition strategy when applied to building renovation. Yet, as mentioned these are singular cases not collected before in an organic and comprehensive theory as this work aims to accomplish. It is crucial to underline that the addition has been so far investigated and applied because of its economical benefits of reducing the payback time of the intervention by creating extra real estate value or as architectural concept at the base of the renovation project. There are other values and key aspects in the renovation of existing buildings that shall be kept into consideration and that so far have been integrated with the potential of the addition strategy. In particular, the social aspects connected to the housing function shall be taken into account. Inhabitants are in fact often passive actors of the process and there is, in all the previously shown best practice, a uniform approach to the building and facades as if it would be possible to imagine that all the dwellers were wishing and needing from their apartment the same exact thing.

Energy efficiency in housing and in renovation practice is more than a technical problem. Quoting Cedric Price and the title of a famous lesson that he held (Where?), Technology is the answer but was the question? The instruments and knowledge achieve by architects, planners and the construction industry has led us to a point where instruments are there to facilitate and pursuit the energy refurbishment of the entire building stock in need. Yet, as mentioned before, little are the cases where the renovation process comes to an happy ending. This reflection guides us to define an under-estimated aspect, which alone represents the major barrier: *the* *human factor*. Houses, because of their direct and intimate link with everyday life, resources and experience, shall be expected more than any other type of building to be evaluated and treated as objects of *use* value rather than *commodity* value.[43] The sort, quality and the variety of the dwellings define the identity of a city or neighbourhood. In these terms, retrofitting and re-designing dwellings may represent a great opportunity for a combined technical, formal and social revision of European cities, by addressing different issues and improving the built environment at the same time. Interventions and constructions in the field of Mass Housing have always dealt with the idea of *collectivity*, which is intrinsically linked to public housing, up until the past two decades.

The Mass Housing developments that have followed the Second World War and its relatively uniform development through out Europe has generated an enormous amount of dwelling units that are now facing entirely their incapability in answering to society evolution. The uniformity and lack of flexibility in typology and form of the MH complexes is not, contrary from what many believe, a result of the systematic and programmatic standardisation of the building process, it is indeed the evident outcome from the lack of human involvement. Users and inhabitants have been deprived of the natural relationship (Habracken, 1961) that linked human and building as action to create man's proper habitat. Nowadays society is a rapidly and constantly changing mixture of cultures, religions, traditions and it is evident that uniformity can no longer answer to the its housing need. " To enable natural relationship to function a dwelling should be capable of being altered, remodelled, pulled down and rebuilt without affecting any other dwelling […] it should be an independent dwelling".[44]

The theory here proposed is based on the possibility of reinterpreting the renovation of existing buildings through an open process based upon incremental parts and components that can be conceived as infill: variable and adaptable elements that stand on fixed structures that are supporting the variability of the single Additions. A direct reference to this theory can be found in

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[43] Teymur N., T.A. Markus, T. Woolley, Rehumanizing Housing, p.6, Butterworths 1988.
[44] Habraken, J., Supports: an alternative to Mass Housing, ed. by Jonathan Teicher, Urban International Press UK, p.53,59, 1972.

the infrastructures theory of Habraken. The intimate and unceasing interaction between people and the forms they inhabit uniquely defines the built environment. The vision of Habraken was based upon " constructions which are not in themselves dwellings or even buildings, but are capable of lifting dwellings above the ground; constructions which contain individual dwellings as a bookcase contains books, which can be removed and replaced separately,[45] the built environment becomes the product of an on-going, never ending design process in which environment transforms part by part, supports and structure remain stable whereas the dwellings can change and be altered according to the dwellers. Therefore the form of housing shall no longer be dictated by over imposed, rigid schemes but rather be an opened form. It is indeed the concept of the Open Form, Oscar Hansen has devoted his entire career and upon which he developed all his theories and scripts. The concept, which referred to the theory of sculpture and architecture put forward by Katarzyna Kobro and Władysław Strzemiński, could be construed sociologically as a structure of space shaped by various types of human activities. Hansen always stressed the humanistic element in architecture, never the technological angle. He wrote: "*Open Form is about variable compositions – the processes of life highlighted by backgrounds*." The principle at the foundation of the Open Form is that *" no artistic expression is complete until it has been appropriated by its users or beholders*". The Open form stands opposite to Closed form which is market by a reductionist approach towards the human being, criticizing the blindness of closed form to the residents' individual needs. H. formulated the theory in 1959 and presented it at the CIAM congress in Otterlo, where it was enthusiastically received by young architects who went on to establish Team X and the Groupe d'Etude d'Architecture Mobile. The goal of the young architects was reorganising the congress – considered the most influential institution of modernist architecture – as well as the theoretical redefinition of modernist architecture in general. The shift in approach regarded a stronger consideration of subjective needs and spontaneous, unpredictable developments as well as turning o society and culture in place of technological rationalism. The belief was that architecture can play a key role in the shaping of society[46][47]. As also Alice Coleman's *Utopia on*

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[45] Ibid.

[46] Van den Heuvel, D., M. Risedala, Looking into the mirror of Team X in " Team X. In search of an Utopia of the present, NAI Publisher, Rotterdam, 2006.

[47] Ronduda, L., F. Zeyfang, Society of algorithm, Game Actions and Interactions: Oscar Hansen open form, 2007.

Trial arose[48], there is an underlining contradiction in believing in the innocence of design and technology in creating disadvantaged social conditions but also on the other hand it is a mistake to derive that technology alone dictated and determines the social factors in Housing environments, throughout the decades. It is thus necessary to find the right balance between the social factors and the physical features: the methodological dilemma in dealing with such a discourse is the extent to, and the models in which the analysis can present both sides an argument while retaining a clear degree of autonomy.[49] The connection between design and technology is related to the possibility of defining an overall quality that is subject to constant mutations and alterations, the open form and the possibility of designing a framework for the housing evolution is the ultimate path that technology shall take to live the necessary freedom to the social aspects connected to the living and private spheres.

Those renovation intervention, that are not aiming at the creation of new residential compounds but instead to the redefinition of the existing one inherited from the past, should still focus the attention to the *collectivity* and to the social aspects related. To be able to better understand the possible results and positive implications of the involvement of the inhabitants in a revolutionary approach to building renovation, it is necessary to step back and investigate what was the original relationship between those buildings and their final users. The internal layout as well as the architectural representation of those buildings often mirrors the society they were designed for. Just some examples: the Dutch building blocks still are characterised by generous fenestrated surfaces that reflect the idea of the open dwelling, optimising the light gains and showing the inner soul of the living space to the outside. The German housing districts carry still nowadays the influx from the communist soviet culture: the apartment is introverted and the space is divided in generous size bedroom while the kitchen and living spaces are generally reduced in size as dictated by the typical scheme of the soviet apartments. On the other hand, the apartment blocks in southern Europe (e.g. Greece, Italy, Spain) present semi-public spaces used as inter-action and socialisation areas among the neighbours. When socialisation spaces

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[48] Coleman, A. M., Utopia on Trial: Vision and Reality in Planned Housing, Hilary Shipman Ltd, London, 1985.
[49] Teymur, N., The pathology of housing discourse, in Rehumanising Housing, Rehumanizing Housing, Butterworths 1988.

are not foreseen in the buildings people often carry chairs down the street to gather, meet or simply play cards. The kitchen is the centre, core and most alive space of the house, where food is cooked and meals aroma shall spreads around the house and the entire neighbour. The internal layout here is often characterised by larger apartment units when compared to the northern European standards and the space dedicated to the daily functions is larger and differently organised. The kitchen is often located close to the entrance, in a predominant location, mostly on the street front. The orientation of the kitchen was generally north, north-east to answer to the past need for cool storage of perishable food, requirement today no longer necessary thanks to the advent of the refrigerators in every kitchen. By observation and investigations through the dialogue with the inhabitants of these neighbourhoods, many report that this characteristic allowed the aroma of the freshly cooked meals to reach out from the house. However, analysing the current condition of Social Housing districts in Europe, it has been registered that the original addresses of the buildings have drastically and rapidly changed in the past decades generating an important and significant *incompatibility* between the building as living space and its inhabitants, an intrinsic user-inappropriateness.

As stated technical decay is strictly connected to social decay.[50] This explains the migration of high social groups from an environment characterised by technical weaknesses and the consequent settlement of lower social groups in the majority of these old residential compounds. This constant turnover lead to a complete lost of the original feeling of belonging, of personification between inhabitant and environment, generating disadvantaged and unfavourable areas. These neighbourhoods suffer from stigmatisation due to spatial concentration of poverty, unemployment and lack of safety[51]. Those areas that once where the physical representation of the socialist utopia, are now turning into segregation ghettos, mainly occupied by immigrants, low income or elderly people; buildings are not only in obsolete physical condition and they can no longer answer to the specific social needs of their inhabitants. The sociological, ethnical and religious aspects related to the architectural and

[50] Thiemo E., Re-face refurbishment strategies for the technical improvement of office facades, 2010.
[51] Priemus, H., E. Louw, E. van der Krabben, Spatial development policy: changing roles for local and regional authorities in the Netherlands, Land Use Policy 20 (4), Pergamon, 357-366, 2003.

formal configuration of the buildings' necessary shall follow the structural and technical revision from the beginning of the renovation process until the end, being tightly bonded to it. When forecasting an intervention and redesign, it becomes priority to consider the inadequate aspects that arose by this change in users' composition and firstly investigate what are the current needs of the dwellers, mostly different from the original ones.

Moreover, by placing the user at the centre of the renovation process, it becomes clear that a key aspect regards the evaluation of the impact that the intervention might have on the people currently living in the building who are not intentioned to move out from their apartments during the refurbishment. The centrality of the dwellers' role in the process becomes even more evident considering that the authorization for intervention needs to be unanimous; if this consensus is not met, the refurbishment proposal – even if highly innovative from a technological point of view - will never be approved. Still, this aspect represents an under estimated factor in the evaluation of the renovation's feasibility. Thus, the question upon the feasibility of the refurbishment project can no longer be detached by the users' participation and approval.

Renovation projects are meant to improve both social and physical structures in the neighbourhoods. There are some practices or policies that more than others could generate connections and sense of belonging with the territory in which they take place.[52] By returning to the inhabitants the right of deciding and enact upon the (re)construction of the buildings they live in, it is possible to implement the overall sustainability of the renovation process by integrating a social component, currently still under-estimated.

This would result, not only in a simplification of the consensus' collection procedure by gaining the support by the dwellers, but also in a higher degree of sustainability, intended not only in its environmental meaning but also in a broader social connotation. The long-term vision is that the

[52] Ruggero A., Self-renovation of public dwelling in disuse: practices of new housing model, New Housing Researchers' Day 2011 – 4th of July, Toulouse

delivery of housing policies processes and designs should be re-interpreted in a socio-technical perspective as integration and inclusion practices: the interest of people is at the centre of the decision making process, and people who will benefit from it are fully participating in their development. Tab.3 sums up the current best practice methodologies in terms of participative strategies used by social housing providers and policy makers throughout Europe to involve tenants and residents. The main goal is to understand what role could the resident play and the possible approaches to put them at the centre of the renovation project.

Not only Society but also Nature is based upon the law of greater variety rather than uniformity: the real question is thus related to how could the design and, in specific, the re-design of Housing involve and control multiple variation. How can the renovation process lead to a representative product of the current and constantly changing needs? In other words, how can the structure of these buildings open-up to be able to foreseen the unforeseeable mutations of the future society?

All the participation and integration strategies currently under study well embrace the idea of a participatory process that places the inhabitant back at the centre of the discussion, trying to consult, involve and activate residents participation; what is left out is a way to reconcile the integrity of a design with human needs in the environment53. The users are still not in charge of the decision making process, they are generally consultants whose opinion needs to be listen as input to derive final conclusion which are matter for ‘experts’ committee.

[53] Mace at al., Linking descriptive and experimental analyses in the treatment of bizarre speech, Journal of applied behaviour analysis, 1991,24,553-562, number 3

MEASURES (increasing level of engagement)	ACTIVITIES	CHALLANGES
Mobilising residents	• Supporting resident & tenant associations • Carrying out face to face meetings • Information campaigns on rights and possibilities to get involved • Events to socialize • Training and capacity building for residents • Workshops and creative sessions • Use of external experts	• Difficulties in involving residents facing harsh socio-economic conditions, less inclined to participate to consultation processes or be active in local associations. • Migrants and people from ethnic or religious tend to be less involved. It is important to pay attention to linguistic and cultural diversity in planning (for instance by translating available documents in different languages). • Adolescents and young people are often difficult to mobilize, but their active presence is essential to ensure social mix and peaceful life in neighbourhoods. The use of *Internet based tools* (websites, blogs and social networks) can also help to attract more participation from young people. • Size matters: the bigger the housing estates managed, the more difficult it is mobilise the residents and understand the dynamics.
Collecting users' inputs	• Satisfaction surveys and questionnaires • Complaint/information services • Setting up local 'one stop shops'[54] • On-line forums	• Defining a clear strategy and 'rules of the game': → What should be obtained through participation → The scope of the participatory practices → Roles of residents and landlords → Monitoring and evaluation tools which serve as a basis for revising the strategy
Consulting tenants in decision-making	• Consultation committees, report on a regular basis • Negotiations with tenant/residents on issues of common interest (in particular maintenance or changes which can affect rents/cost of utilities) • Thematic forums/groups dealing with specific issues • Open planning sessions • Signing local 'agreements' with residents: activities and works are planned according to the specific local needs	• Training in participatory methodologies is necessary both for the staff of the housing organisation as well as for the tenants/residents. • Information on the rights and duties of residents and the possible channels for participation is also central. • Participation usually require specific premises, communal facilities and equipment (computer, etc), but also shared areas and facilities for the local community. • Specific budget for tenants' associations/groups/ committees. • Communication to reach out to as many residents as possible but also to other (potential) partners • Consulting residents and involving them in the decision making takes time and can cause a delay of the works' schedule but also in time savings during implementation by avoiding arguments and obstructions.
Involving residents in organisation's management and the delivery of services	• Housing providers creating a board in which tenants are represented • Inspectors/auditors to report on problems and making suggestions • Residents contributing to social activities and maintenance of communal areas • Residents acting as advisors to other inhabitants • Partnership with other local social/civil society organisations	• Overcoming lack of confidence: this is particularly true in run-down, segregated areas and neighbourhoods, where the resident population might lose confidence and trust in the housing provider and/or the local administration. From the previews projects' experience, it seems that the best way to overcome this problem is the establishment of a personal relationship with tenants. • As above, communication to reach out to as many residents as possible but also to other (potential) partners • Communication of the results: people start trusting a housing provider when they see their opinions have a concrete impact: it is therefore extremely important to provide feedback on residents' requests and complaints and constantly prove that they are taken into consideration.

Tab. 3 Derived summery chart grouping the findings carried upon the study conducted by the Housing Europe Observatory from initiative of, and in cooperation with, the French federation Union Sociale pour l'Habitat[55]

The technologies and instruments used so far are not thought in an open form perspective and do not allow mutation and alterations that are fundamental to leave the inhabitants free. It is only an half step towards restabilising the natural relationship: the dwellers should not only be involved but be given the utmost responsibility of discern and chose upon the quality and form of their dwellings.

The current potentials of prefabrication applied to modular energy renovation systems and technologies allow quicker construction times and easier replacement, exchange or improvement in performances of the different parts or entire portions that compose the buildings (envelope, cladding, insulation, structural parts, installations, plants, etc…) (See Chapter 3). The support utopia as expressed by Habracken has indeed a great potential as it gives back to the inhabitants their right to decide upon their home. Moreover, the recent emergencies in energetic terms have shown that we need to move towards highly adaptable systems, that can be produced, installed, exchange and dismantled in a totally new manner compared to traditional construction systems. The actual shift in the construction market towards highly efficient prefabricated elements that can be inter-changed, substitute and transform without compromising the entire building structure makes it possible to imagine the renovation and construction practice under the theory of Habracken not as a visionary ideology but rather as innovative and sustainable solution.

A first attempt to involve the inhabitants not only within the project phases but also in the manufacturing process for the renovation components has been conducted during the European Project More Connect.[56] The project tries to find solutions to directly engage inhabitants by developing prefabricated, multifunctional renovation elements for the total building envelope (façade and roof) and installation/building services according to their wishes,

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[55] Pittini, A., The place of inhabitants residents' participation in creating sustainable housing and neighbourhoods, Zquadra BVBA, 2011

[56] Significant experience has been conducted during the European Project More Connect. The project main aim was to : i. Develop cost optimal deep renovation solutions towards nZEB concepts with the possibility of extra customize cost-effective features (Plug and Play). ii. Develop and demonstrate prefabricated multifunctional modular renovation elements, in a mass production process through automated production lines for multifunctional modular renovation elements (BIM integration system). Iii Offer of a one-stop-shop to the end-user to renovate their homes. More info at : http://www.more-connect.eu/

instructions and needs. The elements can be combined, selected and configured directly by the end-user, based on their specific needs. This information can be used as input into advanced Building Information Modelling systems to control and steer the further production process of these elements. In this way unique series of one can be made in a mass production process for the same reduced price of mass production.

Given the various character of the existing barriers above illustrated, it has emerged that the multi-objective and integrated character of the intervention has to face the problematic through a holistic approach. Therefore the central challenge of contemporary practice in building refurbishment consists in finding an integrated answer for the two sides of this dilemma above illustrated. On one hand the process needs to take into account the inhabitants' point of view and meet their approval, seeking for an alternative to the anonymity of these areas through user-oriented solutions. The system shall be adaptable, flexible and open to future transformations in order to allow inhabitants to enact on their dwellings and decide according to their needs. On the other hand there is an urgent need for a technical revision of the envelope as complex system to improve the performances, reduce the costs and offer products that can adapt to the different façade typologies and configurations of the existing building.

The following chapter will illustrate a prefabricated technology that could be applied to create volumetric additions and building components as proposed in a multi-objective strategy that has been proven able to overcome the existing economical, technological and social barriers. Thus, the research will focus on the validation of the possible integration of volume and surface Addition to the energy renovation of existing building, testing on the three chosen case studies the potential of the proposed approach and validating it in quantitative and qualitative terms.

PART 2

CHAPTER 3_ TECHNICAL, ECONOMICAL AND LEGISLATIVE FEASIBILITY

3.1 Renovation through prefabricated façade components and volumetric addition

The idea of a multi-task and highly efficient façade is nothing new, already before the energy efficiency revolution, the goal of producing an integrate façade system was envisaged by Mike Davies, back in 1981, who formulated the idea of a polyvalent wall in an article signed with Rogers and titled '*A wall for all seasons'*. Here, several functional layers within a glass element were meant to provide sun and heat protection, and to regulate the functions automatically according to current conditions. The wall itself was conceived to generate the necessary energy for the building and perform at its best according to the different housing needs and climates. Davis idea, not yet realized today, still acts as a driving force for new façade technologies, and many researchers have been engaged in this topic over the last two decades.[1] The façade concept was born as highly innovative technology for the façade of the future, but what are the benefits that such technology and system could bring when applied to building renovations? When intervening on existing buildings, the possibility of producing a light prefabricated element for the façade transformation, substitution or improvement hides a great potential, yet not fully exploited. Applying the existing technologies to the market sector related to Deep Renovation means fostering and combining them to create a new innovation level by simply increasing the efficiency in the production and assembly phases and adapting the existing products to the application on existing buildings.

Nowadays, advanced technologies for survey and measurement can significantly support the renovation project. Starting with an accurate 3D scan of the existing building that is intended to be renovated, a full three-dimensional model can be transferred into the computer and studied point by point, with high precision. The design of the new façade can then be based upon this model. By supposing a division of the entire envelope into separate elements, it is possible to produce the design through prefabrication off site with CNC machines that ensure a high

[1] Knaack, U., Klein, T., Bilow, M., Auer T., Façades: Principles of Construction, Birkhäuser Basel, 29 dic. 2007

correspondence in measures and junctions with the existing building, thus reducing the risks for errors during the next phases. The new façade components can be added to the existent building envelope as an additional layer to improve the overall performances or, in case of need, substitute entirely/partly the existing façade. (Fig.1) The main problem is that, for the production of prefabricated façade panels to be economically justifiable, it is necessary to produce them in large scale and this is highly related to the different morphology of the façade and the opening types. This minor problem in case of a new building becomes consistent when trying to apply this technology to existing buildings' renovations: the enormous variability of the existing housing stock makes it impossible to develop a catalogue of fixed options since every panel should be customised and produced according to the information of the single surveys. The process would be highly un-economic especially considering the social housing market and its generally low budgets.

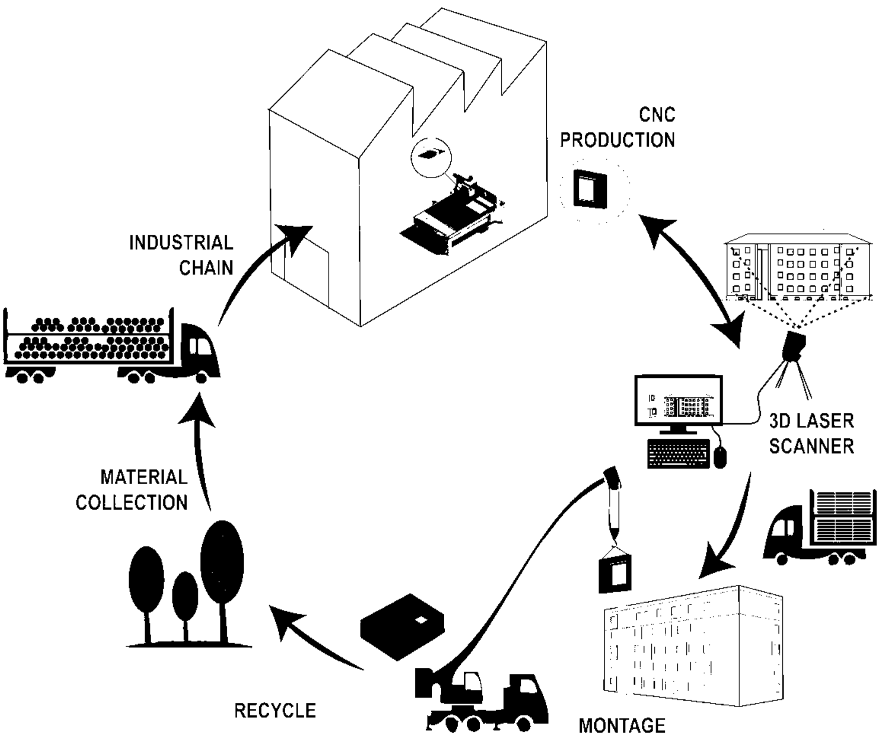

Fig. 1 Cradde to crane cycle of the façade modules

In order to reduce the extra costs and still offer the combined benefits of façade products that can be designed, customised and at the same time produced at economy scale with high precision, the challenge stands in creating new synergies among the available instruments, methods and technologies to ensure the application of the existing most up-to-date techniques in the construction market to new fields and ambits related.

In the specific case of the energy renovation field, the innovation stands in the new relationship that today is possible to establish between the design and the production phase, two separate phases in the past that now can become a single one. The design and production of the new façade panel can be developed today through computer-aided tools that are based on the definition of precisely those geometrical parameters that can vary and represent the problem mentioned above, allowing the producer to simply set these parameters differently every time and send the 3d model and drawing to the CNC printer. The new façade panel could be conceived to integrate plant installations and answer in one integrated technological component to all the physical needs of the building renovation. To better clarify the high potential of this refurbishment methodology, it is important to underline the following four aspects:

- The façade modules can be standardized in construction, layers and joints
- The façade modules can be flexible in architecture, form and cladding
- The façade modules can be combined with each other with non prefabricated (conventional) retrofit options[2]
- The façade modules can even become three-dimensional spaces as volumetric additions and offer the possibility of extending the liveable surface of the building (increasing also its real estate value).

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[2] René L. Kobler, Armin Binz, Gregor Steinke , IEA ECBCS Annex 50 Prefabricated Systems for Low Energy Renovation of Residential Buildings Retrofit Module Design Guide, , University of Applied Sciences Northwestern Switzerland, School of Architecture, Civil Engineering and Geomatics, Switzerland March 2011
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The possible application of mass industrialisation logics at service of increasing the customisation potential and the specificity of the final products could drive the market towards an intelligent prefabrication of façade elements. The geometrical parameters would change and follow the specific characteristic of each building case and the specific wishes/needs of the users. This would ensure that one singular production line could work on a large number and variety of façade components. In other words, the production should shift towards a mass prefabrication system based on modularity and variability not in the final production phase but in the preliminary design phase; IT tools available today (especially considering the potential of laser scanner, CNC machines and 3d printing systems) allow to set up a unified process to produce multiple designs, by setting up the process rather than the final outcome. In fact, by determining those variables that could change and those that are fixed, it is possible to obtain hundreds of different types of the same piece of façade, avoiding the need of developing a different design and changing the process every time, for every façade component, for every inhabitant, for every building, for every country. By transferring the customization and prefabrication logics into the field of Energy Renovation, it is possible to re-interpret the residential artefact, no longer in its dimension of building object with a close and rigid configuration, but in the adaptive nature typical of the housing function, subjected to time transformations and users changes.

A first basic division in the proposed system has to be made between the variant and invariant parts that compose the building intervention; variant are those elements such as the façade components that could assume different connotations (balconies, rooms, serras) with different sizes and qualities according to the customers while invariant are those elements that by functional reasons they shall remain fixed (mainly referring to the structural parts and plant systems). To determine the possible variation that the variant components of the façade can be subject of, the starting point consists in the analysis of the envelope as architectural and technological complex system, suggesting a shift in coding the façade and its elements, changing the focus from the cell-scale or the building-scale to the module-scale. The process starts from a discretisation and division of the façade into a regular grid, finding out the base unit and its variants. The buildings considered in this study, residential apartment blocks built between the 50s and 80s, are generally characterised by repetitiveness and rhythm in the elevation layout, mostly governed by the distribution scheme (staircases and accesses). Façade elements are often repeated and replicated identically. The division elements are those corresponding to the staircases and/or the toilet rooms where openings as well as the balconies or loggia disappear to leave space for different geometries a change in material or again a volumetric transition.

After a preliminary analysis of the elevation drawing, its formal development and the functional character of its different parts, it is possible to determine the '*Alfa*' element that can define the façade basic unit. The variation of the *Alfa* component will generate all the other different components that constitute the envelope. Dividing and partitioning the façade in sub-components allows conceiving the envelope as an inter-exchangeable skin, a puzzle that can be deconstructed and reconstructed to reach the best combination of functionality and performance. The secondary phase consists in the definition of a secondary scale of design looking at the architectural span, intended as the space between two staircases or breaking elements in the facade after which, generally, the facade components are repeated identically. The third design scale unit is determined by the entire building. The possible design solutions are studied from the primary cell; according to the suggestions of the planners and the inhabitants a first set of options is produced. The variability of the different elements of the new façade are numerous and can be increased or changed according to the specific case study. The division in phases allows the designers, planners and the used algorithm to control the results of a design with multiple possible configurations (see paragraph 4.4) at all the scales, from the components variations defined by the inhabitants up to the overall building where coherence shall be guarantee.

The approaches to renew and rebuild through prefabricate envelope components can be very divers. This is not only because buildings themselves are divers. Even for identical buildings, there are various possibilities to meet high performance standards in Energy Renovation and to implement a system to produce prefabricated modules that can substitute or improve the existing façades and roofs. Four different approaches to the subject have been analysed according to the IEA ECBCS Annex 50 which was dealing precisely with Prefabricated Systems for Low Energy/High Comfort Building Renewal. The following approaches were presented by national teams from Austria, France, Portugal and Switzerland:

- The Swiss solution is based on small modules with a high degree of standardisation. The prefabricated façade modules focus on the window area as the area with the highest concentration of technical details, whereas the plain façade parts are insulated traditionally. Also the façade finish – ventilated cladding or rendering – is done on site. The junctions and connections within the elements are accurately studied as well as the connection layer that is located between the old envelope and the new components. The Swiss method has been used also for the development of roof elements, for flat or sloped roofs.
- The Austrian solution is based on large glazed façade modules, which are fully prefabricated. The solution is similar to the Swiss one in terms of technology but the panels are not small units that are composed on site but rather big elements that cover entire façade portions: the panels are as high as the average inter-storey high of the building, and up to 12 m long. The façade modules are prefabricated off site and directly mounted on site; several tests have been already conducted in various demonstration buildings in Graz.
- The French solution for prefabricated systems was based on large vertical façades. Unlike the Swiss and Austrian systems that are based on wooded elements with a wooden frame under construction, the French elements are made of a metal/steel under construction. The increase in weight of the elements is balanced by the possibility of reducing the sections of the profiles. Special attention is given in this system to avoid the thermal bridges at the junction and connection in the corners. The elements are produced in large-scale unique pieces and correspond with the entire façade development.
- The Portuguese solution concentrates also on fully prefabricated but smaller sized modules. They are based on easy mountable metallic and insulated façade panels that are installed on a sub-structure directly applied when possible to the existing building.

The Swiss option is the one that has proven to be most effective both for ecological reason, practical and economical and it will be used as a base for the design proposals that will be texted in chapter 5. All the above-described technologies can be used to install directly a new layer on the existing façade or substitute it after removal in case of total obsolescing conditions.

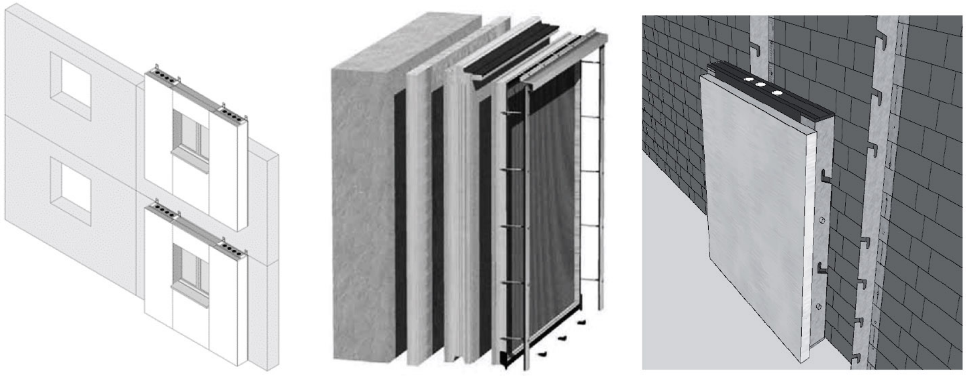


Fig. 2 Examples of prefab modules developed by IEA ECBCS Annex 50 project (source: Geier, S., Höfl er, K., Cousin, S., Silva, P., Kobler, R., 2010 (draft) 'Retrofi t Module Design Guide', IEA ECBCS Annex 50, Prefabricated Systems for the Low Energy Renovation of Residential Buildings,133 pp., Swiss Federal Laboratories for Materials Testing and Research, Switzerland, 2010.)

Evaluating the sustainability of the renovation intervention by looking at the possibility of an extended life cycle of the building, the suggested proposal is based on the assumption that light prefabricated elements that use wood as main material are the favourable option. The load transfer scheme is mostly thought to be independent from the original structure in order to avoid a worsening of the static conditions, especially in seismic areas. An additional structure supporting the new façade modules will be placed on next to the existing building.

This structure is similar to a portal structure and can be connected by junction crossing elements on the roof. At a second stage the support structure could also become more complicated and the simple façade modules could be seen as entire extra units, volumetric additions (Add-ons) to the existing volume. Further researches on the topic conducted by the Department of Architecture of the University of Bologna demonstrated with preliminary calculations the positive potential impact that these systems could have as aid to the existing structure when involved in a seismic event.

As mentioned above, the basis for an effective application of prefabricated building elements (bi-dimensional as panels or tri-dimensional as volumetric Add-ons) is a frictionless digital workflow from survey, planning, off site production and mounting on site based on a precise initial 3D scanning measurement. This allows a high degree of precision and correspondence between the new façade elements and the old façade, reducing time waste, errors and risks in the construction phase. The benefits in terms of results and costs in using prefabricated façade modules rather than the standard approaches to building renovation are involving all the fields connected to Deep Renovation: not only from an ecological point of view but also for the architectural, structural and plant aspects and from a socio-economical perspective. The following table groups together the benefits that the proposed technology has when used for Deep Renovation on existing buildings. The possibility of integrating both the façade renovation and the extension of surface as volumetric bonus to the energy renovation into one technology embodies a great potential considering the pay-back time reduction and the increase of value in the real estate market.

FIELD	**BENEFIT**
Ecology	Quality of an ecological building system based on recycled materials
Architecture	Possibility of redesign of the façade and entire building envelope
Engineering	Possibility of improving the structural elements and integrate new prefabricated structure that could cooperate with the existing in case of seismic event. By adding an external steel structure that could be used as support for the addition or prefabricated wooden elements in correspondence with the existing structure, preliminary evaluation have shown the potential benefit in terms of seismic performances.
Plant	Integration of the Heat Ventilation Air Conditioning directly in the façade or in the construction system. Plug and Play solutions could reduce the time and costs of the intervention. Possibility of integrating active solar components such as PV panels or solar collectors.
Energy Efficiency	Increase of the performance of the existing envelope by: adding extra insulation; removing existing envelope components that are no longer meeting the standards (window frames, old insulation, cladding); integrating innovative systems such as dynamic façade, ventilated and mechanical systems, etc.
User participation	Possibility of application of a great variety of cladding materials, layout configuration and façade transformation according to the user's needs and taste. Possibility of volumetric addition and spatial transformation within the same construction system
Life Cycle Assessment	Great impact in the Life Cycle Assessment of the entire building
Economy	Possible integration of spatial and volumetric addition (Add-ons) within the same construction system and intervention time-frame. The new surface, in the real estate market, represent an important pay back accelerator for the initial consistent investment made for the renovation

Tab. 1 Different benefits of the proposed strategy for renovation in different fields: ecology, architecture, engineering, plant etc

The type of expansion could involve not only the increasing of one room size but the entire roof top level, the underground level, the side or the in-between space at the urban level as well. Moreover a combination of building system and space components would help to standardize and minimize the connections between space modules. “Near-zero energy solutions” introducing space modules self-sufficient in energy, could be one solution to simplify the connection of extensions to existing building systems. Town planning measures have been developed to increase the density of existing urban structures which can be achieved by adding roof floors, neighbourhood specific infill developments or extension of building spaces in a frame work that envisages the refurbishment need as an opportunity for re-interpreting and re-designing the first periphery of our cities. The geometry of the building may be modified by adjusting the openings and integrating loggias or balconies to the heated living area. The following diagram shows the cradle to crane cycle of the proposed methodology. Annexes or extensions can be added to the building increasing the productive floor area. The possibility of transferring building indexes from not-yet built area to the existing neighbourhood in urban exchange perspective could represent an important strategy to control and reduce the current urban sprawl. In many countries of the EU, the political parties are already moving towards a more flexible framework for energy renewal interventions. The open discussion on the potential of increasing the volume of existing building is an important occasion to review the current legislative framework in favour of an indispensable liberalization of the normative. The urgency for densification policies that Europe is facing requires a direct engagement from both the Research and Development sectors and the Industrial sector. Therefore it does not surprise that the last European edition of the Solar Decathlon (June 2014, Versailles) has identified the five central topics of the competition in relation to the main issues related to sustainability in European cities: density, mobility, sobriety, innovation, and affordability.[3] This important occasion of discussion and confrontation on sustainability and architecture thus reflects a clear shift from the search of a formal application of green active energy systems in figurative architectural connotation, to an urban and social application of housing prototypes that are thought capable to answer to the emergency that European cities are facing. In one sentence

[3] www.solardecathlon2014.fr Solar Decathlon Europe 2014

the project has to be designed within its environment and is supposed to develop around, above and within the built environment. What illustrated above, both as methodology and technology could be applied to the production of façade components but also to entire building part intended as units, independent Add-on dwelling as many were produced as design elements also during the '60s and '70s[4].

Many of the highly efficient prototype of homes presented have been designed to be directly integrated into the urban tissue as volumetric additions, rooftop extensions and/or infill between existing buildings. The prototypes that will be built in Versailles as well as the preliminary studies and similar research experiences show the possibility of building this *parasite architecture*[5] through the utilization of light and prefabricated systems (wooden panels). This type of construction system will ensure the rapidity of realization, the reversibility of the intervention and will avoid structural interference with the static condition of the existing building that will 'host' the addition. The estimative research carried at the FH Frankfurt during the solar decathlon competition was aiming at a numeric evaluation of the potential of the OnTop strategy.[6] The highly replicable nature of this punctual densification, the important impact on the mobility and the social benefits that could outcome from the add-on densification strategy, demonstrate that this is more than just a proposal: it is the right path towards an effective renovation of our cities and a step forward in defining a new paradigm of sustainability.

The energy renovation project can therefore be divided in three consequential and incremental steps, each independent one for the other but in order of impact and consistency of the transformation:

- **Level 1 Façade transformations**: according to the preliminary survey, evaluation and structure type of the existing building it is possible to apply the new façade in addition to the existing one (especially in case of external load bearing walls or façade whose

[4] See as examples the prototypes for the Nakagin Capsule (1960), the Futuro house (1969), Venturo (1971)
[5] Marini S., Architettura parassita, strategie di riciclaggio per la città, Architettura Ascoli Piceno, 2008 Quodlibet Studio
[6] Rikort, A., Markiewicz, M., Herrmann, M., Kreisel S., 3D Spatial analysis: Determining the buildings of Frankfurt of potential and suitability for the solar concept "OnTop", Fachhochschule Frankfurt am Main University of Applied Sciences www.geko-master.de, 2014

structure and state does not require demolition) or façade in substitution to the existing one (in cases where the existing façade has reached the end of its life cycle or can no longer meet the minimum requirements).

- **Level 2 Horizontal extensions**: incorporating volumetric addition, new rooms or transformation of the existing balconies, loggias, walkways. The transformation in surface increases the real estate value of the apartments involved in the transformation and also the degree of participation of the inhabitants.
- **Level 3 Vertical extensions:** the volumetric addition can involve also the rooftop and generate entire new housing units. The economical payback of the intervention will then be reduced and the roof surface can be used for production of solar energy.

It is clear that the realisation of level 1 is the most frequent and nowadays applied scheme, the most standardised and economical. The extension would anyway represent the future scenarios that could help overcoming the existing barriers.

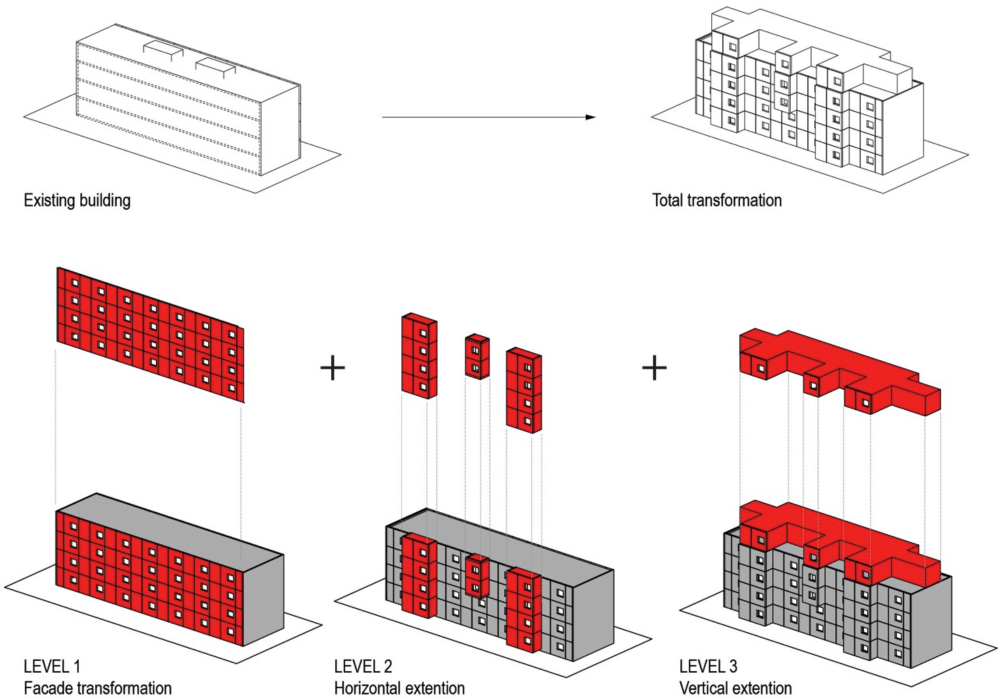


Fig. 3 The scheme represents the three levels of Deep Energy Renovation through prefabricated modules, one technology embodies all the possible transformation. The three levels can be combined and incrementally be implemented one with the other.

Planners and experts, involved in the process should therefore consider a preliminary analysis case by case and suggest an integrated approach that leads towards step 2 and step 3. The following characteristics have to be met in order to be able to proceed from level 1 to level 2 and 3:

- Reserves in distance spaces and heights according to the existing building regulations
- Reserves in permitted urban density of buildings according to development plan
- Existing circulation system adapted for an extension (change of building class, escape routes, accessibility…)
- Simple building geometry (few setbacks or cantilevers, openings of simple geometry)
- Load reserves in supporting structure (up to the foundation) would represent a plus by reducing the cost of additional structure
- Original building with an anyway need for refurbishment
- Ownership favourable for investment and/or inhabitants willing to participate in the initiative

3.1.1 Level 1: Façade renovation

The new façade layer can be placed in addition to the existing façade when the quality has been tested and proved to be still within high standard levels. The second option, in case the existing façade is no longer suitable to the living and energy standards, is to remove (totally or partially) the existing envelope and replace it with the prefabricated façade modules. For load bearing structures, generally, it is favourable to prefer the first option although the wall thickness increases considerably and the light gains are reduced. On the other hand for columns and beams structure or load bearing panels structure, the possibility of removing (totally or partially) the existing façade and replace it with a highly efficient one is the preferable option. The possibility of renewing the envelope is moreover an occasion to include new elements such as shadings or decorative elements to meet the requirements of the inhabitants. The pattern of the façade as well as the coating at the materials used offer a wide range of variation which could enrich the existing building not only from a performance point of view but also at an architectural and urban level. It is also important to consider that in warm climate for example, the role - played in the energy balance – by the colour of the façade is significant as well as the orientation and the shading systems adopted. A new and contemporary strategy for efficient facades can thus be integrated also in this first level of renovation that already allows a good reduction of the consumptions (about 50% for building that consume yearly more than 160 kWh/m^2). The existing building façade layout can present different configurations: it could be a linear continuous façade or present already balconies/loggias.

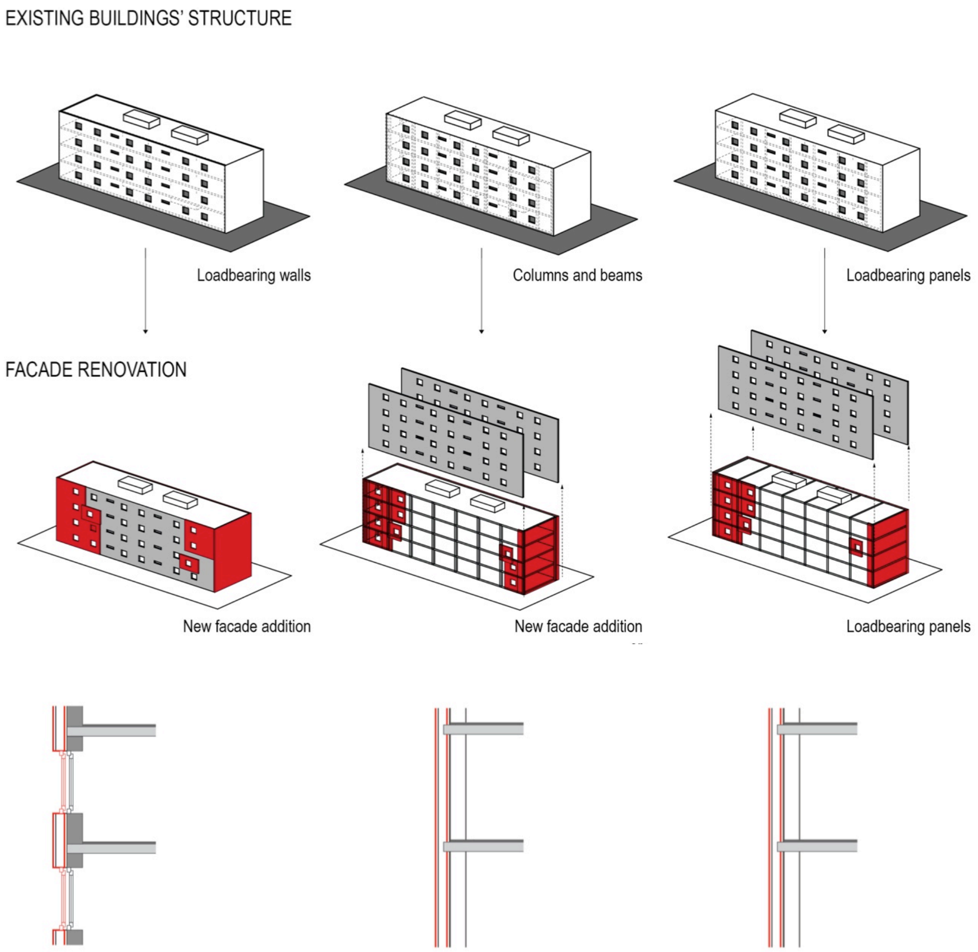


Fig. 4 Façade transformation in case of (from left to right) a load bearing, skeleton or loadbearing panels structure

The projection of the building volume can present interruptions or rather be continuous and linear. Fig. 5 shows the possible transformation that the building could present at level 1. The existing façade can be reproduced identically or can also be altered for example by adding transparent façade component where once there was a balcony or rather enclose the open areas creating extra indoor space and allowing for internal readjustment in case it is requested by the users. The transformations can be multiple and vary according to the planner sensibility and upon the personal/specific requests of the inhabitants.

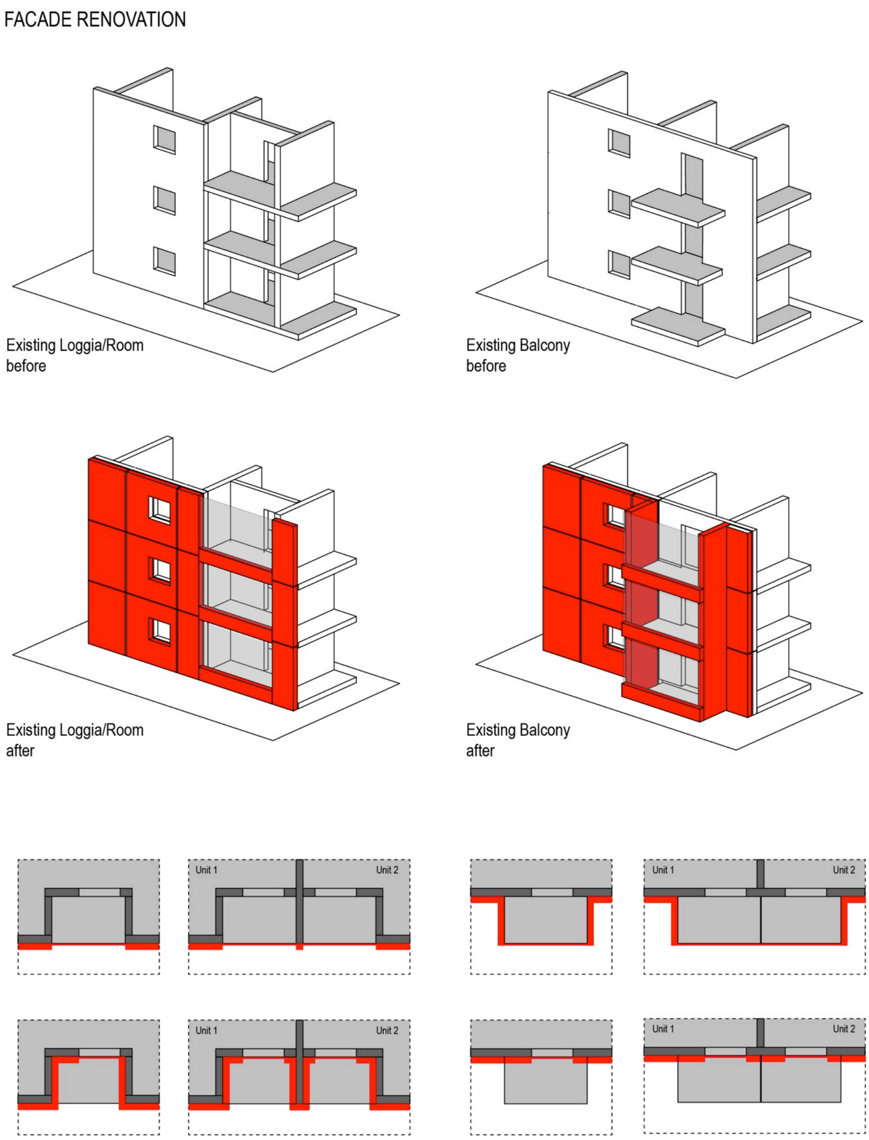


Fig. 5 Façade transformation options according to the different building layouts. Level 1

Often great inspiration for this first level of intervention can be found in the preliminary study of the existing façade since often informal actions have been taken by the inhabitants already to improve the performance of the building (shading systems, plants, extra opaque elements to increase privacy etc.). The base façade module for deep renovation can essentially accommodate all window sizes and various numbers of ventilation duct runs[7]. The sizes of the individual components follow a regular pattern established by the planner at the beginning of the project phase. The module size is normally not longer than 10 meters and not higher than 3,5 meters. Within the module it is possible to open and adapt all sort of windows and doors according to the original façade. In case of existing balcony or loggias it is possible to enclose the area in the new façade and turn it into living space or follow the original contour of the building and leave it as it is. Although the exploded drawing of the module and the above explained methodology might appear complex at first sight, this merely reflects the attempt to collect and tackle many "problems" simultaneously within a single base module. All components shown below can be factory-assembled. The assembly procedures, together with the joint typologies has been studied and would need to be tested using a full-scale working model.

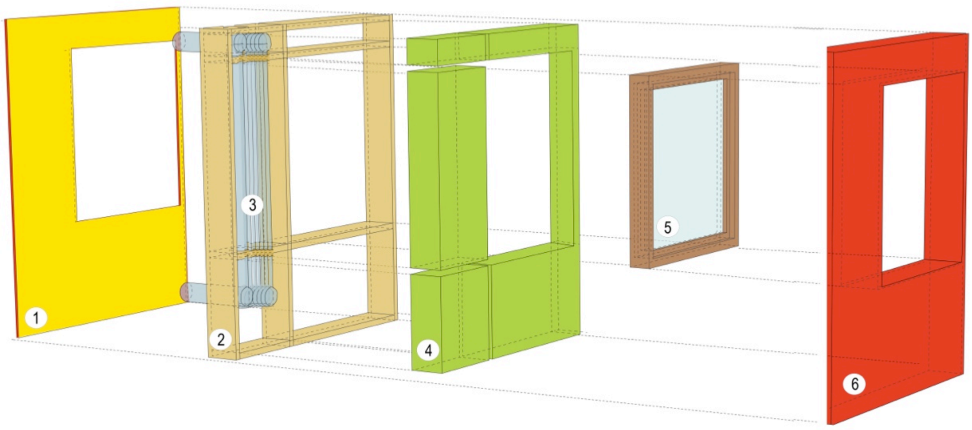


Fig. 6 Explosion of the basic module. Division of the layers: 1. Adaptation layer (optional) 2. Structural layer 3. Plant system incorporated in the façade module 4. Insulation layer, thicknesses to be defined according to the energy evaluation 5. Window frame (optional) 6. Cladding

[7] A survey conducted by the Competence Centre for Typology and Planning in Architecture (CCTP) at Lucerne University of Applied Sciences and Arts [V] showed that the F4.1 base module would be applicable to some 2.3 million openings in 106.000 residential buildings in German-speaking Switzerland.

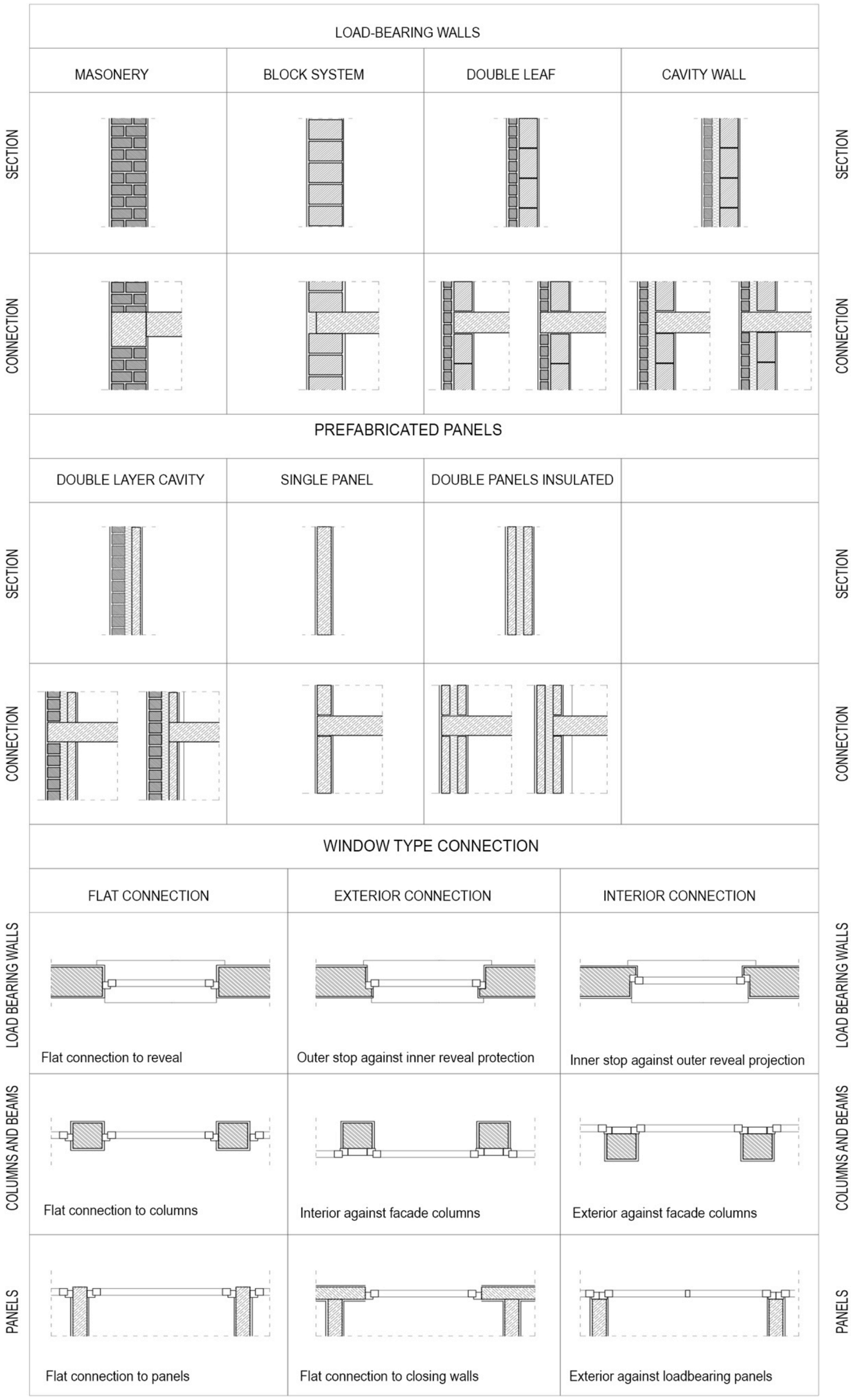


Fig. 7 Sections illustrating the possible wall typology and construction system of the existing building

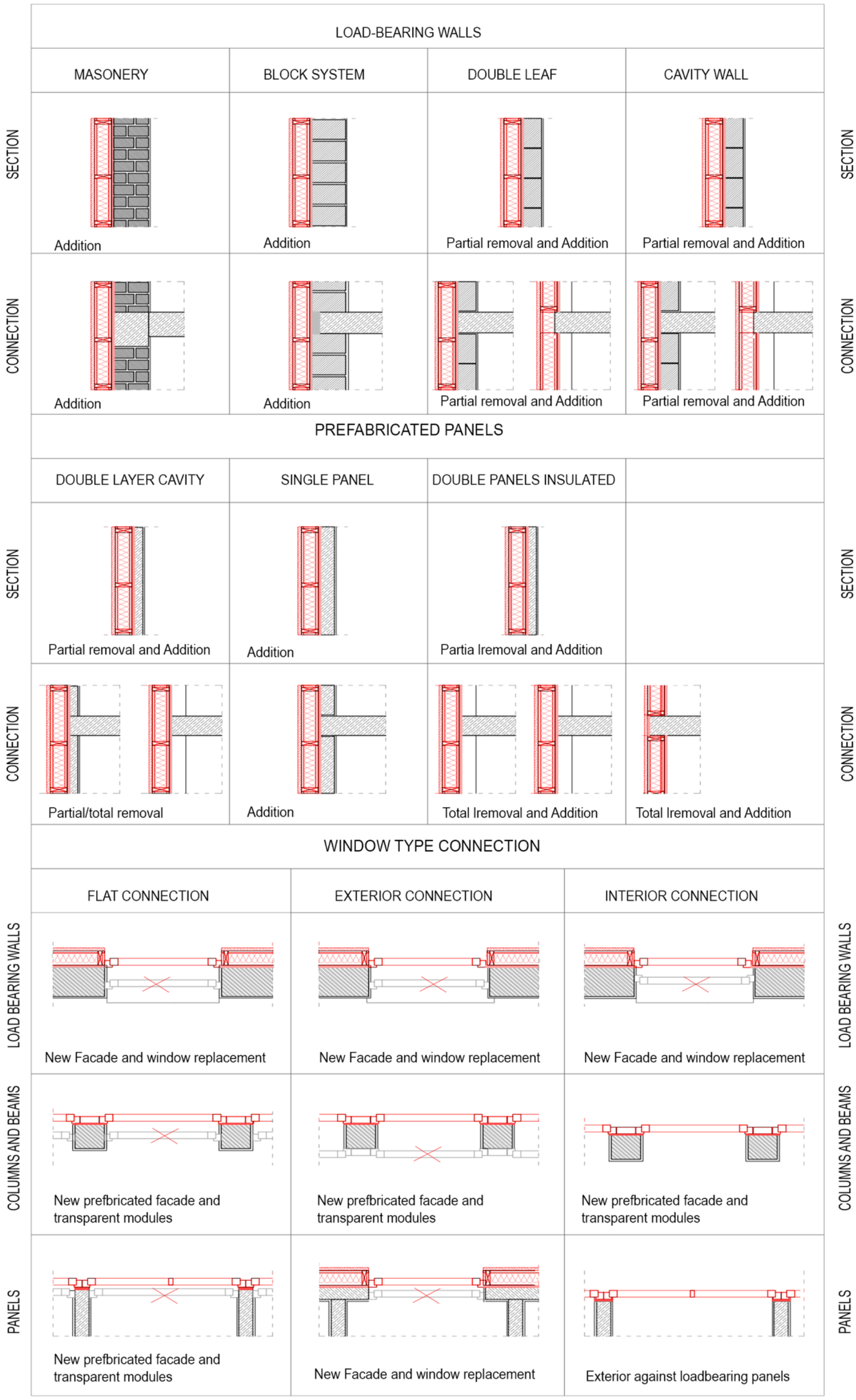


Fig. 8 Sections illustrating the possible variation of the section and layers after the façade transformation of level 1. The red elements are those prefabricated elements that can be added or substituted (totally or partially) to the existing façade.

Fig. 7 and Fig. 8 show the technological detailing of the possible facade transformation considering the different construction typology that can be encountered in the building object of this research. The distinction has been made between load-bearing elements, prefabricated panels and window frames showing how the application of an extra layer panel (or substitution of the existing facade when possible) could affect the different building components. The benefit of the strategy are numerous as already explained, it is thus important to underline as well shown by the above schemes and details, that the thickness of the existing facade is significantly increased by the application of this strategy. It is therefore important to consider the light gains and study solution that could ensure a good radiation of the rooms in the units even thought the facade thicknesses are increased by the application of the extra module facade.

3.1.2 Level 2: Horizontal extension

In case the building is characterised by a low depth, it is possible to consider also to extend the façade by adding extra space, increase the size of the existing balconies/loggias and/or add new rooms to the existing unit according to the needs of the inhabitants. The ratio of opening and the light gain should be enough to allow the intervention in this direction. The height of the rooms as well as the depth of the building play a central role in this evaluation. By performing horizontal extension it is possible to also reconfigure the internal layout and circulation of the building by adding a new elevator for example and proving *ballatouires* to access the unit or a walkway aside the building. The possibilities are various and strictly connected with the original drawing of the façade, some have been shown in Fig. 6 as example of the possible configuration of horizontal extension. The horizontal extensions can result in punctual addition elements or in a uniform offset of the existing façade that creates extra space throughout the entire façade. In case of buildings that do not have balconies, horizontal extension can offer the change of including in the renovation external space to be used by the inhabitants or enlarge the existing balconies and/or loggias. Significant additions, in terms of surfaces, can occur horizontally but on the side of the building not on the front, representing a side extension of the existing construction. In this case it is possible to design an entirely new structure, connected or disconnected with the original one and an independent circulation systems, adding entirely new dwelling units and increasing the number of inhabitants of the area. In this extreme case, the economical benefit and real estate value can result not only in an increase of the rents for the tenant like in the previews cases but can also cover, with the profit from the new dwelling unit, part of the initial investment as already shown in Chapter 3.

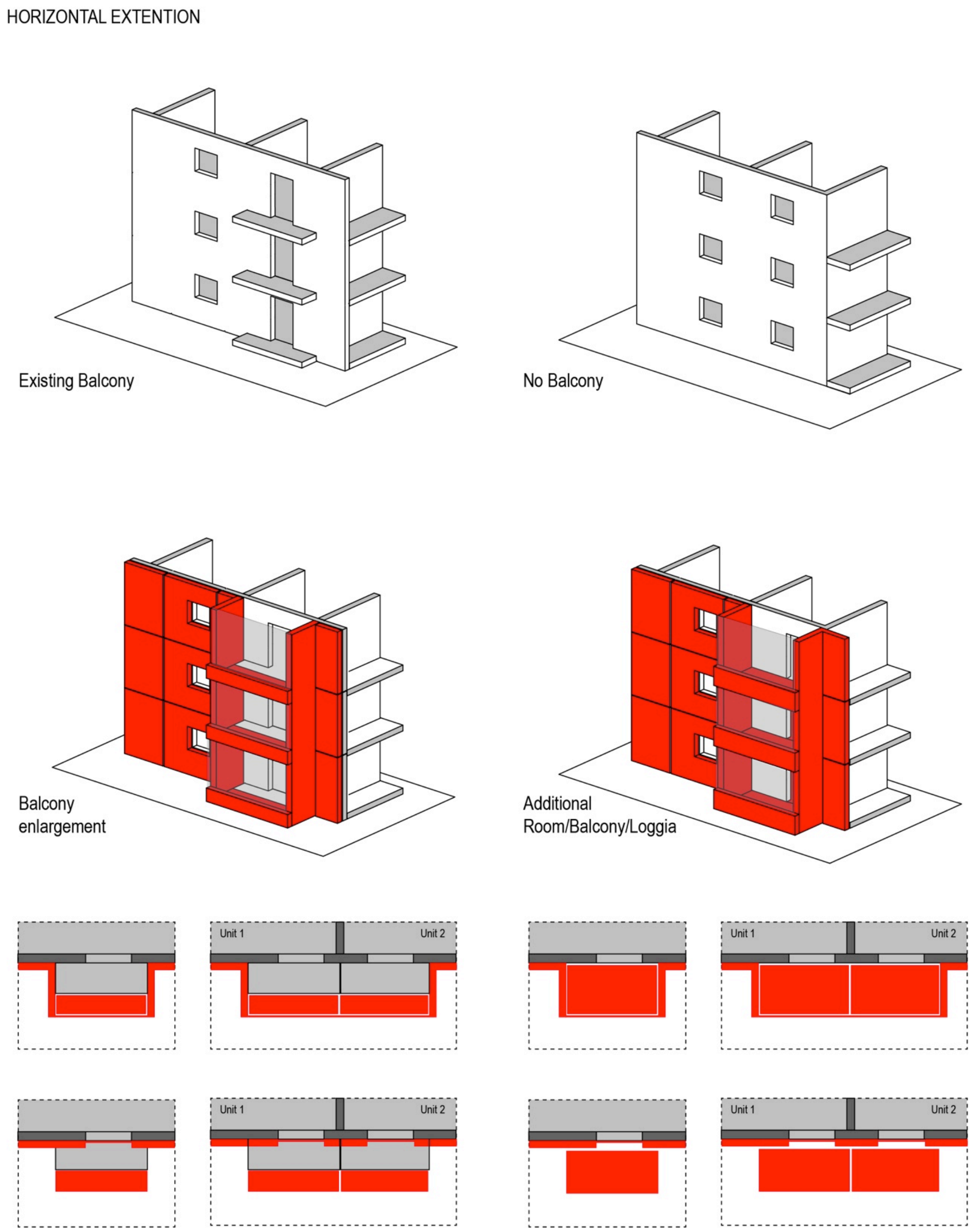


Fig. 9 Layout and horizontal extensions' options according to the different original layout. Level 2.

The structure of the horizontal addition, in both cases whether it is a front or a side horizontal addition, can be entirely independent from the existing one or collaborate with it. The schemes illustrated in Fig.10 show the possible sub-structures of the façade transformation (top left) and in case of front addition extension (level 2). The construction system are generally prefabricated and mostly use wood or steel elements as pillars and beans with simple and modular connection methods. Another overall intervention technique type is represented by the insertion of metal bracings enabling the increase of the resistance of existing structures regarding to horizontal actions, for the increase of rigidity conferred by the metal structure and the consequent reduction in dislocation. The structural and technical potential of this type of intervention considering have been further analysed in the paragraph 3.2.

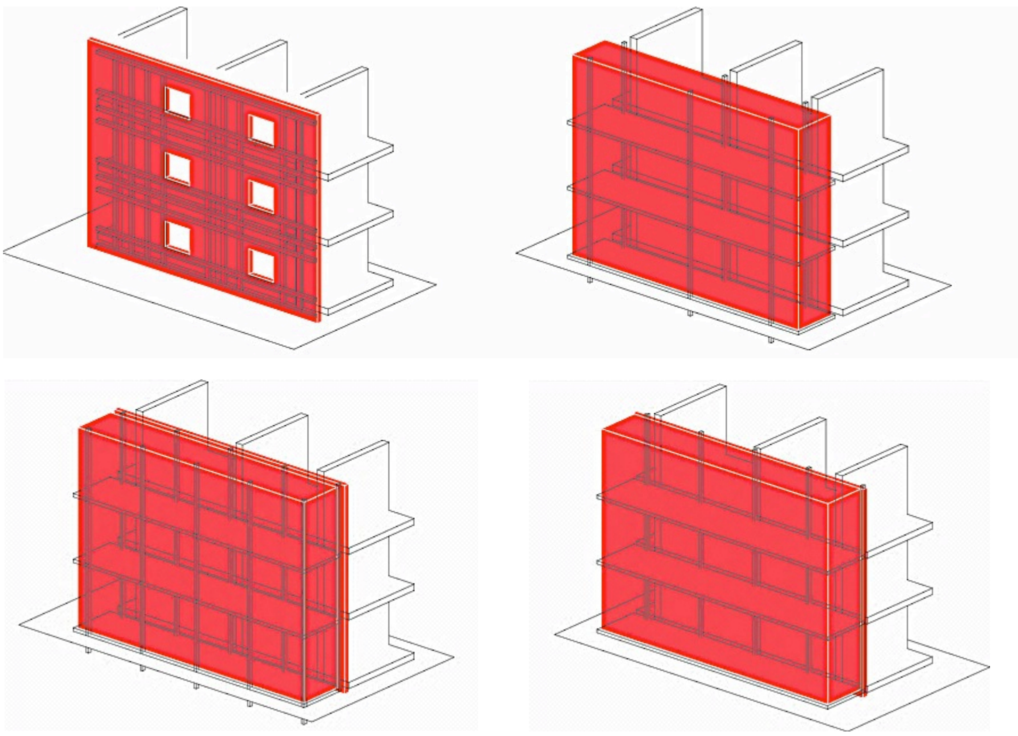


Fig. 10 Possible wood frame or steel structure to support the horizontal extension. Level 2.

3.1.3 Level 3: Vertical extension

One of the most important characteristics of rooftop buildings is that a new dimension is added to a building and district. In most of the rooftop buildings that have been constructed to date, it is usually an architectural contrast that has been achieved. The location and the view can offer compensation, but the main gain should be sought in the architecture, for which new concepts are and have to be devised. For instance, the roof offers all kind of opportunities to experiment with flexible buildings that can be dismantled. The most natural construction systems for rooftop construction (timber frame or steel frame construction) already possess these intrinsic qualities, which make it possible to create genuinely dynamic buildings that expand or contract to meet the demand of the users.[8]

The evaluation regarding the possibility of creating additional living space on the rooftop of the existing building is strictly related to the structural safety of the existing building. In general terms it is possible to elevate the existing building of at least one storey when they are four or five storeys high and with a concrete structure. This is valid for the building codes and regulation in non-seismic areas. In seismic environment the situation is more complex and the extra building on top has to be structurally independent from the pre-existent one or rather to be tested for behaviour under seismic event. Moreover the layout and circulation of the building have to allow the extension; especially in the urban sphere, since the number of inhabitants will increase and the residential density as well, there has to be the possibility to implement the infrastructure, parking number and the services to compensate the increase in number of population. In cases where there is already an attic level (used as storage room or under ceiling space) the transformation into living are becomes easier. Independent of the geometrical and design purpose of the vertical extension, the structure is strictly related to the original structure of the existing building and the evaluation regarding the reserve in static terms of the existing roof. As shown in Fig.11, the structure supporting the vertical extension can run aside the existing or new façade and therefore supply a structural support also for

[8] Vreedenburgh E., E. Melet, Rooftop Architecture, building on an elevated surface, p.11, NAi Publishers, Rotterdam, 2012.

level 2, horizontal extensions. In case the existing building and the local static regulation allow the construction of the vertical extension directly on the existing roof, the new structure will replicate the structure typology of the existing building trying to minimise not coherent extra load on the existing structure. The main possible structures that can be encountered in the existing building stock (load bearing masonry, skeleton structure or load bearing panels) and the possible construction systems that can be exploited to build a vertical extension on the rooftop. As shown, in case of residual structural capacity the addition will insist on the structural elements of the building and discharge the loads directly, in case of no sufficient resistance of the structure or in seismic areas it will be necessary to add an extra support structure that transfers the loads to the ground and to an addition foundation system. In case this third level of intervention is combined with an horizontal extension (level 2) intervention it will be possible to directly build the rooftop addition on the support structure that is carrying the façade or side extension (and is generally configured like a bracing portal that crosses the building thus creates an extra structure also on the roof).

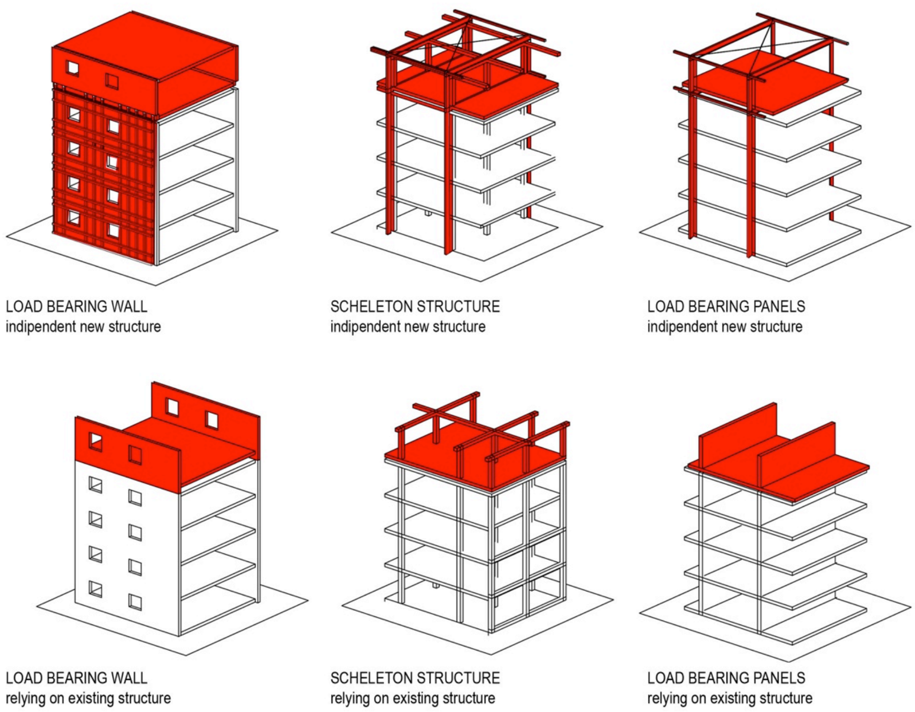


Fig. 11 Possible roof-top extensions and related structural behaviour

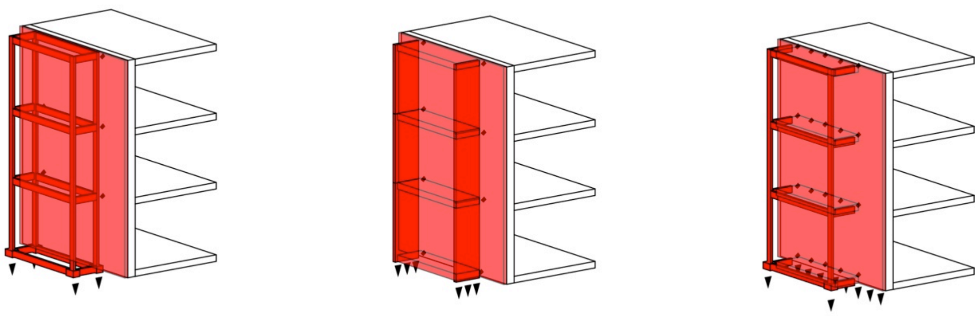
Regarding the plant systems, the existing cavities and canalisations have to be able to reach the top level. The benefit of combining this type of renovation with the previously mentioned ones has effect on the economical level but also on the energetic one. The most disadvantaged and dispersive units are generally those located on the top level, on the ground floor or on the side. By creating an extra floor the top units' energy losses are automatically reduced and the roof surface can be used to integrate solar panels. The analysis of the best practice and the most applied design strategy for the rooftop extension there has shown that the geometrical relationship between the new volume on the roof and the existing building can be: a. In line with the existing façade, b. Set back offering a space for terrace or walkway and reducing the impact of the new element from the street high, c. Overhanging, emphasising the role of addition and extra volume of the new element.

From an economical point of view, rooftop extensions offer a great potential for investment by creating extra surface in consistent amount. The payback given by the real estate added value is generally almost enough to reduce to half the normal payback of deep-renovation. Moreover intervention on the top of the building can include directly the installation of photovoltaic panel for the production of solar energy, increasing further the effectiveness of the intervention.

3.2 Overcoming the technical barriers: structural and safety evaluation

This chapter is under development. The seismic simulation will be carried to demonstrate the potential positive impact of the add-ons to the existing structures thanks to an improvement of the safety performances of the building. The new prefabricated invariant structure could guarantee an extra resistance of the existing structure to horizontal stresses, typical of the seismic events. The following schemes represent the possible load transfer mechanisms that have been considered possible when creating an adjacent structure to the existing building as support for the Add-ons.

INDIPENDENT STRUCTURE



COOPERATIVE STRUCTURE

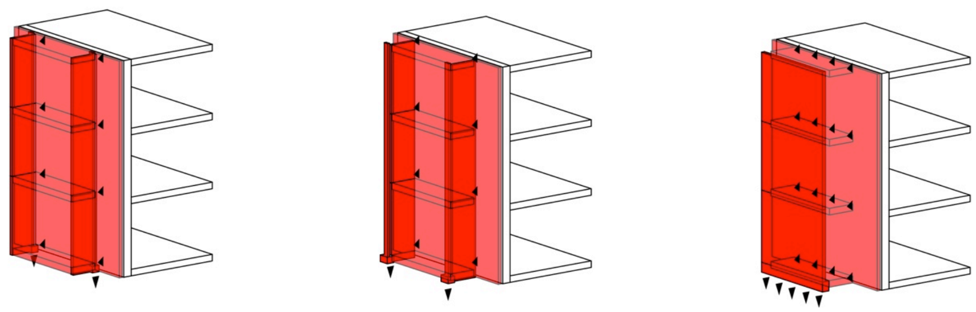


Fig. 12 Load transfer of the horizontal extension, level 2. The structure supporting the horizontal extension can also support the vertical extension when specifically dimensioned. The schemes presented are therefore the core representation of the structural problem.

The traditional system of braced metal inserted to the structural frame, could have similar operative difficulties for the installation compared to internal baffles of reinforced concrete for occupation of interior space. The structural system for horizontal extensions introduces a metal structure with efficient stiffness, however, applied externally to the existing structure, with benefits in regarding the construction site, since it does not require the performance of special operations inside the buildings. The installation is less complicated than that of the walls in reinforced concrete and the need of foundation is significantly lower, with a significant reduction in terms of cost of the base/profound structure.

For the advantages of increased rigidity and the consequent reduction of displacement, the system increases the number of vertical elements on which are distributed the horizontal forces due to seismic action, with consequent reduction of the shear stresses on the individual pillars of the existing structure of reinforced concrete.

The element of great importance for the system is the bond that can link the existing structure in reinforced concrete and the new metal structure. In order not to burden the existing structure with vertical loads due to the new metal structure, but rather to create an effective collaboration to horizontal actions, this is configured as a vertically sliding joint, double constraint that allows only vertical movement, leaving the structures autonomous for static loads.

On the seismic and structural side, simulations modelling using FEM software (EN 1998), performed for different residential buildings, have shown an overall reduction of horizontal displacements and stresses of the retrofitted structures with a percentage up to the 50%.

Fig. 13 sums up all the possible structural loads and systems for each of the component involved in the renovation, in case of façade renovation (level 1), for horizontal extensions (level 2) and for vertical extension (level 3) combined or not with the horizontal extension also. In the end some of the possible foundation schemes are also presented since the new structural system will have to be equipped with proper foundation ensuring no interference between these and the pre-existence.

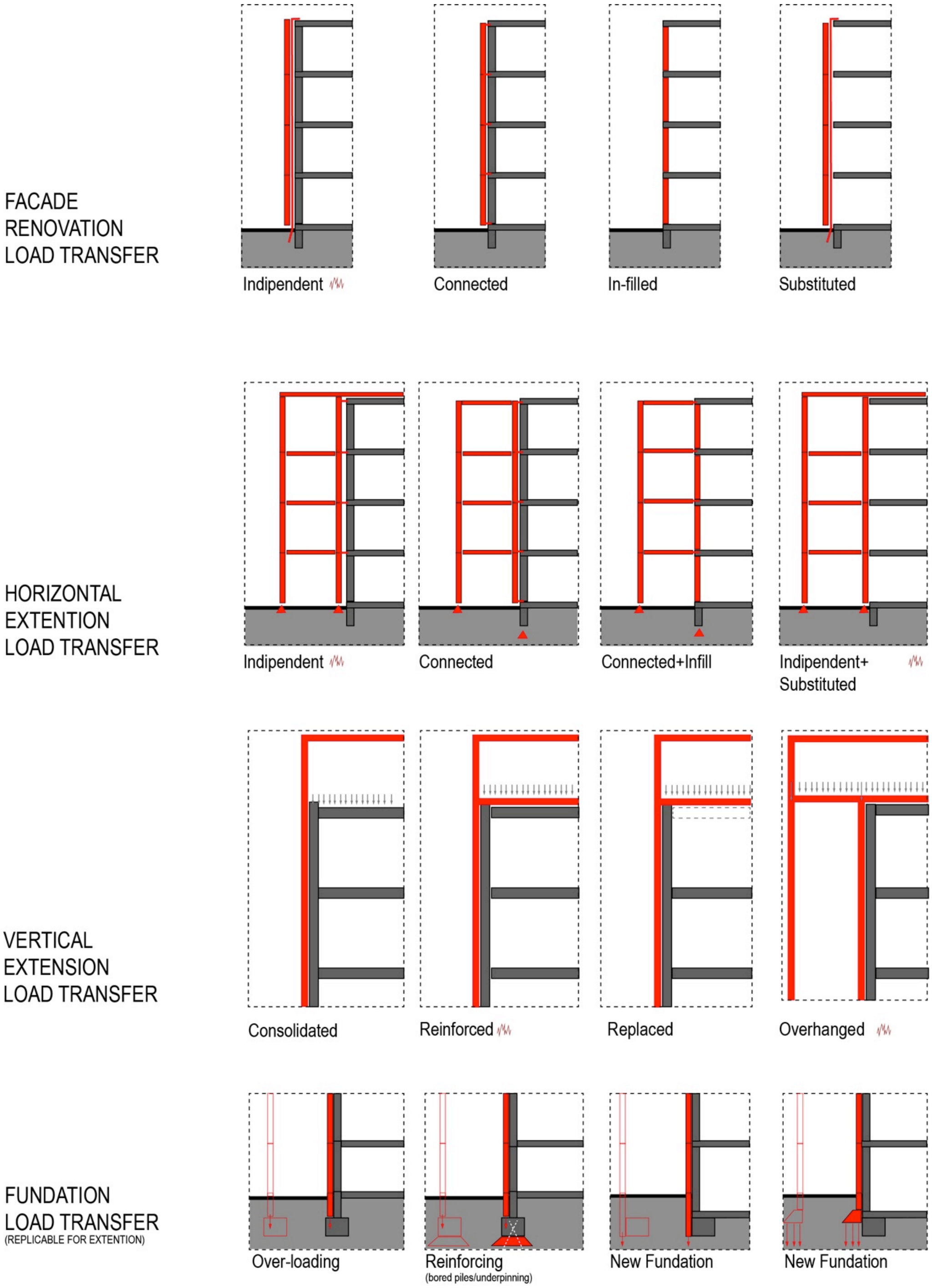


Fig. 13 Load transfer schematic sections for the three intervention Levels and possible schemes for the fundation (reinforcing existing and/or addition of new one)

In the perspective of a maximum compatibility and a minimum invasiveness, the strategy to be adopted follows primarily the execution of an overall intervention that increases the resistance of the building as a whole and only secondarily to operate locally on remaining vulnerabilities, minimizing or/and avoiding interventions that are not cost-effective and very invasive when applied extensively . External metal bracings are a valid solution to add to the resistance of existing structures to horizontal actions by increasing the rigidity and the consequent reduction in displacements[9]. The new structure (b) – in this example metallic pillars and beams, steel stiffeners and XLAM plates-, when connected to the nodes of the existing building resulted in a reduction of displacements and stresses on existing structures (a) between 35 and 50%. By using this model the project will exploit existing solutions, some of them currently applied in the building sector other than residential, i.e. seismic strengthening in industrial buildings[10]. The traditional system of braced metal inserted to the structural frame, could have similar operative difficulties for the installation compared to internal baffles of reinforced concrete for occupation of interior space. The presented system introduces a metal structure with efficient stiffness, however, applied externally to the existing structure, with benefits in regarding the construction site, since it does not require the performance of special operations inside the buildings.

Fig. 14 Possible steel seismic improvement structure; Fig. 15 Possible wood seismic improvement structure

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[9] In accordance with the European standard EN 1998-3 Eurocode 8: Design of structures for earthquake resistance - Part 3: Assessment and retrofitting of buildings, the proposed intervention falls in those defined in section 5.1.3: Type of intervention, namely at point d) Addition of a new structural system to sustain some or all of the entire seismic action.

The installation is less complicated than that of the walls in reinforced concrete and the need of foundation is significantly lower, with a substantial reduction in terms of cost of the base structure. The element of great importance for the system is the bond that can link the existing structure in reinforced concrete and the new metal structure. In order not to burden the existing structure with vertical loads due to the new metal structure, but rather to create an effective collaboration to horizontal actions, this is configured as a vertically sliding joint, a double constraint that allows only vertical movement, leaving the structures autonomous for static loads.

The research is based upon the integration of existing solutions, some of them currently applied in the building sector other than residential, i.e. seismic strengthening in industrial buildings, by exploring the potential of shifting them within a renewed approach towards the highest efficient use in terms of safety, energy saving, users' requirements. The resulting implementation addresses the development of an effective system to be applied in residential buildings, within the specific cluster of apartment buildings in seismic vulnerable areas. Thus, rather than on the innovation into products, the innovative aspect relies on the approach: the user and the building at the centre of the energy retrofit, in order to successfully implement energy strategies and solutions for deep renovation.

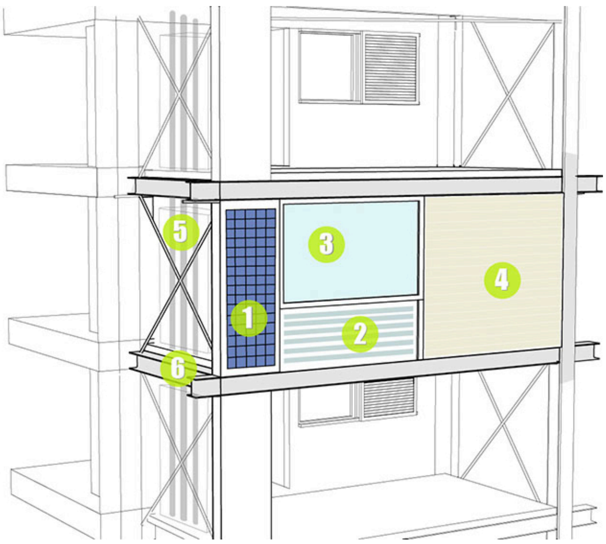

Fig. 16 Integration of existing solutions and technologies: 1 OV façade panels, 2. Solar collectors, 3. High performance windows, 4. Prefabricated façade modules, 5. Plug and play plants, 6. Steel or wooden structure to improve the seismic performance of the existing building

Concerning technical plants, the system can be provided by new network lines (thermal fluids, electricity, etc.), as well as the predisposition for future systems (i.e. water drainage pipes, telecommunication lines) integrated in the external structure for a “plug-and-play” connection with internal devices. External allocation of all main plant system (EHP, PV system, hydronic pipes, allows simple maintenance and substitution in plant retrofitting. These Plug & Play connectors make it possible to reduce the renovation time. Smart combinations of components and executions ensure extra performances for nZEB concepts, healthy indoor climate, safety and accessibility. The various components communicate by integrated (wireless) sensors and control components for performance diagnostics and control.

Depending on the existing plant systems (centralised or independent) and internal room configuration, two different system’s configurations are possible:

a) Central heating/cooling hydronic system (integrated PV/EHP or GHP) at the basement (or rooftop) of the building [4] in Fig. 17; external insulated distribution system a junction box for ready connection with internal distribution pipes, equipped with manifold and metering system (the manifold allows simple pipe connection with existing radiators, or radiating floor systems) [1];
b) Independent integrated HVAC system based of an integrated PV-EHP for each apartments, located on the external structure [6].

As a whole, the proposed structures can be equipped with several installation plants[11]. The proposal includes a deep transformation of the existing building’s shell with external strengthening structures, which generate energy efficient buffer zones (by reducing radiation in summer, providing solar heating in winter, and hosting flexible/adaptable plug-and-play installations), and increase the flat volume (with balconies, loggias, sunspaces and extra rooms, according to users’ needs or expectations).

[11] The structure may also respond to need to equip with suitable connections to the telecoms infrastructure, such as to ensure easy access to superfast broadband services, as required by new EU directives for new and renovated buildings (ref: Directive 2014/61/EU of the European Parliament and the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks.

Fig. 17 Installments schematic section. The façade includes plug and play solutions that allow the renewal of the plant system in an efficient and cost-effective manner. In the scheme: 1. Plug and play new installments solutions, 2. Horizontal volumetric addition with extra sesimic improvement structure, 3. Extra roof top option, 4. New heat pump and plant systems, 5. Existing building volume, 6.independent integrated HVAC system

These solutions have been designed and analysed in a large set of existing buildings[12] (Fig. 18- section a typical apartment building – calibrated on the Peristeri case study). Finally, the increased value of the buildings and the users, which can benefit from the extended space, is quite clear. The resulting building may provide:

- Comfort of users (combined with a proper ventilation system);
- Increased attractiveness even from social sectors which are usually more reluctant to change like elderly inhabitants, providing them with balconies and loggias for small

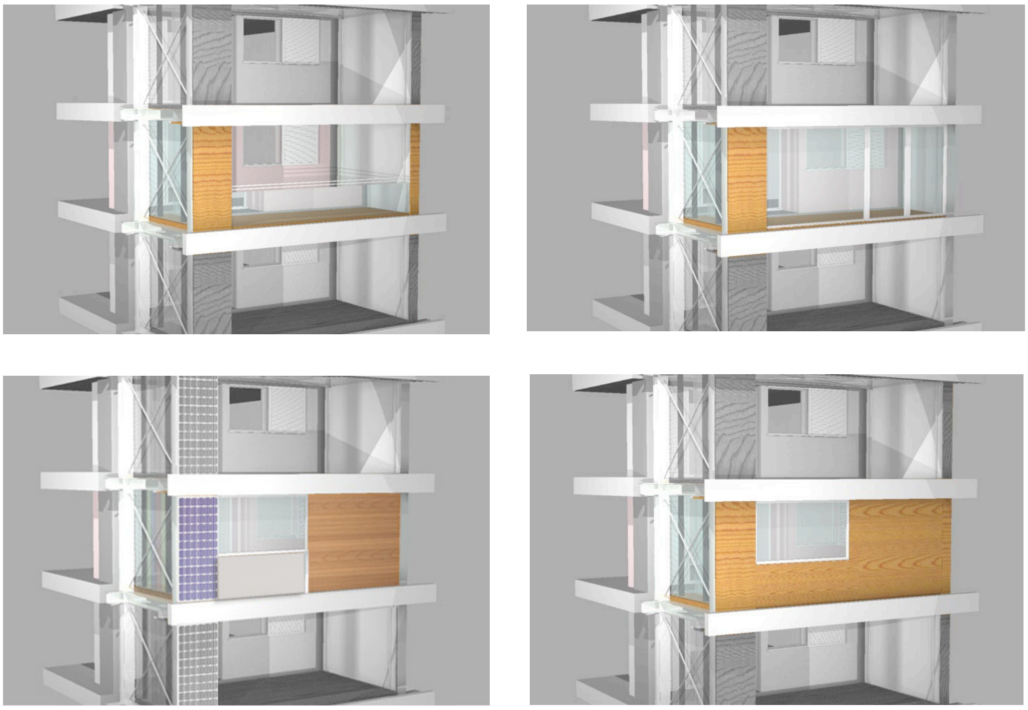

Fig. 18 Possible enclosures according to the different request of the inhabitants : 1. Extra balcony, 2. Winter garden/serra, 3. Room enlargement with PV panel, 4. Rome enclosure

[12] Ferrante A., Towards Nearly Zero Energy. Urban Settings in the Mediterranean Climate. Elsevier, 2016

3.3 Overcoming the legislative barriers

The critical aspects connected to the research presented are case-based aspects mainly. The planners and designers shall consider the specificity of each building context and evaluate the potential applicability of the strategy and the right degree of transformability possible. The results are, as for general architectural intervention, strictly related to the sensibility and aim of the planners and architects involved in the process. However the methodology presented lies upon highly standardised principle and ensures the possible replicability of the technology in a vast number of case study. In general terms the main critical aspect still impeding the implementation of the volumetric addition strategy as systematic tool to increase the potential of investment towards energy renovation lies in the legal and normative framework. Throughout Europe it is indeed still missing a common price regulation on the subject, and still the different Member States and regulations apply in these cases different measures and attitudes.

In this context, it is necessary to have a complete framework of legislative aspects and regulations relating to deep-renovation at the target regions and Europe level. On the basis of the critical analysis of this legislative collection, it will be possible to suggest recommendations to public authorities about the improvement of the coordination of professionals in the energy renovation of social housing At EU level, the energy efficiency and the deep renovation of the building sector is mainly regulated by two Directives.

The Energy Performance of Buildings Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (EPBD Recast) has significantly affected the redevelopment of legislative aspects for all EU countries. In particular, Article 2 of the EPBD Recast defines nearly Zero-Energy Building as “a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby”. Article 9 of the EPBD provides that all new buildings in the EU should from the latest 2021 be built as nearly zero energy buildings, with the exemption of public buildings, in relation to which the deadline is 2019. Furthermore, said article sets out that Member States shall “draw up national plans for increasing the number of nearly zero-energy buildings” and “following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings" . All buildings being rented, leased or sold are required to have an energy performance certificate (EPC) that contains information on its energy performance and recommendations for improvements (with indicative costs). A review of the recast EPBD is underway and that was a public consultation that is ran until the 30th October 2015. Implementation in the Member States is not as good as it should be with some Member States in Court for the EPBD and proceedings against many for the EED.

The other important Directive is the Energy Efficiency Directive 2012/27/EU of 25 October 2012 on energy efficiency (EED), amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. Said EED sets out a common framework of measures to "remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy". In this perspective, the EED requires Member States to develop long-term renovation strategies for their national building stocks. In particular, Article 18 of this EED lays down specific activities to be carried out by Member States, among which the promotion of the energy services market and the support of its proper functioning are required .

According to Article 1 of the mentioned EED, "the requirements laid down in this Directive are minimum requirements and shall not prevent any Member State from maintaining or introducing more stringent measures" tailored to the different target Regions' profiles.

3.3.1 The Italian framework

With particular reference to Italian legal framework, starting from the end of the 1970 Italy has introduced laws aimed at regulating the carrying out of deep renovation interventions on the existing building stock, mainly involving plants installations and energetic implications , as well as anti-seismic aspects (also focusing on the additions on top) . Recently Italy has approved Law Decree 28 March 2014, no. 47 as converted in Law 23 May 2014, no. 80, the "Piano Casa"

("House Plan")[13] which, inter alia, sets out measures for the enhancement of the offer to population of social housing buildings. In order to reach this objective, the House Plan finances the deep renovation interventions of existent buildings aimed to improve their performance from building services and energy efficiency perspectives. The Plan was born initially as instrument to accept and regulate all those irregular building extensions and transformation that especially in the big cities have often lead to disruption of consolidated structure or landscape. Indeed in the current version and considering the possible implication/application of the Plan to the residential buildings' patrimony, it is possible to read a great potential when considered the benefit of the volumetric additions as studied in this work. In particular related to this matter the article 4 of the House Plan has relevance. Art. 10 dedicated to social housing buildings. At comma 1 of the same article it is stated that *"the purpose of the measure is to reduce the law quality of housing for low income families and inhabitants who are benefitting of a reduced rental scheme by the social housing public institutions. The aim shall be reached without consuming extra land, in respect of the existing urban regulations and favouring energy saving, energy renovations; supporting urban integrated policies to regenerate areas and compartments that are dedicated to social housing."* By stating this it is clear that the central governmental objective is to renovate and improve the social housing conditions by also integrating energy efficiency and integrated urban policies. The connection with the proposed work and the possibilities offered by the volumetric addition strategy is evident and significant. More in detail, regarding the amount of extra surface that can be built in addition to the existing one, the House Plan defines the type of intervention that are included in the law prescriptions and the maximum percentage of extension in comma 5 of the same article: *" the allowed interventions are : a. building restoration, renovation and retrofitting, extraordinary maintenance, local empowerment, seismic improvement and upgrading; b. construction substitution also through entire building demolition and its reconstruction maintaining the same building shape and volume; c. variation in building usage; d. creation of services and functions connected and complementary to the residential and commercial function - excluding the big selling structures – necessary to guarantee social integration of the inhabitants in social housing buildings, in the measure of an*

[13] Annex 2 includes a full text of the House Plan law

extension of maximum 20 % of the overall surface allowed; e. creation of housing quotes that can be destined to the creation of temporary allocation of inhabitants coming from social housing buildings that are under maintenance or for some reasons not usable." Within 90 days from the approval of the Housing Plan each region had to define the specific regulation on the matter, the maximum and minimum values and the coherences of the norm with the existing urban plan instruments. Interventions can also be realized as exceptions of the House Plan as also stated in the law text, as far as it has been prove their respect of the urban, landscape, health, sanitation and heritage prescriptions. There is however a tight prohibition to apply the norm in case of buildings that have been built without a permit and in the historical city centres where heritage protections, where it is prohibited entirely to build. The percentage of 20 percent, in case of condominium buildings could represent a significant quota of extra surface that could be added to the existing since it is considered calculated as incremental bonus per each housing unit and can be additional. In this last version of the law it is not mentioned an absolute maximum amount of the law above which it can not be possible to extend the surface, the volumetric addition is considered only calculated in relation to the existing building surface. The application of the plan to single housing building and to big residential complexes is therefore significant and can involve a total different perspective in economical, financial and architectural implications. The function destination of the extra surface is still confined to the 'services and functions that are complementary to residential. It would be interesting to experiment the possible results of a specific request for additional residential units and evaluate what each region has determined in this aspect. The possibility of extending the function of the 20 percent bonus surface also to the residential function indeed would introduce the possibility of creating a societal mix that would significantly improve the living condition of the low income social housing inhabitants. By integrating new housing units, with high building standards and the possibility of selling 'as new' would call for new inhabitants in the neighborhood with higher income, especially considering those original compounds from the 60s and 70s that often are placed in the first periphery of the cities (see the case study in Reggio Emilia or Frankfurt. The real estate value of volumetric addition in those areas of the cities is higher than average rating)

At last, comma 7 opens up to the possibility of applying the principle of urban equalization (in Italian *perequazione urbanistica*) to this edification additional right by stating: "*each region within 90 days from the approval of the Housing Plan shall determine the overall surfaces that can be* *ceded, in total or in part, to other operators or authorities, meaning that can be transferred to other public or private areas, for the same intervention objective, excluding those areas that are destined to agriculture or where construction is prohibited by the current urban planning instruments."* This specific possibility opens up to envisioning also an incremental addition of surface going beyond the above-cited 20 percent. Those compounds where it is not possible to intervene with an addition or transformation could transfer their bonus to those where indeed the urban, service and architectural layout favour and offer the possibility of a deep transformation (as shown in the presented case studies). Since it has not been fixed a maximal limit of the extension, the projects shall be evaluated case by case by the different regional al local authorities. The Housing Plan, especially in this last version, offers a fertile terrain to open up the discussion and negotiation table. It is an important and relevant starting point to define a regulation that includes the volumetric addition as tool to foster energy renovations in European cities and – for some aspects – an innovative legislative tool in the European scenario where very little laws deal and regulate social housing and renovation in general.

As for the incentive and public subsidies, the Law nn. 296 (2007) several times renewed up until the Legge di Stabilità of 2016, aims at stimulating financially energy renovation intervention. Up until the 31.12.2016 it will be possible to claim fiscal benefits (on Irpef and Ires taxes) for interventions on the single dwelling unit as well as on the common areas of condominiums. The bonus is calculated as the 65% of the entire investment for the eligible costs (for a maximum of 100.000 euros per year) Among the possible interventions included in the plan there are the construction works necessary to improve the energy performances of the building, window replacement but also shading systems, remote control devices for the plants, new plants installations that use Renewable energy sources. This incentive shall be divided in equal rates during a period of ten years from the renovation intervention. To receive the incentive it is requested to present the APE, Attestato di Prestazione Energetica, that proves the energy consumptions reduction according to the technical requirements for each intervention.

The subsidies are supposed to be available until the end of 2016 and the percentage will be decreased to 36% from 2017. The energy bonus can be requested by private owners but also from housing associations or institutions that own the building in object.

In case of volumetric addition the incentive shall be calculated solely upon the expenses that cover the renovation of the existing building, excluding the construction costs for the Add-on.-

3.3.2 The Greek framework

Numerous laws have introduced taxes incentives with the aim to promote energy efficient technologies and interventions. The Hellenic Ministry of Environment, Energy and Climate Change issued a program Exoikonomia, 'Saving Energy at Home', for subsidizing energy efficiency investments in the residential sector.[14] The programme aims at providing financial incentives for energy-saving interventions in the residential building sector with a view to reducing energy needs. The types of housing that can be subsidized by the programme are: Single-family houses, apartment blocks - for the part of the block, which relates to all the apartments in the building and individual apartments.

"*The Program provides incentives for citizens to make the most important interventions in order to improve the energy efficiency of their home. Specifically, the program provides homeowners with capital subsidy and low interest loans combined with an interest rate subsidy and covers the cost of energy inspections. The eligible categories of interventions for improving energy efficiency are: Replacing window frames and installing shading systems; - Installing thermal insulation in the building envelope, including the flat roof/roof and 'pilotis'; - Upgrading the heating and hot water system. The implementation period of the measure will be from 2011 to 2015 and the total new energy savings in the period 2014-2020 are estimated to be 82.4 kgto$_e$.*[15]

The Program concerns interventions in buildings and provides for the issuing of an Energy Performance Certificate (EPC). The methodology used for calculating energy savings is based on analysing and evaluating the EPC data issued in connection with the Program. Specifically,

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[14] Annex 2, web source http://www.exoikonomisi.ypeka.gr/Default.aspx?tabid=629&locale=en-US&language=el-GR
[15] Ibid.

after processing the results of the EPCs from buildings on which all the program's interventions have been fully implemented, it appears that the average primary energy consumption is 420.5 kWh/m^2, the average energy savings achieved by the Program is approximately 39% and, consequently, the average primary energy savings are 161.4 kWh/m^2. Moreover, the average surface area of the buildings in the program is 106.5 m^2.

The most significant article related to the Add-ons strategy taken from the program is the **Art. 10**[16] Extra environmental motivations with increase of the construction percentage. In the case the plot is min 4.000 m^2 and the non built part is for public use (100%) it is possible to increase the actual percentage for construction by 35% and increase an extra 30% of the maximum height allowed in the region (these new legislation is for projects that aim to set to zero energy the existing buildings).

"The Law 4178/2013 'Tackling illegal building - Environmental Balance and other provisions' (Government Gazette, Series I, No 174, 08-08-2013) provides that a joint decision of the Ministers for Finance and for Environment, Energy and Climate Change may allow the amounts paid for services rendered, work and materials on the energy upgrade and the structural adequacy of buildings erected before 2003 to be offset against the special fine, up to 50% of the fine. Moreover, Article 51 provides that for legally existing uses of buildings or facilities which are retained, and also for uses covered by building permits issued under Article 26 of Law 2831/2000, it is permitted, within a period of three years, to carry out energy upgrading works and works on the layout of building with the purpose of improving the environment, on the basis of the building regulations which were applicable at the time the derogation was granted.

The Laws 4110/2013 (Government Gazette, Series I, No 17, 23-01-2013) and 4172/2013 (Government Gazette, Series I, No 167, 23-07-2013) repealed the exemptions for expenses for energy efficiency improvement interventions, as implemented under Law 3522/2006

[16] Annex 2, web source http://www.dsanet.gr/Epikairothta/Nomothesia/n4067_2012.htm

(Government Gazette, Series I, No 276, 22-12-2006) and Law 3842/2010 (Government Gazette, Series I, No 58, 23-04-2010)."[17]

However, the new legislation is expected to introduce a reduction in income tax at a specific percentage of the costs for energy upgrading interventions (install a natural gas system, thermal insulation, solar systems etc), of buildings. As for the incentive and subsidies provided by the program, the proposal (combination of interventions) for energy upgrade as to be eligible shall cover the following requirement which is the minimum energy objective of the Programme: it must upgrade by at least one energy class or, alternatively, provide an annual primary energy savings greater than 30% of the reference building consumption (kWh/m2). To make sure that this requirement is met, the materials and systems to be used for the interventions must be energy certified. Moreover, building materials and electromechanical systems which are subject to a relevant requirement under applicable law, should bear the CE mark. The eligible categories of interventions for improving energy efficiency are:

- Replacing window frames / glass panes and installing shading systems
- Installing thermal insulation in the building envelope, including the roof and open parking space in place of the ground floor
- Upgrading the heating and domestic hot water system

The income categories of beneficiaries are as follows:

Category A1: Beneficiaries whose individual or family declared income does not exceed EUR 12,000 or EUR 20,000 respectively. The incentives offered in this category include a loan of 30% with 100% interest subsidy and a grant of 70% of the final eligible budget, as established after the second energy inspection.

[17] "Energy Efficiency trends and policies in Greece"(Minas Iatridis, Centre for Renewable Energy Sources and Saving (CRES), Greece ,Fotini Karamani, Centre for Renewable Energy Sources and Saving (CRES), Greece, 2015)

Category A2: Beneficiaries whose individual declared income is greater than EUR 12,000 and no more than EUR 40,000or whose family income is greater than EUR 20,000 and no more than EUR 60,000. The incentives offered in this category include a loan of 65% with 100% interest subsidy and a grant of 35% of the final eligible budget,

Category B: Beneficiaries whose individual declared income is greater than EUR 40,000 and no more than EUR 60,000or whose family income is greater than EUR 60,000 and no more than EUR 80,000. The incentives offered in this category include a loan of 85% with 100% interest subsidy and a grant of 15% of the final eligible budget, as established after the second energy inspection.as established after the second energy inspection.[18]

As for the cost-benefit simulations that will be carried in Chapter 5 for the Greek case study, Category B will be considered since the hypothesis is that an external contractor such as an ESCO would invest in the Deep renovation and benefit from its profit for a limited time frame.

3.3.3 The German framework

Building regulations in Germany are defined in part on a nationwide level, but most of them at the level of the federal states: the Federal Building Code (Baugesetzbuch) regulates the legal competences of urban planning at the national level. In general terms, the German Federal Ministry of the Environment BMU, has set the energy target of the German energy policy as follows[19]:

- Climate-damaging greenhouse gas emissions are to be reduced by 40% by 2020, 55% by 2030, 70% by 2040 and by 80 to 95% by 2050, compared to reference year 1990.

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[18] CRES, Center for Renewable energy sources and savings, Energy Efficiency Trends and Policies in Greece, Athens, 2015
[19] German Federal Ministry of the Environment BMU.

- Primary energy consumption is to fall by 20% by 2020 and by 50% by 2050.
- Energy productivity is to rise by 2.1% per year compared to final energy consumption.
- Electricity consumption is to fall by 10% by 2020 and by 25% by 2050, compared to 2008.
- Compared to 2008, heat demand in buildings is to be reduced by 20% by 2020, while primary energy demand is to fall by 80% by 2050.

At the level of federal states, the state building codes rule the building law of each region and therefore the requirements for the buildings (building materials, components, requirements for the plot, etc.). Considering the strictly binding policy above described, it is probable that the local and regional authorities will undertake a revision of the existing regulation and apply a favourable attitude towards all the possible intervention that would increase energy savings and improve the energy performances of the building sector. In case of possible volumetric addition or transformation on existing building[20] if the plot taken into consideration for intervention is included in a binding scope according to the current land-use plan, then regulations of the plan must be met. Derogations and exemptions from the land-use plan are possible in a certain scale, but they have to be applied for directly to the competent authority and must be approved case by case. The existing land-use plan can be subject to changes by the authorities at any time if there is the wish to speed up and promote urban densification in a certain area. Especially the main cities in Germany (Berlin, Hamburg, Koeln, Frankfurt, Stuttgart, Muenich) are not regulated by binding land-use plans. Therefore the volumes and characteristics of the neighbouring developments define the standard and viability of an extension, which leaves room for interpretation by the authorities.

According to § 34 section 1 of the German BauGB it is possible to realize a construction only if the building fits into the surrounding area related to the following parameters: purpose and intensity of use, construction form and the plot area to be built on. However, section 3 - that has been reintroduced into the BauGB in 2004 to follow EU regulations - applies in case of an

[20] In this case for explicative reasons, the legislation from the Bayern region has been considered

extension, alteration or renovation of an existing residential building, extension being defined by the law as supplement to the existing building in order to intensify its use by means of structural measures/alteration. Alteration includes intervention onto the building substances reaching from sanitation to constructing a new building.

Renovation can be defined as modernisation of the existing building. Conducting an extension and simultaneous renewal or modernisation of a residential area has to be „justifiable from an urban planning point of view" and the permit is granted after individual assessment by the local urban planning office. The margin of the local authorities can be described as wide since the legal regulations are formulated rather vaguely and not utterly precise. Hereby, not only the buildings in the vicinity decide upon the applicability and suitability, but also the existing building serves as criterion for a decision of the responsible[21,22].

The presence of car parking facilities or areas, which can host extra load is generally the main factor upon which the authorities determine their approval regarding possible increase in volume. A part from specific cases where a project has been approved for buildings located on the border of the reference plot, in general certain distances have to be kept in case of additions or extensions of existing building. The required distance that shall be kept to the border of the plot is generally 5 m (but depends on the different regional regulations); the distance to neighbouring buildings depends on the height of the outer wall and the overall urban layout: normally it corresponds with the full height of the highest building. Often inside the cities those distances are not respected also among existing buildings therefore it is possible to apply exceptions or reduction to the prescription according to the local authorities evaluation, as far as the illumination by daylight of the surrounding buildings is still guaranteed. *In any case the minimum distance that has to be kept to the neighbouring building is dependent on the height of the building (=1H, measured at the pint of the wall that sticking out most and then horizontal to the wall of the adjacent building) has to be kept. The minimum distance to be kept is however 3 meters; balconies are irrelevant for the measuring as long as they are not „sticking out of the*

[21] German Town and Country Planning Code, Baugesetzbuch Art. 34
[22] http://www.php-recht.de/media/download_gallery/BauBG_BauNVO_34_BauGB.pdf

wall" more than 1,5 meters. Tilted roofs do not count as walls as long as their tilt is lower than 70 degrees. Additions to a rooftop do not count as wall as long as they are indented of the roof for more than 50cm while additions that are not defined as a building and that are no higher than 2,50 can always be added t the wall [23]

In regards to fire protection and safety standards, all the existing buildings must comply with current building inspection requirements applicable to their establishment. They benefit from grandfathering. This prevents the building from having to be adapted to the constantly changing regulations. If an extension is added to the existing building, this protection of the existing building is lost in case of[24]: 1. Change in use of the building 2. Risk to human life or health 3. Refurbishment measures lead to the creation of a new building (the extension outweighs the original building volume).

According to the 430 subsidies funds the KFW Bank, a state public bank, finances directly part of the investment for the renovation. The percentage that is covered by the subsidies is calculated directly by the specialists of the bank institution according to the documentation and certificates delivered by the planners. The evaluation is based up on the level of efficiency that the housing unit reaches after the intervention. The energy efficiency classes in Germany are divided in KfW classes going from 115 (when the primary energy need shall not be more then 115% compared to the primary energy need of a comparable new building and transmission heat loss shall not be more than 130% of the transmission heat loss of a comparable new building) to 55 (when the primary energy need shall not be more then 55% compared to the primary energy need of the respective reference building[25] and transmission heat loss shall not be more than 70% of the transmission heat loss of the respective reference building). The law regulation Energieeinsparverordnung (EnEV) determines the specific characteristics and related calculation necessary to define the class of the building as above described. Having proven to meet the energy requirements according to the EnEv, it is possible to apply for subsidies from

[23] Essen Building Regulations Essen Bauordnung Art. 6
[24] Battran L. Kruszinski T. Brandschutz im Bestand. Bestandschutz auf Basis historischer Bauordnungen Bayern. – Köln: Feuertrutz Verlag für Brandschutzpublikationen, 2010. pp. 15 et seq.
[25] Reference to chart 1, Annex 1, EnEv

KWF Bank to support the renovation investment. The covered cost regard energy renovation measures such as components transformation/substitution and/or heating and ventilation system as defined by the following:[26]:

- One measure renovation: 10 % of the eligible renovation costs up to a maximum of 5.000 Euro for each housing unit
- Heating and ventilation system: 15 % of the eligible renovation costs up to a maximum of 7.500 for each housing unit
- Renovation certified as 115 KfW: 15 % of the eligible renovation costs up to a maximum of 15.000 for each housing unit
- Renovation certified as 100 KfW: 17,5 % of the eligible renovation costs up to a maximum of 17.500 Euro for each housing unit
- Renovation certified as 85 KfW: 20 % of the eligible renovation costs up to a maximum of 20.000 Euro for each housing unit
- KfW-Effizienzhaus 70: 25 % of the eligible renovation costs up to a maximum of 25.000 Euro for each housing unit
- KfW-Effizienzhaus 55: 30 % of the eligible renovation costs up to a maximum of 30.000 Euro for each housing unit

Allowing through these incentives also an extended reduction of the investments cost but not specifying a specific case for volumetric additions, which should also be subject for incentives.

3.3.4 Comparative analysis and policy recommendation

The above mentioned regulation, referring to the European regions where the methodology proposed has been tested and its potential has been proven show the presence, at an early and preliminary stage of potential discussions within Europe. The possibility of enlarging and increasing the existing volume or surface of building has already been taken into consideration

[26] KFW, Bank aus Verantwortung, Merkblatt Bauen, Wohnen, Energie Sparen, Frankfurt am Main, 2014

by the different legislative organs in the different countries, partly answering to different needs as the Italian Piano Casa initially shows. The possible application of these instruments to the energy renovation of residential building blocks, as multi-property realities where the possibility of investing for renovation is considerably low otherwise, offers a significant occasion to reinterpret the legislative instrument to use them as leverage in fostering the energy renovation.

The Greek legislation shows a possible application of this volumetric bonus also in case of renovation offering a percentage related to the overall surface of the areas. This increases the possible volume from the standard maximum of the 20% allowed by the Italian regulation in cases of deep energy renovation. The relative freedom left by the German regulations (and generally from many northern countries such as The Netherlands, Denmark, Sweden) shows the intention of leaving open the possibility of deep transformation and densification also within the cities and already urbanized territories. The general rule for these countries is not to approve strictly stated rules, norms and regulation stating a maximal or minimal boundaries but to leave to the local authorities the chance to discuss and verify case by case according to the needs and possibility of the moment. The evaluation is therefore depending from the project and possible benefits generated by the intervention. This has often lead to a larger number of experiments in the field of building transformation and densification that have been approved in Germany, The Netherlands and Austria. In these countries the public sensibility towards the energy reduction agenda guides a more open approach towards the possibility of implementing innovative schemes. It shall also be considered that the current urban layout of these countries is not characterized by such a strict and bounding situating as it happens in Italian or Greek contexts, where freedom of densification would result in chaos. The potential and possible densification in Germany and Austria and in general in the northern countries is in fact higher that the potential in the Mediterranean region where already the urban tissue is highly compact and dense. The general openness and freedom allowed by the German regulation shall not therefore be taken as an example for other countries around Europe although the possibility of experimenting in Germany the strategy my increase the confidence also from local authorities in accepting the possible normative revision.

The existing European Energy Union together with the Energy Efficiency Financial Institutions Group should include in the agenda the study and evaluation of the volumetric addition strategy as tool to increase the investor confidence and the existing financial and economical schemes to foster energy renovation on a broader scale. The possibility of defining a surface and volumetric index that sets the maximum possible additional surface that in case of renovation it can be added to the existing surface to cover the upfront cost shall be set. The index is considered as the result of a series of evaluations that are based on the context, existing services, possibility of increase the service net, residual density load and factor of the area as well as the potential of the existing market. As shown in the case study, the extra surface has been calculated in this research as function of the selling potential of the addition, considered as return of the investment due to the total renovation costs. In a broader vision, it is necessary to develop urban maps of the cities where the possible surface increase is market and singed through an urban index.

The development of these maps could help planners and stakeholders in defining the possible investor sectors and the potential investments where the payback time for energy renovation would be consistently reduced. Considering also the public authorities perspective, it is important to underline the positive effect of the strategy in diminishing the urban sprawl and land consumptions. Through this strategy it could be possible to distribute the construction indexes directly upon areas that have already been urbanized, equipped with services and already consolidated. It is suggested to consider the transferability of the current construction rights from agricultural land or periphery areas, partly into the existing consolidated areas where still the existing services and the existing layout could allow a controlled densification through additional volume on existing buildings. The dual benefit would therefore consist in the possibility of renovating old buildings with lower return of the investments time and reduce the urban sprawl in the peripheries.

3.4 Overcoming the economic barriers: self-financed nZeb through Add-ons

A consistent number of pilot EU experiences have already displayed that payback of larger scale interventions (considering roof extensions/elevations, construction of new units or densification) together with the direct benefit of real estate investors which gain space and money by possible Add-ons, have a very positive effect on the technical and economic feasibility of the energy retrofitting interventions. Considering the hypothetic investment of inhabitants, ESCO or external investors in Deep Renovation through Add-ons, the gains obtained by sales of the new flats or surfaces would counterbalance both the standard energy retrofit and the cost of RES (photovoltaic panels) to set the energy demand of the whole building to zero. The elevated upfront costs in energy retrofitting as well as the excessively long payback times (up to 45 years as demonstrated in Chapter 1) have driven some experimental European projects[27] as well as pilot experiences in Austria and The Netherlands to focus on the strategy to investigate the possible paths to overcome the existing barriers. In particular, roof or side extensions as additional volumes could significantly benefit the investment attractiveness: the surplus value in real estate terms is used to counterbalance the energy renovation costs. The volumetric Add-ons on the roof of the buildings, as infill or façade extension represent therefore a powerful design strategy not only to foster the refurbishment process, gaining the economic surplus necessary to overcome the existing economical and financial barriers but also an important occasion to sign a turning point in land and urban development, towards a new sustainable idea of planning and building smart cities.

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[27] Studies identifying key categories of hurdles (economic, technical, credibility, social, legislative) in delivering deep buildings' energy renovation are contained in: 1. A guide to developing strategies for building energy renovation: Delivering Article 4 of the EED, BPIE, Published in February 2013 by the BPIE. 2. Studies of financial institutes (e.g. KfW in Germany); 3. The EU multiannual Roadmap for the EeB PPP, led by E2B consortium providing recommendations for building energy renovation. 4. Guidelines for strategies on renovation provided by the concerted actions EPBD, EED and RESD 5. EU projects (FRESH, SURE-FIT, SHELTER, RESHAPE, TRAINREBUILD, iNSPiRe and POWERHOUSE).

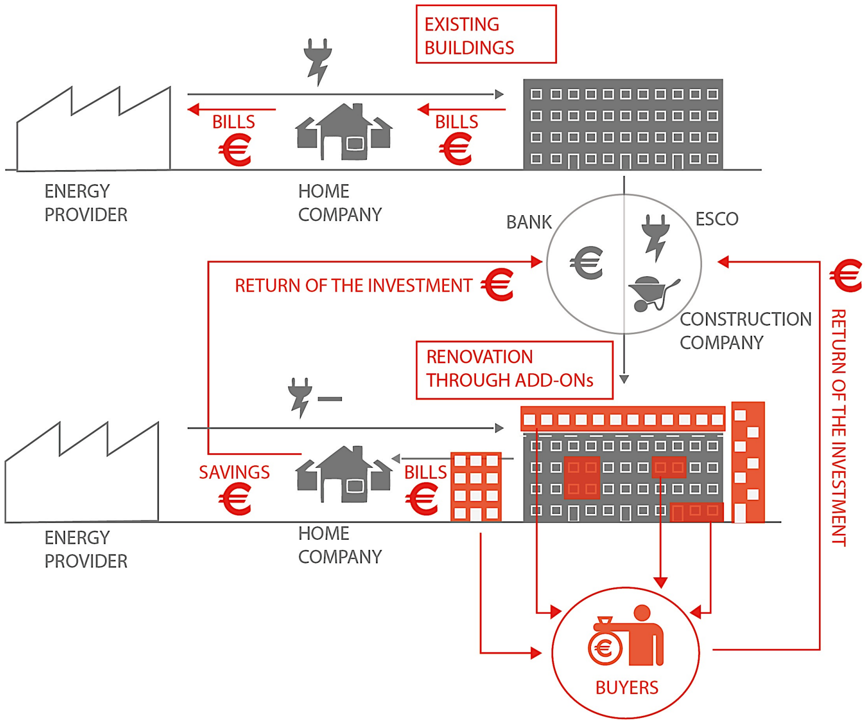

Fig. 19 Self sufficient financial scheme to increase the profitability of the renovation through volumetric addition and façade transformation

The scheme illustrated in Fig. 19 shows the self-sufficient financial scheme of Deep Renovation through Add-Ons. Initiative to improve the initial status of existing buildings shall be undertaken by an ESCO or a Construction Company CoCo (or a joining venture among them and a guarantee entity such as a Bank institute) which make the initial investment to renovate and build. In this case, the return of the investment will be guarantee to the ESCO/CoCo by the Add-Ons revenues (after that interested private buyers have entered the circle) and by the energy bills from the existing buildings' inhabitants or house manager. As in many financial schemes for energy renovation, in fact, the inhabitants or home company will continue paying the bills as before the intervention for an agreed period of time (5-10 years) whereas the benefit in energy reduction given by the renovation will be corresponded to the Esco-CoCo as payback for the initial investment. The earlier the investment is repaid, the earlier the investors start earning from their initiatives, therefore the initial gaining given by the possibility of selling the new apartment units or living space created as Add-Ons, empowers the investors with a relatively safe and profitable mechanism. The combination may result in a win-win solution: in fact, on the one side the dwellers or owners may benefit from a reduced fee or a reduced number of years to reimburse the ESCO/CoCo and on the other side ESCO/CoCo will receive revenues which can be immediately available from the first 5 years.

Performed cost-benefit analysis considering an hypothetic investment in energy renovation up to the Deep Renovation standards (reduction of 80% of the consumptions) and RES plant, showed that the potential economic gain obtained by the solely reduction in energy consumption can already reduce the payback time of the intervention when compared to standard renovations (with payback times over 40 years as shown in chapter 1). By adding an extra value given by the possibility of selling extra surface or new apartment units as Add-ons on the existing building, the reduction in pay-back time of the investment becomes extremely significant, triggering a potential revolution in the appealing of building renovation investments. Deep renovations through Add-Ons have consistently higher up-front cost when compared to "lighter" standard solutions (insulation and windows as simulated in Chapter 1), but the reduced payback as well as the IRR and the NPV of the investment show important financial figures.

3.4.1 Cost-benefit analysis of deep renovation with Add-Ons

To provide and better quantify the real potential of Add-Ons in Deep Renovation, modelled and simulated cost-benefit scenarios have been developed for a sample case study building considering the Italian framework. In Italy through the Casa Plan it is allowed to renovate and improve the energy consumptions of existing buildings also including in the intervention a quota of extra-surface, a volumetric addition. The surface bonus shall be calculated as an increase up to 20% of the existing Usable Floor Area (UFA) with a maximum of 70 m^2 for each real estate unit, considered as unit with function autonomy (separate entrance). In the case of condominiums as multi-property buildings, every apartment with an independent entrance could benefit from the bonus autonomously, generating a sum of bonus that becomes consistent for an entire apartment block. The real estate surface bonus together with the energy reduction after the intervention and the energy production by RES represent the counterbalancing factors that should compensate the upfront costs for the building renovation and the construction of the Add-ons as new liveable surface. The following table show the overall costs per square meter to engage a Deep Renovation, thus a reduction of the actual energy consumptions over 85%, and to building new units or surface as Add-Ons.

DEEP RENOVATION

		€/m2
INTERVENTIONS	External thermal insulation + finishing	100
	Roof insulation (with non heated under-ceiling)	50
	Windows replacement with double glass windows	350
	HVAC improvements/replacements	70
	Related demolitions and reconstructions	30
	Scaffoldings and safety installations	30
	TOTAL RENOVATION COSTS	**630**
		€
EXTRA COSTS	New heat pump	50.000.000
	Photovoltaic system to be located on the rooftop	-
	TOTAL PLANT COSTS	

Tab. 2 Break down costs for Deep Renovation, aiming at a reduction of 80% of the current energy consumptions of the building. The following assumptions have been made to define the above costs: - COSTS PER SQUARE METRE– (referred a sample building located in Italy) The cost per square metre (€/m^2) of each intervention is referred to the Usable Floor Area (UFA) of each housing unit. The UFA does not include the extra surface of balconies, loggias or extra-rooms. Some costs (like the window replacement costs) are initially calculated according to the façade area, then referred to UFA, considering an average ratio between façade area and UFA equal to 0.5. - WINDOWS AND OPENINGS– The ratio between transparent surfaces and UFA in existing buildings is equal to 0,125 (1/8). Their area is then calculated dividing UFA by 8. New buildings meet same day-lighting requirements, possibly increasing transparent surfaces. - CONDITIONING SYSTEMS – In traditional deep renovation, “HVAC and water heating systems improvements and replacements” consist of heating and air conditioning generators replacement, partial distribution pipes replacement inside floors and walls, new control systems and metering devices, not necessarily new radiators. - MAINTENANCE AND REPLACEMENT COSTS – During average yearly maintenance costs for external façades are considered 0,05 % (non exposed structures) and 0,26% (exposed structures)[28];

CONSTRUCTION COST FOR ADD-ONs

		€/m2
INTERVENTIONS	Raw construction with prefabricated wooden systems	250
	Insulation	150
	Windows with double glass	300
	HVAC installations	150
	Electric and plumbing works	50
	Scaffoldings and safety installations	30
	Finishing	40
	Labour	80
	TOTAL ADD-ON COSTS	**1.050**

Tab. 3 Break down costs to build new units or UFA as addition to the existing building. The cost varies according to the different context, for this survey the Italian market as been considered.

[28] Di Giulio, 2002, “Relationships between building condition assessment and maintenance costs in the evaluation of real estate refurbishment programmes”, CIB proceedings W070 2002

The total cost of the initial investment for deep renovation according to Tab. 2 can be calculated as:

$$I_i = i * S \tag{f}$$

$$I_i = 630*2.000 = 1.260.000 \text{ €}$$

Since Deep Renovation reduces the overall consumptions up to of 85%, in total, the yearly consumption of the building before and after renovation are

$$C_{before/after} = c \cdot S \tag{b}$$

Where:

C is the total yearly consumption/Savings of the building in kWh
c is the total yearly consumption/savings of the building in kWh/m²
S is the total liveable surface of the building in m²

$$C_{before} = 200 \cdot 2.000 = 400.000 \text{ kWh}$$

$$C_{after} = 30 \cdot 2.000 = 60.000 \text{ kWh}$$

In the simulation the building is equipped with gas boilers and will be integrated by a centralised gas heat pump, with COP (Coefficient Of Performance) of 0,9. The COP of the previews plant was certainly below 0,8. Thus, the total productivity of the new instalment is 90 %. Due to the losses of the gas boiler the real kWh of yearly consumption, before and after the intervention are:

$$C_{real} = C_{before/after} / COP \tag{c}$$

$$C_{real,before} = 400.000/0,8 = 500.000 \text{ kWh}$$

$$C_{real,after} = 60.000/0,9 = 66.700 \text{ kWh}$$

In a qualitative evaluation such as the one that is carried out here to define the potential of Add-Ons in Deep renovation, we can state that the overall annual thermal energy cost, net from inflation rates are:

$$E_y=(C_{real}/g)\cdot e \tag{d}$$

Where:

Ey is the total yearly thermal energy cost in €/y
Creal are the real consumptions of the buildings, considering the plant losses
g is the productivity of the gas, estimated as 10 kWh/m³
e is the current gas price is 0,950 €/m³

$$E_{y,before}= (500.000\ /10)*0{,}950 = 47.500\ €/y$$

$$E_{y,after}= (66.700\ /10)*0{,}950 = 6.335\ €/y$$

The price for gas has been accounted as 0,950 €/m³ taking the Italian market as reference. This means that the housing associations, the municipalities and/or the single housing through Deep Renovation could save up to 41.000 € every year to heat the apartments; the economic figure is significant. For the following cash-flow analysis, the energy benefits of the deep renovation that have been considered are:

Gas consumptions		
50.000	m³ per year	Gas consumptions before
6.670	m³ per year	Gas consumptions after
Energy Price		0,950 €/m³
Energy savings		
433.300	kWh per year	Energy savings after intervention
41.165	€ per year	Savings after intervention

Tab. 4 Energy consumptions and reductions for the Deep Renovation scenario

Already with the simple Deep Renovation instead of a standard renovation intervention, the payback time of the interventions can be significantly reduced, passing from the 20 in case of incentives schemes or 45 years without incentives schemes as illustrated in Chapter 1 to 15 or 32 years for Deep Renovations.

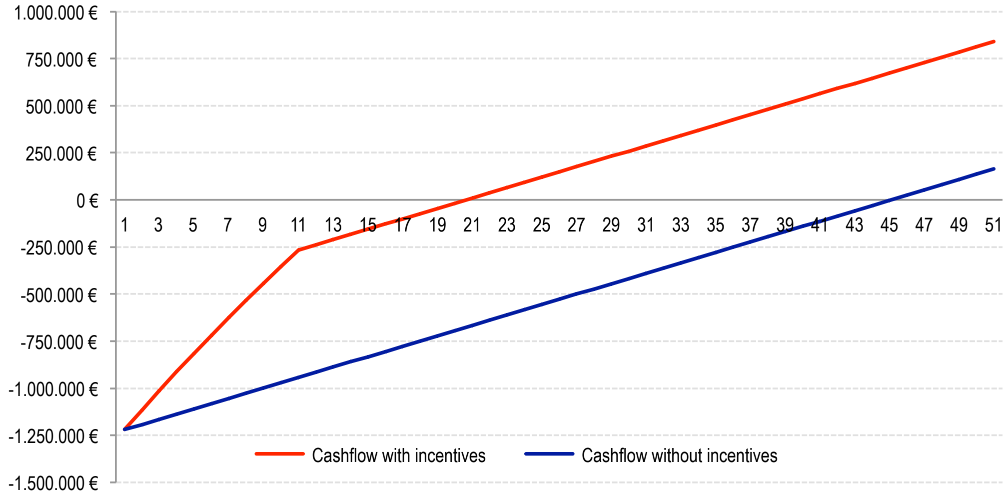

Fig. 20 Graphic showing the results of the clash-flow evaluation on the investment for standard renovation as carried in Chapter 1. Red line represents the incentive scheme and the blue one is the investment path without incentives

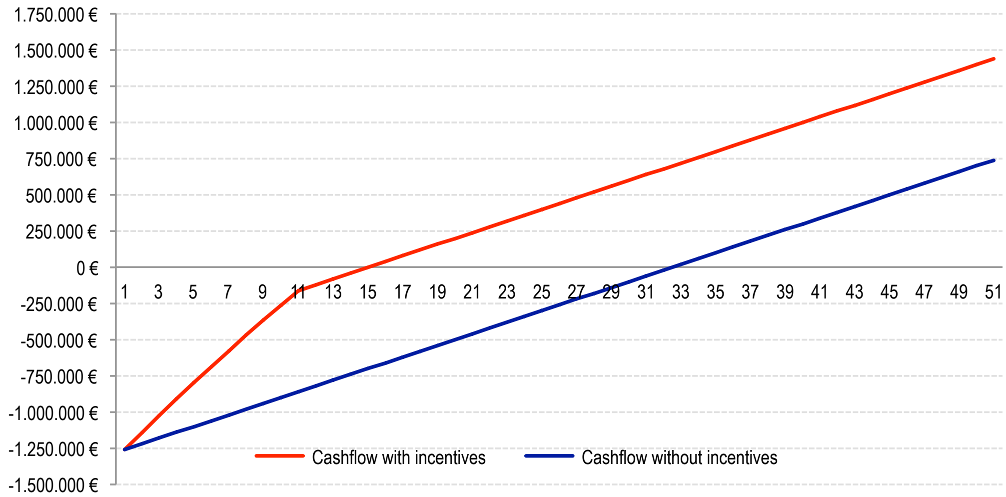

Fig. 21 Graphic showing the cash-flow evaluation on the investment for Deep Renovation. Compared with Fig. 20 it shows the benefit of intervening through deep renovations.

Fig. 20 and Fig. 21 represent the investments' cash-flow in case of standard renovation (Fig. 20) and in case of Deep Renovation (Fig.21) offering a rapid visualisation of the benefits of choosing the Deep path. Yet the pay-back time and the fiscal values are not competitive to be considered as interesting investments from financial authorities, Escos or private investors. The following cost-benefit analyses will include the possibility of building Add-Ons and further reduce the pay-back time. The sample building considered for the simulation run in chapter one has the yearly consumptions of an average social housing building, before the energy renovation, a value of c = 200 kWh/m^2 (thermal kWh) and a Usable Floor Area of 2.000 m^2 in total (25 dwelling units). The potential Add-On surface suggested is accounted as the 20% of the original UFA would be:

$$A_{dd} = 0{,}2 * 2000\ m^2 = 400\ m^2$$

Considering a cost of construction of *x*, equal to 1.050 €/m^2 as calculated through the estimation illustrated in Tab. 3 for the Italian demonstrative case and the possibility of building an extra floor on the roof with new building units for a total of A_{dd}, the cost of the Add-Ons would be

$$I_{add} = x * A_{dd} \qquad (n)$$

Where:

I_{ra} is the total investment for the Add-ons
x is the construction cost in €/m^2
A_{dd} *is the total available surface for addition, in the example the roof surface*

$$I_{add} = 1.050\ €/m^2 * 400\ m^2 = 420.000\ €$$

The overall investment considering the initial one for renovation and the one for Add-Ons will be of:

$$I_{tot} = I_i + I_{add} = (1.260.000 + 420.000)\ € = 1.680.000\ €$$

Considering a real estate value of the new construction for the Add-on equal to y, in Italy for the demonstrative case in a medium city, the average low market value, as it happens for the Italian market, could be around 2.200 €/m^2. The economical gain given by the Add-ons, which in case of renovation might reduce the cost of the initial investment $I_{i,}$ would be:

$$R_{add} = A_{dd} * y \tag{o}$$

$$R = 400\ m^2 * 2.200\ €/m^2 = 880.000\ €$$

The energy benefits and reductions remain the same mentioned for the Deep Renovation as illustrated in Tab. 4. The following tables shows the actualised cash flows and the overall NPV and IRR keeping into account the total investment value as I_{tot} and the energy benefits due to the intervention, as calculated above. The inflation rate for the energy cost has been set to 0,0211[29] and the investment interest rate has been set around 3%.

The time of reference for the investment as been reduced, compared to the simulations run for the standard renovation, to 25 years. It is in fact more reliable to consider and evaluate the NPV and the IRR upon a reduced time frame to guarantee also that the building will not require further maintenance. At year zero, two time have been considered: at a first stage the renovation and Add-on construction investments have been considered as expenditure while at a second stage the profit from the sale of the Add-on have been calculated as proceed. The overall pay-back time, without considering any source of fiscal reduction and state incentive has been reduced down to 21 years. Applying the fiscal incentives rate, in Italy currently accounting for the 65% of energy renovation intervention (calculated only on the quota of the investment referring to the renovation and not the Add-on construction), the payback time is reduced down to 8 years.

[29] Data collected from the Istat report for the period 2006-2014

	Renovation investment	1.260.000,00	€		
	Add-Ons investment	420.000,00	€		
	Total investment (Renovation+Add-Ons)	1.680.000,00	€		
	Savings (non weighted)	41.163,50	€ per year		
	Profit from Add-ons' sale	880.000,00	€		
	Interest rate	0,0300			
	Energy inflation rate	0,0300			
	Incoming	Outgoing			
Year	Savings	Consumptions	Cashflow	NPV	Sum
0	0,00	0,00	-1.680.000,00	-1.680.000,00	-1.680.000,00
0	880.000,00	0,00	880.000,00	880.000,00	-800.000,00
1	41.163,50	6.336,50	41.163,50	39.964,56	-760.035,44
2	42.398,41	6.526,60	42.398,41	39.964,56	-720.070,87
3	43.670,36	6.722,39	43.670,36	39.964,56	-680.106,31
4	44.980,47	6.924,06	44.980,47	39.964,56	-640.141,75
5	46.329,88	7.131,79	46.329,88	39.964,56	-600.177,18
6	47.719,78	7.345,74	47.719,78	39.964,56	-560.212,62
7	49.151,37	7.566,11	49.151,37	39.964,56	-520.248,06
8	50.625,91	7.793,10	50.625,91	39.964,56	-480.283,50
9	52.144,69	8.026,89	52.144,69	39.964,56	-440.318,93
10	53.709,03	8.267,70	53.709,03	39.964,56	-400.354,37
11	55.320,30	8.515,73	55.320,30	39.964,56	-360.389,81
12	56.979,91	8.771,20	56.979,91	39.964,56	-320.425,24
13	58.689,31	9.034,33	58.689,31	39.964,56	-280.460,68
14	60.449,99	9.305,36	60.449,99	39.964,56	-240.496,12
15	62.263,49	9.584,52	62.263,49	39.964,56	-200.531,55
16	64.131,39	9.872,06	64.131,39	39.964,56	-160.566,99
17	66.055,33	10.168,22	66.055,33	39.964,56	-120.602,43
18	68.036,99	10.473,27	68.036,99	39.964,56	-80.637,86
19	70.078,10	10.787,47	70.078,10	39.964,56	-40.673,30
20	72.180,45	11.111,09	72.180,45	39.964,56	-708,74
21	74.345,86	11.444,42	74.345,86	39.964,56	39.255,83
22	76.576,24	11.787,76	76.576,24	39.964,56	79.220,39
23	78.873,52	12.141,39	78.873,52	39.964,56	119.184,95
24	81.239,73	12.505,63	81.239,73	39.964,56	159.149,51
25	83.676,92	12.880,80	83.676,92	39.964,56	199.114,08
26	86.187,23	13.267,22	86.187,23	39.964,56	239.078,64
27	88.772,84	13.665,24	88.772,84	39.964,56	279.043,20
28	91.436,03	14.075,20	91.436,03	39.964,56	319.007,77
29	94.179,11	14.497,45	94.179,11	39.964,56	358.972,33
30	97.004,48	14.932,38	97.004,48	39.964,56	398.936,89
		NPV	30 years	2.078.936,89	
		IRR	30 years	0,05134	
		Pay-back time	21 years		
		CO_2 Reduction	kg	88.826,50	

Tab. 5 Cost-benefit analysis carried for deep renovation with Add-Ons of 20% calculated on the current UFA. The payback time resulting from the NPV (2.078.936 euro) is 21 years and the IRR is 5,13%

Renovation investment		1.260.000,00	€
Add-Ons investment		420.000,00	€
Total Investment (Renovation + Add-Ons)		1.680.000,00	€
Savings (non weighted)		41.163,50	€ per year
Profit from Add-ons' sale		880.000,00	€
Fiscal incentive (on renovation investment only)	0,65	819.000,00	€
Fiscal incentive rate (10 years plan)		81.900,00	€ per year
Interest rate	0,0300		
Energy inflation rate	0,0300		

	Incoming		Outgoing			
Year	Savings	Incentive 65%	Consumptions	Cash flow	NPV	Sum
0	0,00	0,00	0,00	-1.680.000,00	-1.680.000,00	-1.680.000,00
0	880.000,00	0,00	0,00	880.000,00	880.000,00	-800.000,00
1	41.163,50	81.900,00	6.336,50	123.063,50	119.479,13	-680.520,87
2	42.398,41	81.900,00	6.526,60	124.298,41	117.163,17	-563.357,71
3	43.670,36	81.900,00	6.722,39	125.570,36	114.914,67	-448.443,04
4	44.980,47	81.900,00	6.924,06	126.880,47	112.731,65	-335.711,39
5	46.329,88	81.900,00	7.131,79	128.229,88	110.612,22	-225.099,17
6	47.719,78	81.900,00	7.345,74	129.619,78	108.554,52	-116.544,64
7	49.151,37	81.900,00	7.566,11	131.051,37	106.556,76	-9.987,88
8	50.625,91	81.900,00	7.793,10	132.525,91	104.617,18	94.629,30
9	52.144,69	81.900,00	8.026,89	134.044,69	102.734,09	197.363,39
10	53.709,03	81.900,00	8.267,70	135.609,03	100.905,85	298.269,24
11	55.320,30		8.515,73	55.320,30	39.964,56	338.233,81
12	56.979,91		8.771,20	56.979,91	39.964,56	378.198,37
13	58.689,31		9.034,33	58.689,31	39.964,56	418.162,93
14	60.449,99		9.305,36	60.449,99	39.964,56	458.127,50
15	62.263,49		9.584,52	62.263,49	39.964,56	498.092,06
16	64.131,39		9.872,06	64.131,39	39.964,56	538.056,62
17	66.055,33		10.168,22	66.055,33	39.964,56	578.021,19
18	68.036,99		10.473,27	68.036,99	39.964,56	617.985,75
19	70.078,10		10.787,47	70.078,10	39.964,56	657.950,31
20	72.180,45		11.111,09	72.180,45	39.964,56	697.914,87
21	74.345,86		11.444,42	74.345,86	39.964,56	737.879,44
22	76.576,24		11.787,76	76.576,24	39.964,56	777.844,00
23	78.873,52		12.141,39	78.873,52	39.964,56	817.808,56
24	81.239,73		12.505,63	81.239,73	39.964,56	857.773,13
25	83.676,92		12.880,80	83.676,92	39.964,56	897.737,69
26	86.187,23		13.267,22	86.187,23	39.964,56	937.702,25
27	88.772,84		13.665,24	88.772,84	39.964,56	977.666,82
28	91.436,03		14.075,20	91.436,03	39.964,56	1.017.631,38
29	94.179,11		14.497,45	94.179,11	39.964,56	1.057.595,94
30	97.004,48		14.932,38	97.004,48	39.964,56	1.097.560,51
			NPV	30 years	2.777.560,51	
			IRR	30 years	0,10481	
			Pay-back time	8 years		
			CO_2 Reduction	kg	88.826,50	

Tab. 6 Cost-benefit analysis carried for deep renovation with Add-Ons of 20% calulcated on the current UFA, including the incentives from the governamento of 65% as for the Italian framework. The payback time resulting from the NPV (2.777.560 euro) is 8 years and the IRR is 10,48%

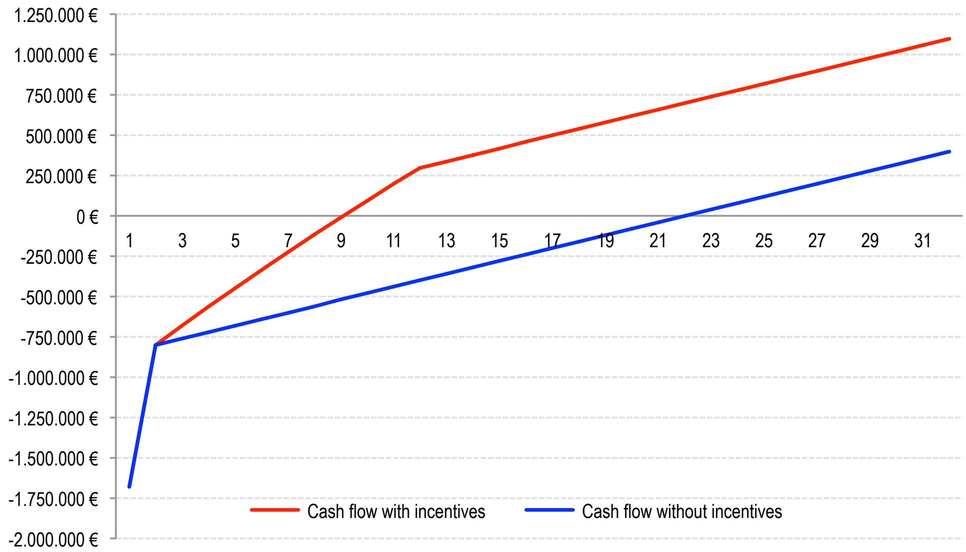

Fig. 22 The graphic shows the comparison between the two cost-benefit analysis carried for deep renovation with Add-On of 20%. Deep renovation with Add-Ons' investments without incentives (blue in the graphic), can reach a pay-back time of 21 years whereas the pay-back time of standard renovation investments, with incentive - for the Italian legislative framework accounting for 65% of the initial investment within 10 years distributed as fiscal reduction rates - (red in the graphic) is about 8 years.

Wanting to decrease the return of the investment beyond the 5 years also in case of no incentives schemes (since the condition differs in all the different European regions) and increase the interest rate up to 5% as required for Esco, banks and the financial agencies. The final step of the economical feasibility study here conducted is thus based upon a reverse approach. The attempt is to derive the necessary amount of square meters, the A_{dd}, necessary to further reduce the pay-back time, considering an interest rate of 5%, below the 8 years also without incentives schemes which means reducing it entirely in case of incentives. In the last part of this work, case-oriented simulations will be run according to three different European scenarios (Italy, Greece, Germany) analysing the real renovation costs, the market conditions and the potential of the strategy to validate it at a European level. Currently the attempt is to make a general theorisation of the proposed methodology therefore the variables regarding market and specific cases are yet left undetermined. In general, parameterising with respect to the renovation costs and the estimated value of the assistant building, we aim at working on the basis of the following formula:

$$\frac{Cr*y+Cc*x-P*x}{R*y} = t$$

where:

t = pay back time of the investment with investment rate of 5%
Cr = unit renovation costs including RES to set to nZEB the existing (actual) buildings (€//m²);
y = surface (m²) of existing building;
Cc = Construction costs of the Volumetric Addition (€/m²);
x = A_{dd} additional surface (m2);
P = Assistant building's real estate market value per m² (€/m²);
R = Energy savings per square meter per year (€/m²).

By the use of this formula it is possible to calculate the simple payback time for the above-mentioned parameters. Indeed, to increase the attractiveness of the intervention for the banks and the financial agencies, we can, i.e., decrease the return of the investment up to 8 years and derive the necessary amount of m^2 that are still necessary to cut the pay-back time, given a specific real estate market (Cr, Cc, P values). The additional living space, the Add-on, can be distributed or combined in several possible schemes, according to the different case study and circumstances becoming:

1. Extra living space for the existing units as bonus to the inhabitants that contribute themselves to the interventions.
2. Extra living space in the roof top addition that could have a second floor as the prototype that have been built.[30]
3. Be considered as a whole, as an Additional satellite building, an Assistant Building, which will be built next to the existing one to support the investment, create energy synergy through net systems and pay back the renovation actions.

In this last scenario the Assistant Building may consist of a bonus, a complementary economic instrument for the investors (real estate investors, construction companies in conjunction with

[30] OnTop prototype, Solar Decathlon 2014, FFH Frankfurt together with BienZencker

ESCO, etc.) also considering the possibility of creating a risk fund with the real estate surplus generated by the new building, that could cover the risk of arrearage for the inhabitants in paying the bills. The Add-ons act as trigger, designed to act as the catalyst or attractor for private sector financing, playing an extremely important role which is of crucial importance in a context of scarce private finance where the search for affordable up-front investments is crucial.

For the three pilot case studies and for any building renovation is then possible to determine the volumetric addition surface x necessary to reduce the payback time of the intervention down to 8 years. From the (a) it can be derived:

$$\frac{\mathrm{Cr}*\mathrm{y}+\mathrm{x}(\mathrm{Cc}-\mathrm{P})}{\mathrm{R}*\mathrm{y}} = 8$$

$$\frac{\mathrm{Cr}}{\mathrm{R}} + x\,\frac{(\mathrm{Cc}-\mathrm{P})}{\mathrm{R}*\mathrm{y}} = 8$$

$$\mathrm{x}\ \frac{(\mathrm{Cc}-\mathrm{P})}{\mathrm{R}*\mathrm{y}} = 8 - \frac{\mathrm{Cr}}{\mathrm{R}}$$

$$\mathrm{x} = \frac{8*\mathrm{R}*\mathrm{y}-\mathrm{Cr}*\mathrm{y}}{\mathrm{Cc}-\mathrm{P}}$$

where:

Cr = unit renovation costs including RES to set to nZEB the existing (actual) buildings (€//m^2);
y = surface (m^2) of existing building;
Cc = Construction costs of the Volumetric Addition (€/m^2);
x = A_{dd} additional surface (m2);
P = Assistant building's real estate market value per m^2 (€/m^2);
R = Energy savings per square meter per year (€/m^2).

To sum up, in the search of forms of compensation and incentives for nZEB in existing buildings, volumetric additions, densification and/or "infill" as the Add-Ons, represent crucial tools to enhance the technical and economic feasibility of energy retrofitting operations. As shown, the costs of these interventions are higher than the standard solutions, but their payback time, together with the direct benefit of investors, which gain space and money, have a very positive effect on the technical and economic feasibility[31].

As a further modelling in this framework, four different hypotheses have been envisaged for the comprehensive renovation of a building of about 2.000 m^2 with 20 residential units of 100 m^2 each and a time lapse of 40 years. The different scenarios consist of: i) The "as built" case of a building block consuming 200 kwh/m2yr; ii) A step-by-step renovation where the plant system renewal is undertaken during the first year (with a consequent Energy Consumption Reduction - 30% ECR) and after the first ten years the replacement of windows' components (15% ECR) with high performing windows is realized; after 20 years all the surfaces of the building envelope have undergone renovation (+25% ECR); iii) The potential gain of constructing a new building aimed at reducing only the 20% of the actual assisted building and mainly finalized to produce revenues to help the payments of the energy bills (sentence not clear); (iv) finally, the combination of a step-by-step renovation with the construction of an assistant building of about 1000 m^2 (repetition) built with passive standards (15kWh/m^2yr) (Fig. 23) and producing energy from renewable energy sources –RES- for its own requirements as well as for the requirements of the "adopted" building. In this simulation the assistant and assisted building are equipped with a PV system to set to nearly Zero the energy consumption of the two buildings[32]

The simulated scenario also considers the revenues of a potential ESCO or a construction company (or a joining venture among them). Results show evidence that the provision of a new building with few or no links with the assisted building does not produce long term investments (the scenario has considered a reduction of the 20% of the energy consumption of the actual building: it is the case, i.e., of investing only a part of the revenues obtained from the selling of the new units in the plant retrofit of the assisted building).

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[31] Secondly (ii), Last but not least (iii) the use of these invariants generates a higher degree of adaptability and variability that facilitates the transition from standardized solutions towards custom-made and tailored designs responses.

[32] A total 21,231 kWp PV plant for the assisted and assisting building has been considered to cover 187.600 kWe for the total net residential surface of 4000 sqm.

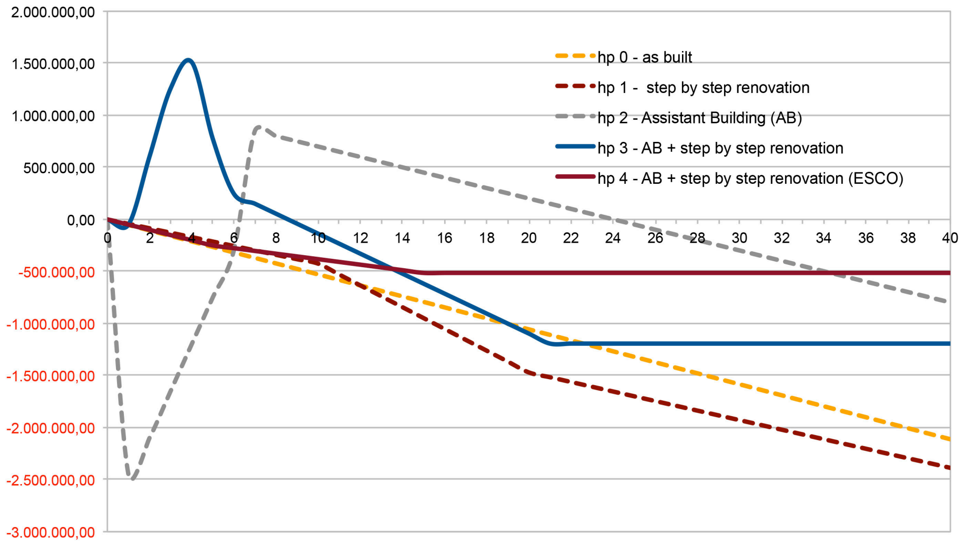

Fig. 23 Cost-benefit analysis performed in the building model. Results show how the construction of an Assistant building can be integrated in the process of a step-by-step renovation. On the right, calculated cash flows for the different hypotheses. Of course it is important to specify that in the hypothesised scenario we need to consider a new (lighter) investment after a time lapse 40 years

On the contrary, in the hypothesis of establishing a binding contract between the construction of an assisted building and the renovation up to nZEB of the assisted or adopted building, a more stable investment scenario climate for market and social actors can be achieved. In fact, on the one side the dwellers or owners may have a reduced fee or a reduced number of years to reimburse the investor (Esco-Construction company) and on the other side the same investor(s) will receive revenues which can be immediately available from within the first 5 years.

This can also produce the result in the co-related benefit of releasing funds for further investments, thus stimulating other deep renovations in a fast, but well-planned, long-term market strategy.

The specific analysis that will be carried out for the case study will underline the differences related to the market and real estate cost/values and will also show the potential in architectural, technological, sociological and economical terms of Deep Renovation through Add-Ons. The pay-back time, in most of the case studies has in fact been reduced to below the 3 years considering sustainable intervention scenarios with Add-ons above the limits dictated by the current regulation in Italy. A revision of the current framework is thus necessary to open up the Deep Renovation to a great potential for the systematization of the energy reduction at European scale. Conclusions and suggestions will be delivered in the last part of the research.

CHAPTER 4_ USER-ORIENTED APPROACH: DESIGNING THE PROCESS, PROCESSING THE DESIGN

[There is an]…anxiety around the failure of the formal structures in the West. Populations are dropping, immigration increasing, manufacturing and economic strength shifting to other nations. Western nations are facing a changing culture at home and a shifting power structure abroad. As formal structures fail informal systems take over.
(Quilian 2006)

Modernist residential blocks are criticized for their lack of sensitiveness to social and cultural needs of the people (Holston 1989). The development of the Weissenhof model throughout our cities has generated same building blocks copying and repeating all over creating the European cities and suburbs. From the alignment of these clean and neat dwelling cells, cities were automatically born and when inhabitants have carried furniture inside the white units, architects have taken distance dissatisfied with the result[1]. The question upon the feasibility of the refurbishment project nowadays is clearly strictly related to the users' agreement. The revision of the process proposed here starts from a direct involvement of the inhabitants in the design phase, seeking for the individuation of those attractive nodes that could be used as incentives in the realization phase to foster the inhabitants' consensus. In other words, where is the boundary between the designed architecture, the planned, and the freedom of the inhabitants to transform it, the unplanned?[2] How could the renovation intervention include the prevision regarding the unforeseeable, implement the existing building with the necessary flexibility and adaptability that an informal system such as housing must

1 Kollhoff H. (2003). Abitare. Area, 68, p.3
2 Molinari, L., 'Dialogo con gli inquilini (che comprano la casa)' Corriere della Sera, 12.09.2015

have? In a complexly structured context where the number of decision-makers and cultural scenarios overlap, where the temporal dimensions and social background of the citizens are dissimilar; where local and global, physical and virtual dimensions co-exist[3] where it is no longer possible to ignore the direct and indirect relations with the context, it is necessary to identify design procedures which can quickly adapt to environmental variations and new requirements. However, succeeding in this endeavour requires more than getting the engineering right[4] and more focus should be placed on the social aspects at community level. In fact, developing more sustainable environment depends upon consumers' willingness to engage in greener and more collective behaviours[5]. Moreover, local urban communities have inimitable advantages in providing infrastructure for more sustainable consumption environment and different types of low-carbon communities as a context to reduce carbon intensity emerging at different scales.[6] Thus, there is a deep need for an effective integration of a technical and economically-based approach in energy retrofitting and a human based, socially oriented urban vision able to achieve an active and greener behaviour in urban environment. In this context, it is important to highlight that some of Europe's leading innovation Nations have included user-driven or user-centred innovation as a way of providing innovative products and services that correspond better with user needs and therefore are more competitive. User-driven innovation is closely associated with design, and involves tools and methodologies developed and used by designers; it is thus a way of providing innovative products, services and systems that better correspond to user needs. Since the formal design is necessary to guarantee a structured and organized process that is called to respond coherently with current energy and safety regulations, fixed components (structural and functional invariants) are needed to be applied in the (re-)design processes of urban buildings. On the other hand, a degree of adaptability and the adoption of processes engaging directly the inhabitants could offer a

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[3] Tiazzoldi et al., 2008
[4] Webler T, S. Tuler, Getting the engineering right is not always enough: Researching the human dimensions of the new energy technologies, Energy Policy 38 (2010), pp. 2690–91.
[5] Peattie, Ken, Green Consumption: Behavior and Norms (November 2010). Annual Review of Environment and Resources, Vol. 35, pp. 195-228, 2010.
[6] Heiskanen, E., Johnson, M., Robinson, S., Vadovics, E. & Saastamoinen, M. Low-Carbon Communities as a Context for Individual Change. Energy Policy, Articles in press, 2010.

real solution both to the anonymity and standardization of these housing complexes. The proposed design approach aims at searching a “swing method” including both formal and informal strategies. Within the reference case studies, this approach has lead to the search of design tools’ sets that compose the variable formal components in the (re-)design of urban blocks, to combine the complementary nature of the standard and planned design with the variability required by the inhabitants; the resulting urban design overcomes the current standard distinction between informal settlements and planned developments. The goal is to re-interpret an evolutionist approach to improve socio-technical environments in the specific contexts of urban planning, collaborative learning, and collaborative software design. The main goal is to offer an appropriate technology to activate 'social creativity' and to make the voice of many heard[7]. Building energy retrofitting may represent a great opportunity for a combined technical, formal and social revision of our cities, by addressing different issues and improving the built environment. This kind of autonomy in the design or production of space means that the final users are directly involved in designing and planning and need to have access to knowledge of processes in order to discern and enact. Design in these terms is more related to means for people to experiment different spatial possibilities in context, so they can evaluate, for example, where to place the openings as well as the size of the rooms. The research towards functional optimization of the interior and exterior layout should first of all keep into account different needs and desires of the users and the existing differences in conceiving the house and its functional aspects. By accepting the involvement and initiative of the user as a starting point for contemporary housing, we may begin to see a way out of the constrains in which we operate. Unsuspected possibilities emerge. Both the technological and the human sides of the housing problem can acquire new perspectives[8]. Indeed, the existing barriers that are slowing down the process of renovation of our suburbs could be overcome by a proper transition from a merely technical approach towards an integrated socio-oriented perspective. This

[7] Gerhard F., 2005
[8] Habraken, J., Supports: an alternative to mass housing, Urban International Press, UK, edited by Jonathan Teicher, 1999

represents an urgent matter in defining the borders of sustainability and becomes unavoidable when referring to the Social housing field.

4.1 Overcoming the social barriers: inter-active inhabitants' participation

Housing is an evolving, interactive process, and the functioning of a home must not be allowed to be unambiguous for a single moment. The process of production led to a grim uniformity rather than a flexible and highly differentiated housing environment. This process of production has resulted in homes becoming functionally closed objects that hardly admit any different interpretations by the occupants. (research TU Delft 1992)[9]. A tailored questionnaire has been produced to introduce directly the users in the process of renovation of the buildings they inhabit. We are aware of the existing limitations of the usage of questionnaires in participative form designs and research. The aim of the presented set of question was indeed to create awareness and inform the inhabitant of the possibility of his or her direct involvement. It was conceived as a first step and a first contact to define the design strategy and the potential scenarios upon which the planners and architects could have developed their proposal. The final goal is not a final solution but ~~in~~ the definition of a method, the proposal is comprised of a series of possibilities and solutions among which once again the inhabitant is asked to chose and decide according to his or her needs. Each individual imagines his own house [...] what is important is the process, not the steps of the process. As for the last step, it does not exist[10]. In the first analytical phase the buildings in Peristeri neighbourhood (Athens, GR) have been analysed (see Fig.1).

[9] Vreedenburgh E., E. Melet, Rooftop Architecture, building on an elevated surface, p.145, NAi Publishers, Rotterdam, 2012.
[10] Friedman, Y., Pro Domo, Actar Junta de Andalucia, Consejeria de Cultura, anno 2010

Fig. 1 Above: Appropriation, self expression and do-it- yourself examples Below: Socio-elevation, examples of the preliminary analysis to understand the self-expression actions already undertaken by the inhabitants in the past decades (peristeri, Athens 2013)

Looking at the pictures above it is clear that the inhabitant have intervened responding to the need arisen in relation to the inadequacy of the building in responding to environmental conditions. It is also evident the tendency in craving for means and ways to express their creativity and personal taste in turning a mere housing unit into a home. In this attempt it is possible to recognize the different cultural background and the very poor level of adaptability and flexibility allowed by the original layout of the building. This phenomena is not peculiar of the Peristeri neighbourhood in

Athens pictured above, it becomes even more systematic in those social housing district characterized by a great cultural mixture and significant differences between the original inhabitants and the current ones. Top-down actions usually ignore the dynamics of users needs variability, and often result in standardized spaces (the formal city of the industrialized period). This corporate logic "is a consequence of an economic process in which it was 'becoming uneconomic for the building industry to meet the specific needs of "users" for new products"[11] this means the end of diversity, and the progressive alienation of users. Owners demand convincing figures for marketing and calculating returns on the investment of the measure whereas tenants benefit from increased comfort and reduced heating energy costs. Modifications offer the opportunity to add future oriented concepts and enduring cultural creation, moreover this type of action encounters a higher degree of supports from the inhabitants that will then support the intervention rather than opposing it. It is necessary to envision an integrated approach that groups all the different phases of the projects and opens up the design from the beginning to the end to the users, exploring the most effective transformation strategy for each and every specific building and inhabitants' group.

The input idea given as a starting point of the proposal, is that non-energy-related benefits play a key role in the deep renovation of existing buildings. In particular, the research team proposes to create a substantial increase of the real estate value of the existing buildings through a significant energetic and architectural transformation. The actual investment gap in the deep renovation sector is due to the fact that high investments are required up-front and they are generally characterized by an excessively high degree of risk and long payback times. It is therefore necessary to develop harmonized, concerted and innovative actions to unlock the needed public and private funds, fill the energy efficiency investment gap and ultimately contribute to re-launch the construction market and create new jobs. The proposed strategy results in the implementation of a punctual densification policy through aside or façade addictions, rooftop extensions or even an entire new building construction, that has been proven capable of fostering the investments in deep renovation of the

[11] Wanzel, J.G., 'Systems and society', in Architectural Design, vol. 39, no. 10, p. 565, Academy Editions, London, 1969.

existing built environment throughout Europe. In the scheme of Fig.2, the proposed process of engagement of the inhabitants is shown in all its phases. Starting from the idea of using the volumetric additions strategy, inhabitants are questioned about their habits, their satisfaction degree and their wishes: where and how the extra volume can be created and built. Planners and architects study the scenarios suggested and have been able to draw primary conclusions from the cross study of the questionnaires and could therefore evaluate the feasibility of the renovation intervention both from an economical and a technical point of view. Once the potential design scenario has been defined according to the inhabitants' expressions, the formal and functional outcome is developed as a series of possibilities, an open form design. Inhabitants are then once more called to participate, they are educated throughout the entire process in order to provide them with the necessary tools to be able to discern and choose according to their needs.

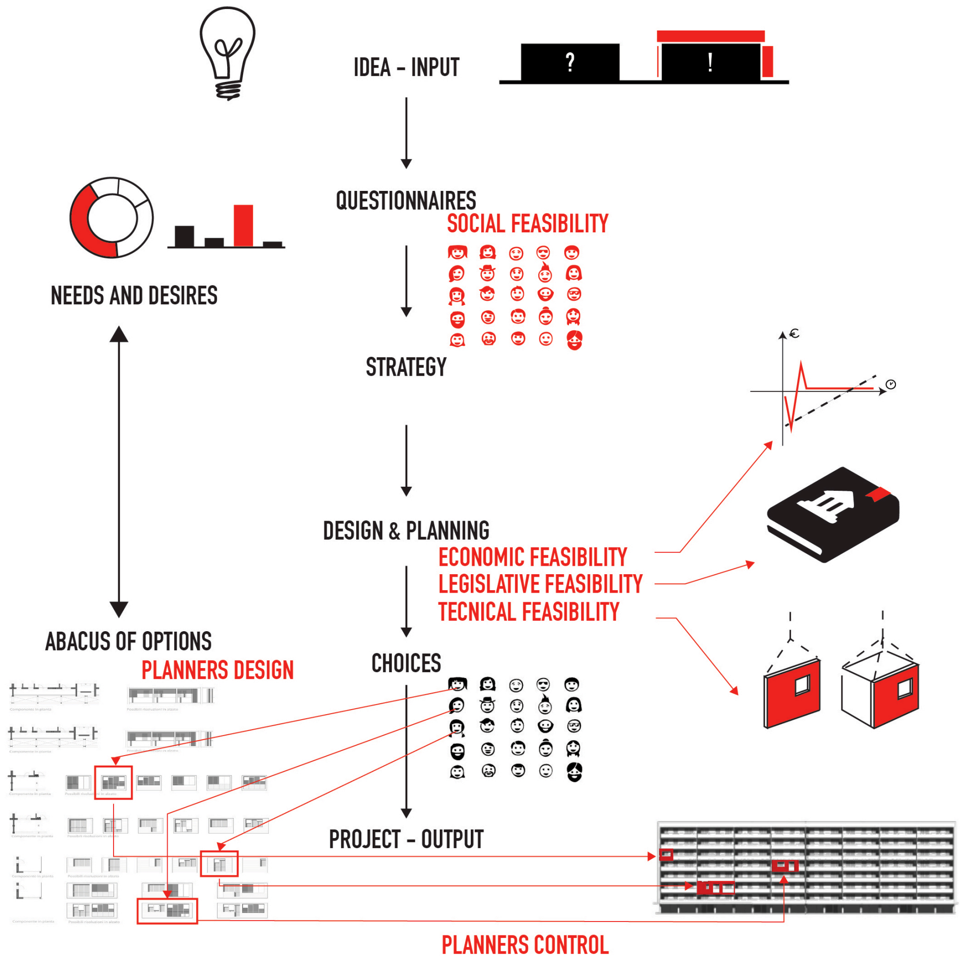

Fig. 2 Scheme of the proposed process

They are given the instruments to become again the architects of their own environment. The final decision is left to the users wile the role of the planner is to control the process and guarantee a coherence and order of the overall outcome, without interfering in the singular choices.

The dialogue with the inhabitants started with the delivery of the Research Questionnaire, translated in English and Greek. The main scheme has been kept the same in Peristeri neighbourhood as for the other case studies throughout Greece and Europe (Reggio Emilia in Italy and Frankfurt am Main in Germany) but some integrative parts have been added according to the specific desires of the housing corporation and/or the research. Also some of the questions have been changed according to the owner-tenant situation, current condition of the housing and possible intervention trough volumetric additions.

The most appropriate methodologies chosen for the social investigation carried, considering the scientific purposes of the research are the *participative observation* and the *structured interview*. The *participative observation* consists of a research strategy where the researcher directly enters for a specific time frame in a specific social group considered in its natural social environment, building direct inter-action relationships with several members of the group, in order to be able to describe their actions and to understand, through an identification process, the reasons and motivations; this allows the researcher to develop a complete 'inside' view and perspective which is the fundamental base for the understanding of the later carried analysis. The *structured interview* is based upon a set of a fixed and ordered number of open questions that all the interviewers will be asked to answer in the same formulation and sequence. To these questions, the inhabitants have been left the possibility to answer freely. This has been chosen in order to avoid the risk of presenting pre-evaluated solutions or problems and leave the freedom of expressing their needs, views and thoughts to the inhabitants without interference from a technical or researcher mind set perspective. This type of interview is not considered a simple technique, it is described in literature as an interaction between two human beings, the results and path of the discussion is not strictly dictated and forecasted. The scheme is not fixed and the results are on-going and different for each individual that is questioned.

The flexibility of this type of instrument allows a broader potential of conclusions that can be derived but, on the other hand, does not base itself on pre-set general rules. The empirical material produced through the interviews is represented by the interview itself, in order words by the motivations, the opinions, the behaviours, the beliefs and the comments that the interviewed provides during the dialogue, through verbal and also non-verbal expressions. As a direct consequence of the constant type of stirrings and the standardized structure of the interview situation, it is possible to presume that the answers can be compared and analysed together, which represents the main advantage of this type of interview[12]. Taking natural sciences and their techniques as model, it can be stated that "the questionnaire can be considered not only as a means to obtain answers, but as a method to put the interviewed subjects under experimental stirrings, even if only verbal ones[13]. The answers can be directly compared one with the others since all the interviewed persons have been posed in the same manner, it is important to maintain the same questions' order, the interview person and the tone of the interview in order to have a uniform conditions of testing.

The interviewer is allowed to intervene during the investigation only in case the interviewee has not comprehended the question; also in this case anyway, the interviewer should repeat the question at least once as it was posed because the misunderstanding is often due to lack of attention[14]. The questions of a questionnaire can be classified according to different criteria, among which, for example, the typology of themes that are placed. The most significant classification, on a methodological level, it is connected to the form of the questions: closed questions, semi-closed questions and open questions.

Since the interview represents a form of interaction whose origin is external, the first difficulty consists in finding the participation from the potential subjects. This task, can be simplified by a brief introduction to the research that should fulfil at least the three following tasks:

- Identify the research's promoter entities or parties;
- Clarify the scope of the research
- Underline the scientific relevance of the contribution given by the subjects that will take part in the survey.

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[12] 2 Goode, W., Hatt, P. K., Methods in social research, 1952, tr. it. Metodologia della ricerca sociale, Bologna 1962
[13] Hyman,H., H., et al., Interviewing in social research, Chicago 1954
[14] Kahn, R. L., Cannell, C. F., Interviewing: social research, in International Encyclopedia of the Social Sciences, 1968, VIII, pp. 149-61

It is good practice to reassure the interviewed subject that the information given will remain anonymous[15]. For this purpose the introduction to the questionnaire of our research has been structured as follows:

> *Dear Madame/dear Sir,*
>
> *The University of Bologna, together with the Marie Curie Project and the Municipality of Peristeri/Reggio Emilia/Frankfurt am Main is carrying out a research to evaluate the awareness of inhabitants and citizens regarding the potential of architectural and energy renovation actions on existing building. More specifically, the University of Bologna, the University of Athens and the University of Applied Science Frankfurt, have proposed a new and innovative approach, through volumetric additions increase the economic feasibility of the interventions. We believe that this strategy has a great potential to develop new dwelling units that could be sold and therefore repay the energy renovation of the entire building reducing the additional economical load on the current inhabitants but still improving the energy performance and the load on your electricity bill.*
>
> *We would like to know your opinion on the subject therefore we are asking you to answer to this questionnaire and participate in our research. By doing this, you would contribute to the first steps towards a more energy efficient built environment and help us in fostering the renovation process of our cities.*
>
> *Please keep in mind that this is a preliminary research and it is solely aiming at investigating the potential of this type of intervention and the opinion of citizens: there is no planned program or project on-going on your building, we are imagining scenarios and not planning future actions. The result of this analysis will be highly confidential and used merely for research purposes, the personal data collected will not be reserved and the interview is conducted in anonymous form.*
>
> *In the attachment to this document you can briefly take a look to the previous design experiments and experiences carried Europe-wide. We are trying to envisage the renovation of existing building and improving the energetic, architectural and urban conditions through an integrated design approach.*

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[15] Galtung, J., Theory and method of social research, Oslo 1967

We believe that our intention of placing the inhabitants' needs at the centre of this process meets your support and approval, we thank you for your collaboration and we ensure that we will inform you directly about the results of our survey and design research.

Thank you for your collaboration,

The research team.

The questionnaire is then composed of an introductory registry part and three sections regarding:

1. The inhabitant's opinion upon the current condition of the building
2. The inhabitant's opinion upon the possible transformations' proposals to improve the architectural/energetic/urban conditions
3. The inhabitant's open suggestions on the subject

The user is then asked if he/she would be interested in taking part in active workshops and activities and to leave a contact detail in order to create a first committee of inhabitants, grouping those that mostly are interested in taking an active part in the project. In the attachment to the questionnaires have been presented some previous design experiments and experiences carried by the research team on other case study building in order to help the inhabitant to have an idea of the proposed strategy. Also the different typology and topology of the volumetric addition as potential transformation of the single dwelling unit have been proposed to the user to understand what they would find interesting among the possible layout transformation. The questionnaire phase is here not seen as minor forms of user representation and not used to find out design options but indeed to investigate the reaction and to be able to program and develop a machine able to set up an active and inter-active dialogue. The main goal is to define trigger nodes that could be used as negotiation points to gain consensus from the inhabitants towards the renovation intervention and obtain an overall support from the community. As an outcome of the questionnaires, planners will be able to draw potential architectural and urban scenarios that will then be evaluated for their economic and technical feasibility, having assured that the type of proposal and volumetric addition suggested are coherent with the wishes of the inhabitants and users that live in the neighbourhood. The proposed method is based upon an open design that remains open from the investigation phase up until the project development and funds collection phase.

A form of thematic analysis was used to analyse the data. Although the flexible and exploratory nature of qualitative data analysis means there is no exact solution, the procedures used closely followed the recommendations described in Braun and Clark[16], which has been very widely used by qualitative researchers[17,18]. Their approach to conducting thematic analysis consists of 6 steps:

(1) familiarization of transcription and data;
(2) coding of interesting features;
(3) searching for themes;
(4) inter-correlation of themes and coded extracts;
(5) defining and naming themes and
(6) production of the report.

These are inter-related processes that occur cyclically throughout the analysis, ensuring that links between the data and emerging ideas are maintained throughout the process. Braun and Clarke's process carries the advantages of rigour and transparency, as well as encouraging both description and interpretation.

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[16] Braun,V.;Clarke,V.Using thematic analysis in psychology.Qual.Res.Psychol.2006,3,77–101
[17] Blaxter, L.; Hughes, C.; Tight, M. How to Research; Open University Press: Buckingham,UK, 2010
[18]Thomas, J.; Harden, A. Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Med. Res. Methodol. 2008, 8, No. 45

4.2 The façade abacus as design tool and its application

The proposal is based upon the idea of developing an abacus of the possible technological and formal solutions that should be used to give the inhabitants the possibility to express their needs within a common order, respecting the guidelines of the project. The potential adds-ons and façade transformations will be considered as a result of combined ethnographic and end user needs involvement aimed at delivering forms of customized and variable components of self-expression in operations of energy retrofitting of existing building stock, with respect to urban dwellers and users' expectations. From a planning point of view, the customization process is able to outline new horizons of evolution of the spaces of the residence, by looking at the house plan as a resultant of an open transformation path, as an outcome of cyclical events leading to an interaction of the scheduling, achievement, practice, care and maintenance cycles, no longer in a temporally linear vision and, above all, based on the users' active involvement in the modification and in the built estate management.

The technology that is suggested as key innovation to tackle the energy renovation field is based upon the utilization of wooden prefabricated façade components and extensions that could easily be produced through a CNC machine. As previously explained, the possible interventions have been categorised into three different levels, at each level corresponds a different scale of the renovation element. Level 1 is based upon the façade element, level 2 upon the horizontal extensions and level 3 upon the vertical extensions. In order to group all the possible typological and geometrical variables that can be produced with the same technology illustrated in chapter 3, an Abacus chart has been chosen to illustrate the range of options. The potential renovation elements shall be considered not only as a technological element for the energy renovation but also as a result of combined ethnographic and end-user involvement aimed at delivering forms of customized components of self-expression. When considering the design and production relationship, it is necessary to exactly and preliminarily understand the morphology of the buildings, the most representative types of openings in the façade and define the possible transformation that each façade module could encounter in the design proposal. It is then fundamental to define the different shapes of the panels that could fit within a large number of scenarios and at the same time could be produced in opened forms and configurations so to answer to a vast number of possibilities, as required by the vast housing stock and various user needs. In this terms, the abacus becomes one of the main design tools for planners and professionals involved in the process: it the catalogue of options among which the inhabitant can choose and will enrich the possibilities of synergies between the technical and sociological proposed strategies. In order to do so the starting point is the data collection through the utilisation of a 3d scanner that enables the planners to collect precisely all the geometrical information regarding the existing façade. The mere collection of points is not sufficient, it is in fact important to study and map the original façade, the main axes, the possible symmetries and the division of the envelope in parts that can then be separately reproduced, built and mounted.

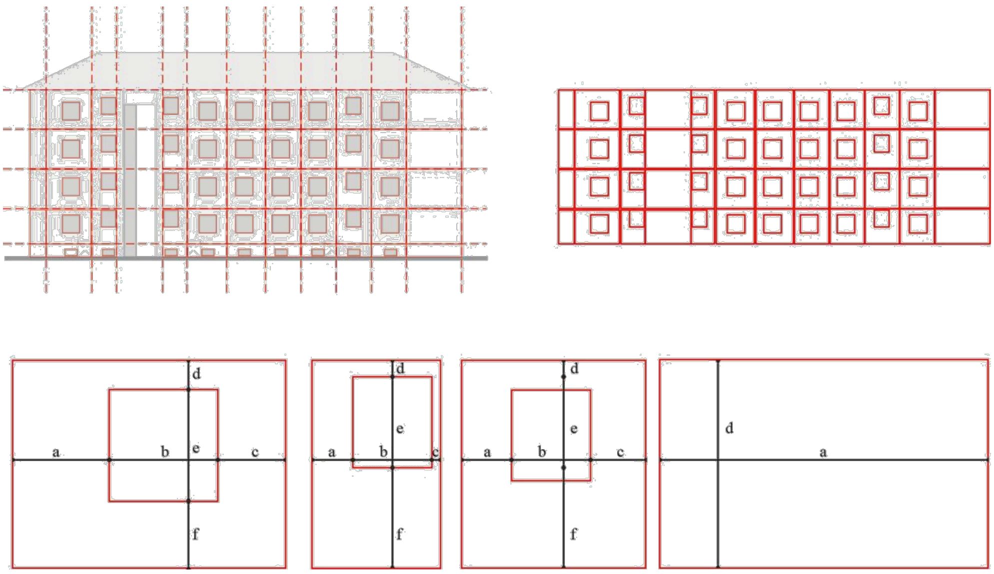

Fig. 3 Example of the possible façade sub-division and panelling

The planners have to define where are the boundaries of the base element and the possible subdivision of the façade in the most efficient and effective base component. The idea is to identify the base element whose dimension can vary in infinite numbers but whose typology stays fixed.

Fig. 3 shows a façade type divided into regular modules. Every dimension of the base façade module has then been given a parameter: the high of the floors, the window dimension, the balconies or loggias outline, the ratio between opaque and transparent surfaces etc. The planners can directly introduce the data that come from the survey on the existing building, each and every time different, each panel and each building, but the definition of the module and the production machine will be the same reasoning on the same parameters. This module is generally the one that is then repeated in the original pattern of the façade. It is however true that the façade chosen for the above example is a simplification and can not represent the large number of cases that could be encountered in the Housing building Stock. A broader catalogue has been studied, although the author is aware that it is an on-going process and should remain an open catalogue continuously updating and enlarging considering a broader range of possibilities and façade element typologies.

The focus of the research is here once again on the methodology proposed rather than on the completeness of the survey upon existing buildings' elements and their typology. The variables that have been selected to define the different model of the original façade that can be encountered are showing Fig.4. The number and size of the openings can vary and is function of horizontal and vertical coordinates (the distance of the openings from the borders of the panel and among each other). By mapping and coding the generic façade panel upon the above listed variables it is possible to define an open geometry through the utilization of Rhinoceros (MacNeel) as three-dimensional modeller and the Grasshopper plug-in to govern the parametrical variation of the geometrical dimensions. The Grasshopper plug-in is a graphical algorithm editor that allows designers with no formal scripting experience to quickly generate parametric forms (Day, 2010). Therefore each of the above panels can be modelled and its parameters (geometrical dimensions) can be left unknown and changed time by time according to each different panel and each different building. The building chosen as example is only a simplification of the broader range of building façade that the suggested methodology could cover. As demonstrated in Fig. 4, for each building the first step consists in the definition of the façade element type and geometry. The second step consists in defining the possible variation that each of the panels can have in the energy renovation phase.

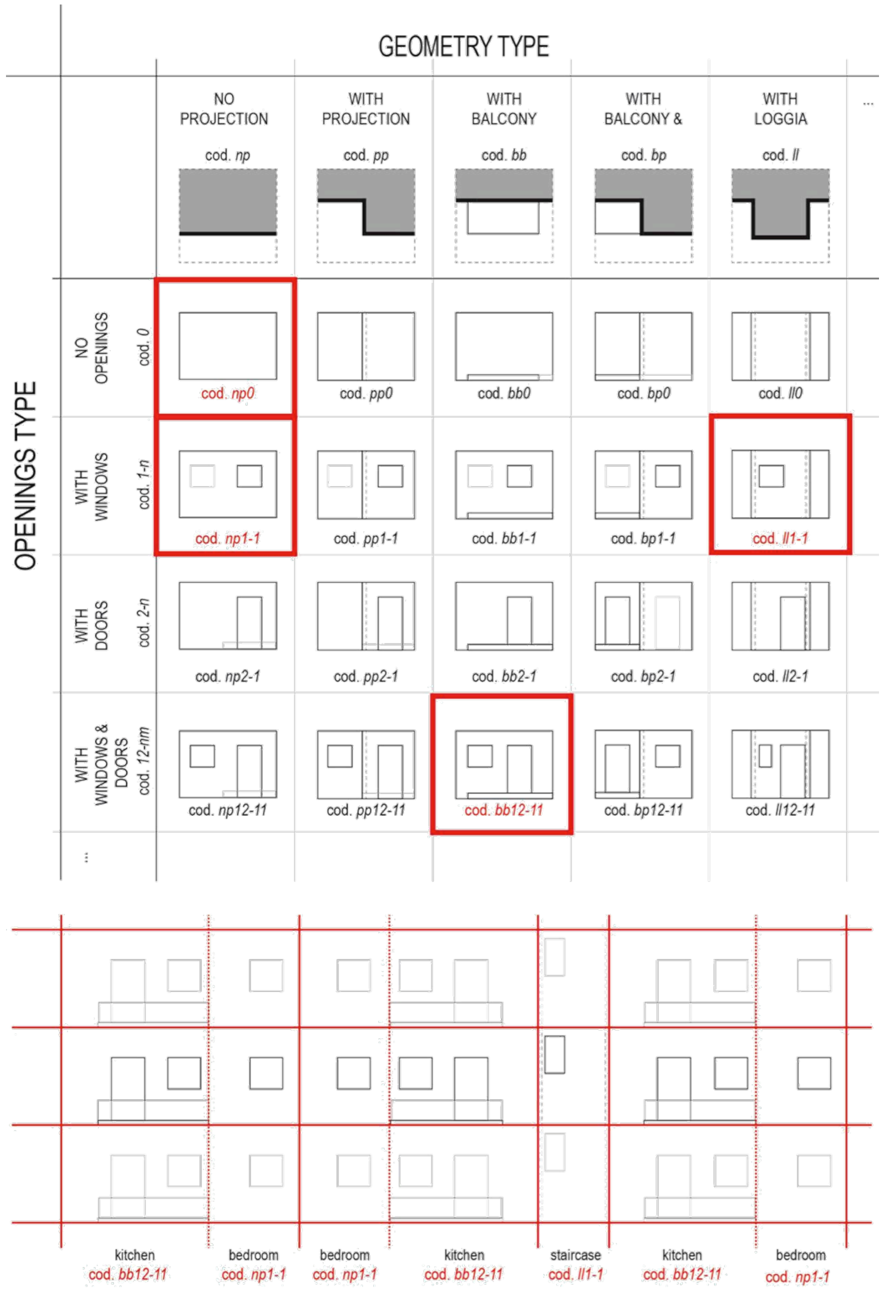

Fig. 4 Scheme reproducing the possible façade typology. According to the geometry and openings type (the number of openings is coded with the variable n) it is possible to define the pattern of the façade and reproduce it exactly in the Rhinoceros environment. Once the code for each façade module is ready the planner has only to enter the dimension and the model generates automatically ready to be sent to fabrication.

This is strictly related to the type and level of intervention planned. In the scheme, Level 0 has been introduced and considered as the stage where the inhabitant does not want to undertake the façade upgrade and there is no alteration. Level 1 of intervention foreseen the façade transformation therefore the existing façade component could be substituted with an identical (but with high performances) façade element (1A) with proper insulation or variation could be foreseen within the façade module of different entity. The grade has been considered increasing in terms of performance and improvement given to the envelope, calculated on the base of the Envelope Performance Index. Same can be said for Level 2, where the horizontal/vertical extension could simply be generated by the extrusion of the existing façade or rather change the geometry of it. As for level 3, in case of vertical extension, the prefabricated module that is added on the roof can reproduce the façade of the existing building continuing the alignment of the façade and openings, or sign an interruption and a break with the existing building. been grouped in this chart that is illustrating the level of increasing upgrade that could be applied to the façade. As shown in Fig. 5 up to six total possible modifications for each base modules have been envisaged (the number of variation can be increased case by case, according to the planners desires). The design process is therefore based upon the idea of developing a collection of possible technological and formal solutions for the new envelope that should give the inhabitants the possibility to express their needs within a common order, respecting the guidelines of the project. The three levels of action, explained in Chapter 3, are characterised by the use of the same technology that could therefore supply to all the incremental stages of the renovation design. The catalogue that will be delivered to the inhabitants will show all the possibilities of transformation, from level 0 to level 2C. The invariant structure designed as adjacent prefabricated and modular structure is thought to improve the structural performances of the existing building and, at the same time, support the Add-on for Horizontal and also vertical extensions. For each option, together with the information related to the costs of the intervention, a detailed evaluation of the energy savings and increasing in envelope performance will be provided. These information will be illustrated and explained in order to be understandable and easy to comprehend the positive impact also from the users' side, intent as mostly non expert audience. The given details are fundamental in order to enable the inhabitant to make the right choice regarding his own needs and economical possibilities, based upon the conviction that an informed choice is the best one.

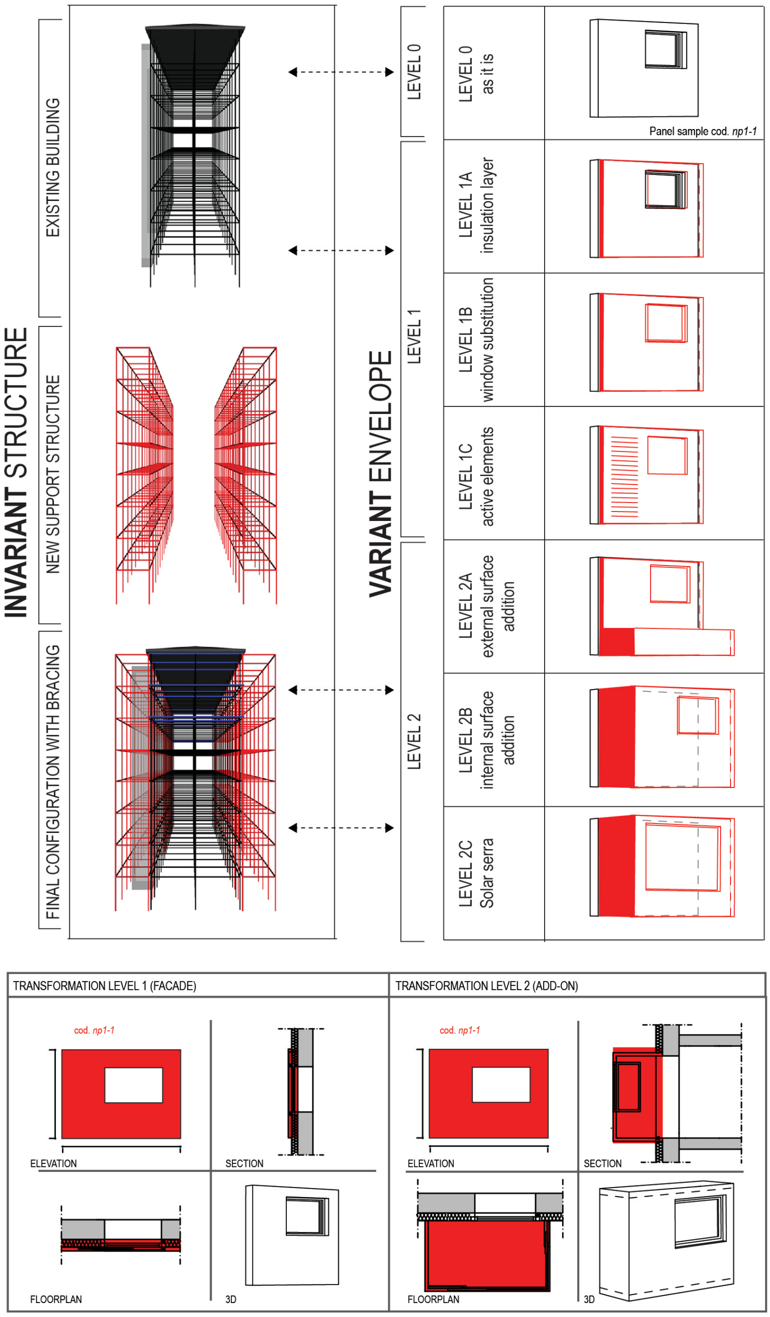

Fig. 5 Structure for the Abacus construction. The design is composed by two sides: the invariant structure, designed as adjacent structure that can also improve the structural performances of the existing building and the variant envelope, composed by a series of facade components that are designed to be combined and include a high degree of flexibility up to 6 levels of transformation. The invariant structure has to support the Add-on and extension and is thought to allow also possible extensions towards the Level 3 of transformation on the rooftop.

Together with the performance aspects, it is important also to set the variables related to the aspect of the façade and the personalisation degree. As example for the purpose of explaining the method illustrated, a set of six different possible parameters have been chosen. They represent the character and possible ambits among which the planner can decide to leave space to inhabitants to decide and take action. Whether the Abacus promotes the breaking of the original geometry or rather maintains the original rigour, as well as the main characterising object of the project is based upon the usage of a special material, its patter or the tiling of the façade has to be determined by the planners according to the previous analysis carried on the context and his/her own sensibility. It is therefore impossible to define a standardised catalogue of choices and possibilities that could fit every circumstances but the suggested method guides the planner in the definition of a case-specific set of elements (façade components, horizontal extensions and vertical extensions) among which the inhabitants could choose and express their preference. The abacus of possible solutions will be different case by case and strictly related to the original building but the methodology, the technology and the type of elements involved in the definition of the abacus itself will remain fixed.

The common method assures that since the 'letters' of this alphabet have been studied as a modular system and can be joined together in multiple combinations, the free 'discourse' that will be produced from inhabitants will have a positive result. The theoretical assumption is based on the possibility of developing multi-variant design for the façade refurbishment to form up to 1,000,000,000 alternative versions. Design codes are not alone as tools with a role to play in enhancing design quality and potential in building renovation, and are certainly not appropriate for all forms of development. However, where they are appropriate, the evidence now suggests that they can make a real contribution to raising the bar and delivering a better quality built environment.[19]

[19] Clemente C., F. De Matteis, Housing for Europe. Strategies for Quality in Urban space, excellence in design , performance in building. Urbact Pubblication, Tipografia del genio civile, Roma, 2010.

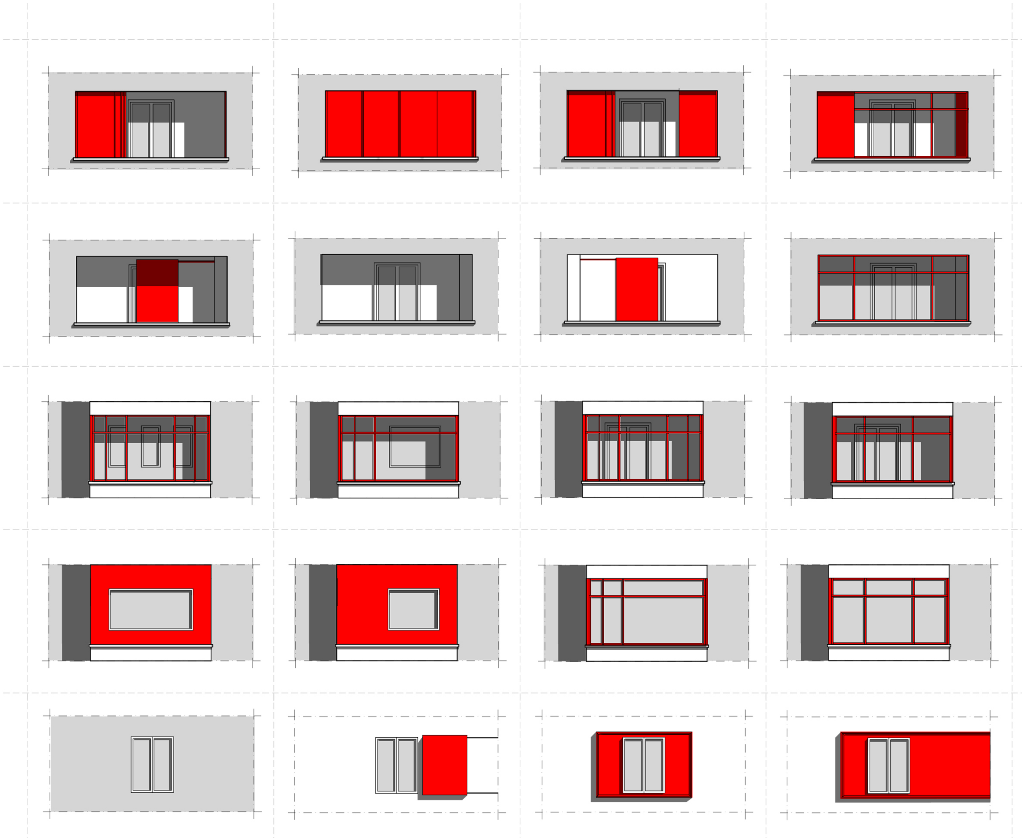

Fig. 6 Extract from one of the design abacus used in the validation and design phase of the research on the Reggio Emilia case study. The six levels of transformation including balconies, facade coating, serra, window renewal etc. have been translated in a conceptual and abstract framework without intending to define at this stage a formal direction for the project. The possibility of choice is left to the inhabitant but the components have been thought to be combined, exchanged or connected maintaining the coherence of the overall facade within a set of prefixed rules.

Planners and designers are empowered with a tool to control the process and at the same time the potential and outcome possibilities of the design are extended. From a geometrical, typological and formal point of view it is important anyway to set the rules for the definition of the new façade outcome. Should the style be defined by the inhabitants directly leaving them total freedom in terms of material, colours, shape and function or shall the architect impose his own interpretation? As anticipated, the sociological component of sustainability is central and plays an important role in the feasibility of the intervention. The topic is once again not new, the problematic has been faced often in the history of architecture and has often landed in simplified answers. Yona Friedman states that "*an architectural style can arise from inhabitants' instinctive and automatic decisions, it is a randomness in order (...) design is a game with no explicit rules*". The same idea is supported from Price as well that writes: "*One uses a tight, carefully designed technology to achieve a loose, free-will social patterning. I don't think this sort of variation necessarily requires any compromise on the validity of the first design intention*." It is, in other words, a search of randomness in order: the idea is that it can be possible to control the chaos, with the aid of a computer and interface, without the need of defining a formal style and any control on the outcome. There is a need for a style that is determined and set according to the context and the pre-existence, according to the taste and interpretation of the designers. The role of the architect is and stands on the formal and interpretative side. There is a need of rejecting the idea of possibly and efficiently being able to chose and discern, interpret and understand the need of the inhabitants and the final decision should be left to the users. The possible solutions and the suggestions should anyway come from the architect that sets a pattern and a series of proposal, together with the rules that stand behind the computer aided program that is then used as an inter-active interface to handle the dialogue with many final users. This ensures the coherence of the final outcome, proposing only fitting solutions and re-iterating the trial and error loop narrowing down the choice among the possible choices, still defined by the architect, that therefore plays the role of moderator and definitions' controller. It is once again the architect that sets the rules of the game, the formal guidelines and guarantees the correspondence of the project with the general needs, requirements and pre-existent context. Within this open form and supports scheme, the inhabitants can chose what is the most fitting option among the possible defined by the planner.

Upon this aspect the author wants to stretch a clear distinction between the proposed methodology and the related design outcome and the reference theories above mentioned. According to the here presented process the architect is and should always be the person that stands behind and controls the entire system. The scheme provided is only a reference illustrating the method that stands behind the creation of the abacus. It is clear that, once the base modules have been found and defined, the formal, geometrical, material and chromatic variations' possibilities will be determined by the architect. In fact, all the aspects that overcome the merely typological analysis have to be evaluated and based upon geographical and climatic consideration, coherently with the planners sensibility, the context and a large amount of variables that are not entering the core of this research. A simulation of the possible outcome of the process and the possible abacus definition will be provided through the case study projects presented in chapter 5.

4.3 User-oriented solutions through a computer-aided approach

Because the architect of the past served a single client, he could become thoroughly acquainted with the client's individual tastes and way of life – he could make the client's decisions for him. The majority of architects designing housing today do not work for millionaires, but for millions of individuals who will work or live in the architects' projects. The architect cannot study the behaviour of each user: instead he constructs an ideal user and plans for this ideal. He should, instead, devise methods of promoting choice among the users themselves.

Yona Friedman

Already several researches[20] have shown the potential of inter-active systems to incorporate a high degree of adaptability within the renewal for office or retail spaces, investigating the possibility from the users to actively intervene on the functional distribution and layout of the building. Still very few has been said about how to incorporate the multiplicity of users needs and habits to the complex sector of social housing refurbishment, where rigidity is generally one of the main constrains. The machine and today the computers can help us in controlling the wishes of inhabitants and integrate them in the decision phase, directly allowing the user to control each one his one part of envelope. The idea of a user oriented design that surpassed the oppressing Modernist generalizations of the "*modulor*" and the "medium user" produced significant movements that envisioned the city as a large non-defining infrastructure fostering desire and difference, allowing the individual to develop his or her own hypotheses. Yona Friedman is considered as one of the fathers of these ideas, with a major influence on groups such as Archigram or the Japanese

[20] Researches conducted by ETH Zurich, 2011.

metabolism. For the first time with F., after the Architecture Machine Group in the United States, the role of the machine is not that of a partner of the architect, he is rejecting the idea of shifting the designer position “from machine servants to machine partners”, instead the machine becomes a controller and calculator, able to bridge between the final users and the architect knowledge, in order to allow the designer to control a huge number of variables and combine multiple in-put and out-put ones within the infrastructure and the fixed elements set in advance. There has been a vast body of literature that consists of early studies (1970-1975) in the development of computer programs empowering non-experts to create their own designs, within the broader historical context of the rejection of the modern movements paternalist practices and the emergence of the demand for a user-oriented architecture. Since the object of this research is to propose a process that allows the users to directly intervene in the energy renovation design, the comparative analysis of these studies brings to light different approaches towards the definition of “empowerment”, the role of computers as mediators of this process and the way this objective can be expressed through software design decisions. It is in the Soft Architecture Machines[21] that the term “computer-aided participatory design” is explicitly used for the first time, providing a synthesis of all the previously discussed approaches. The main written theories that are used as references are:

- “The Architecture Machine”, by Nicholas Negroponte,
- “Toward a Scientific Architecture”, by Yona Friedman,
- “Soft Architecture Machines” by the same author and
- “Architecture-by-Yourself: An Experiment with Computer Graphics for House Design” by Guy Weinzapfel and Nicholas Negroponte.

The main critic that can be moved to this approach is the willing of the architect to reject all the control on the formal outcome of the process, since there is a functional and procedural control

[21] Chang C., Applying agent-based theory to adaptive architectural environment-example of smart skins, Smart Home Systems, Edited by Mahmoud A. Al-Qutayri, 2010.

above the trial and error reiterative process carried by the flat writer but the formal control is left out and this could only lead to disorder and chaos. The availability and accessibility of design software, the growing culture of “making” (or “hacking”) as well as a demand for product personalization, and user-oriented design, the reinforcement of the idea of collaboration through hardware and software online communities, the increasing number of open-source platforms for sharing and confronting the ideas, along with growing concerns on the increasing alienation of architecture from its social connotations, bring the question of computer aided participatory design back to the surface, demanding for redefinitions and reformulations. Hansen called Open Form a philosophy, a position that defined one's attitude toward reality. The concept, which referred to the theory of sculpture and architecture put forward by Katarzyna Kobro and Władysław Strzeminski, could be construed sociologically as a structure of space shaped by various types of human activities. Hansen always stressed the humanistic element in architecture, never the technological angle. He wrote, "Open Form is about variable compositions – the processes of life highlighted by backgrounds."[22] Friedman further develops the open form theory of Hansen and the supports of Habraken, in his infrastructures visions for the Ville Spatial: the defined and structural infrastructure leaves space and opportunity to the inhabitants for self-expression and freedom within the support and fixed schemes. There is a pre-determined order that ensures functions and technical needs to be fulfilled and there is space, within this order, for the disorder and the open formed, according to Hansen ruled and governed by the final users, since only the inhabitants are capable to design and conceived the most congenial space for their own living space. Friedman inserts the idea of the Open Form from Hansen into a programmatic approach of inter-actions between the users and the architect. His idea is based on a trial and error reiterative process that would lead to a continuous enlightenment of the users as non-experts actors of the design process but as the best knowledge carrier about what is suitable for them. The dweller becomes the designer through “domesticated” architecture machines that permit to each resident to overlay his architectural need upon the

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[22] Lagios, K., J. Niemasz, C.F. Reinhart, Animated building performance simulation (ABPS) linking Rhinoceros/grasshopper with radiance/daysim, MA 02138 USA, proceedings of SimBuild, 2010 New York City.

changing framework of the city and fit his own module, within the infrastructure, in the urban context. The suggestion and inspiration for using a machine for this dialogue came directly from the research work developed in the 50s by Yona Friedman who also invented for the world's fair at Osaka the 'Flatwriter', a computer program conceived to enable the process of self-planning. He explained this principle in a lecture that was broadcasted by the French television in 1969. "I call this a choice machine. In practice, we say that there are an incredible number of possibilities for apartments. You can make millions and millions. And in this machine, there is a keyboard, which shows the different configurations, the different forms, the different positions for the kitchen, the bathroom, the toilet, and everyone can use different keys on the keyboard, and print for themselves the apartment that they prefer. The machine at the same time, checks that this person's choice doesn't block the access to anyone else's apartment. And does not block the light and the ventilation. And so at this exhibition, ten million visitors to this exhibition will print, building a town with ten million inhabitants, which is then displayed on a television screen, in front of the people who built the town[23]. The utopic envision of Friedman inspired the continuation of the work and the translation of the questionnaire into a programmatic system that will enable inhabitants to express their desires and receive a direct feedback within possibilities and solutions that will be incorporated and directly compose the over-whole renovation project. Already in Friedman vision for the Ville Spatial it is possible to determine the distinction between the two groups of elements that stand at the base of the here proposed system: the invariant system - infrastructure - that is in charge of guaranteeing structural stability, plants and the variant system made by variable elements -the boxes- that translate the individual needs and wishes of the individuals into physical elements. This approach, opened and adaptable, flexible and *in-fieri*, where inhabitants re-appropriate of their right of expression has been defined by Negroponte as a new form of humanism. It is therefore a methodological and procedural question regarding the process and how to make it possible to translate and interpret the needs of the inhabitants as the main object of the (re)design gesture. Quoting Negroponte: "Yona Friedman has used a mathematical scaffolding to

[23] Media type : Vidéo, Broadcast date : 23 Septembre 1969, Source : ORTF (Collection: Eurêka)

support philosophical positions in a manner which affords the reader the opportunity to disagree with his utopian posture, but still benefit from his techniques (...) If you are a student you will find the paradoxical intersection of two academic streams - participatory design and scientific methods - too frequently held apart by the circumstances of our training" and he continues "given that an artificial intelligence is distant, let us consider removing the architect as opposed to emulating him. The theory is simply that many design endeavours can be achieved by those for whom the environment will ultimately have a meaning. While this position has enjoyed a popularity in circles of advocacy planning, it has usually not encountered the support of computer aids (often a symbol of the antithesis). It has received the serious attention only of Yona Friedman in Paris, France."[24]. Negroponte proposes a framework of a resilient building and information technology and introduces a new type of personalized architecture machine, a "Design Amplifier" that constitutes the interface between the infrastructure and the user's ever changing needs.[25] What he envisaged was a "Designland", replacing Seymour Papert's "Mathland", where "one learns about designing by playing with it", expressing his conviction that even if the users will not be able to perform extremely complex tasks they will be capable of designing own homes better than anyone else. The availability and accessibility of design software, the growing culture of "making" (or "hacking") as a demand for product personalization, the reinforcement of the idea of collaboration through hardware and software online communities, along with growing concerns on the increasing alienation of architecture from its social connotations, bring the question of computer aided participatory design back to the surface, demanding for redefinitions and reformulations.[26]

It is Friedman himself that leaves the door open to his theories and suggests that they could be applied, interpreted and further developed in different scales and ambits of the architectural (and not only architectural) discourse[27]. He suggests that others shall apply his proposal in their own

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[24] Negroponte, N., Soft Architecture Machines. MIT Press: Cambridge 1975
[25] Papert, S. Mindstorms: Children, Computers, and Powerful Ideas, Basic Books, NY , 1980
[26] Vardouli, T., Architecture-by-yourself":Early studies in computer-aided participatory design, MIT Architecture, 2012.
[27] Chang C., Applying agent-based theory to adaptive architectural environment-example of smart skins, Smart Home Systems, Edited by Mahmoud A. Al-Qutayri, 2010

way and eventually develop them: his theories today, applied to housing renovation, could lead to the solution and possible combination between technology and society, including that variety that yeti s missing in the Housing environment of today. *Each individual imagines his own house, what is important is the process, not the steps of the process. As for the last step, it does not exist.*[28] The presented research finds many intersection points with the above illustrated theories and the suggested methodology through the utilization of 3d modelling software like Rhinocheros and computational parametric data controller like Grasshopper.

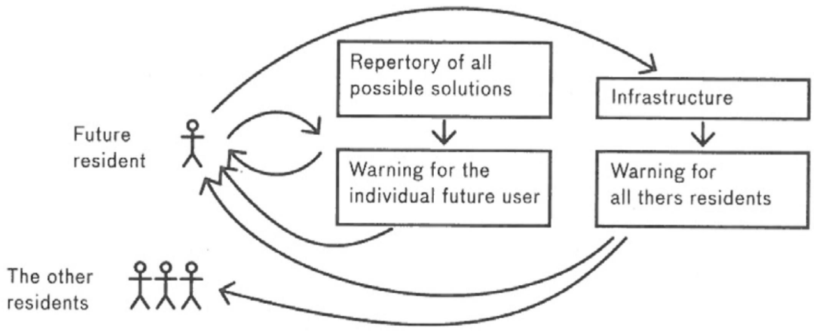

Fig. 7 Flatwriter, double loop scheme from Friedman's sketches. Source: http://www.yonafriedman.nl/

Already in the early 70s a great deal of architects and thinkers, in the United States with the Architecture Machine Group first and in Europe slightly later, computer-aided design was seen as the turning point to possible inter-action between the many (users) and the unique (architect). In this framework the first scheme developed to define the flat writer - Friedman's main instrument and tool to enable the architect to communicate with the users – results in an interesting reference model to set up the dialogue through a computer-aided mean. I will not extendedly explain here the operational outline of the flatwriter (that will be better clarified in an extended version of the research) but the previous drawings in fig.12-13 show the set of trial and error phases through

[28] Friedman, Y., Pro Domo, Actar Junta de Andalucia, Consejeria de Cultura 2010.

which the inhabitant is asked to insert his or her wishes, habits and needs before the computer returns a possible series of configurations, refining the choice and question/answer process down to the definition of the most appropriate option among the possible. The process is characterized by two phases: a first one to define the characteristics of the perfect dwelling unit as a single expression of the single inhabitant and the second phase that aims at inserting the module within the broader contexts of the 'shell', with all the other 'boxes' and modules derive from the same procedure applied to other inhabitants. From the unit scale to the urban scale.

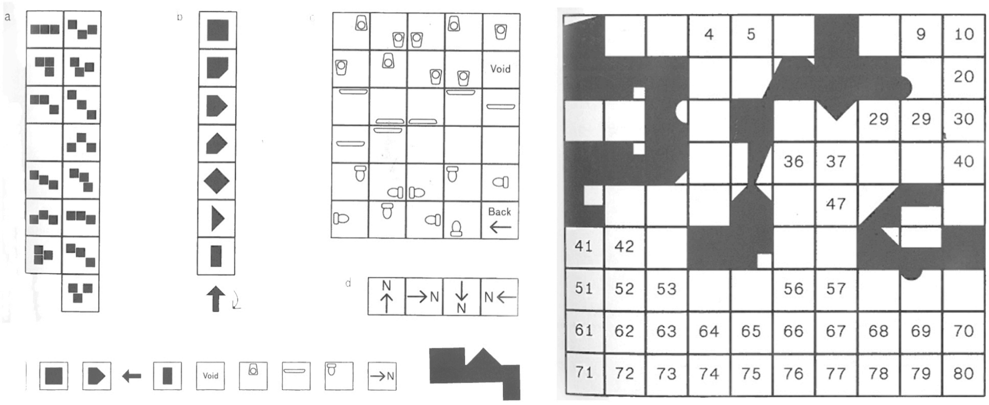

Fig. 8 The decision making structure of the Flat-writer. The infrastructure is designed in order to (a) chose the plan and the character of the apartment – private environment- (b) choose the site of his private environment within the town-public environment and (c) be informed about the particular issues concerning himself, himself and his home. Source Friedman, Y., Pro Domo Actar Junta de Andalucia, Consejeria de Cultura 2010.

Through the Flatwriter Friedman tests and experiments what he defines 'Randomness in order' and its unimaginable visual potential based upon the conviction that an architectural style could be created from the inhabitants instinctive and automatic decision.[29] F. already used the verb print

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[29] Friedman, Y., Interview with myself (kind of balance), in Pro Domo, p.26, Actar Junta de Andalucia, Consejeria de Cultura 2010.

referred to housing when describing its Flatwriter without imagining how visionary his interpretation was considering the development stage that 3d printing has reached in the construction sector:

"I called it Flatwriter, coined from typewriter, since it has no grammar of tis own, it is the individual user who writes whatever he wants. Anything goes. It is a keyboard consisting of 53 key, each printing the figure shown upon it. They represent configurations possible within three volume as well as different forms that can be assumed by each volume. It is thus possible for any future resident to print his preference for an apartment. Mr. X types, using the keyboard, the configuration of the floorplan, the shapes of the rooms, he locates the kitchen, bathrooms and facilities and finally decides the orientation of the house. He uses in he end only 8/9 keys, chosen among the 53 keys of the Flatwriter, thus choosing his plan from some millions of possible plans offered by the machine. The Flatwriter could print the apartment and calculate the price as chosen by Mr. X. In a second stage Mr. X indicates his habits, he is asked how often he goes daily in each room, representing a parameter of his personal way of life. The first warning of the Flatwriter arrives. It indicates for Mr. X what issues can expect concerning his plan and suggests an alternative plan for Mr. X or he might also prefer to change his habits."[30]

The above described functioning of the flatwriter is limited to the apartment scale a second phase will insert the apartment of Mr. X in a broader urban scale. It is important to underline the function and idea that stands at the base of this tool produced by Friedman. The architect has designed a tool to enable the user to choose among millions of possibilities. What seemed rather utopic at Friedman time is now possible and shall be integrated in the renovation practice to offer the necessary variability to the project. Moreover, it is important to point out the role of the process in leaving the freedom of choice to the inhabitant but at the same time consulting him after an analysis of his habits and personal variables with technical knowledge that he does not have. The process should provide the user with the information necessary to improve the instinctive choice and at the same time investigate upon the personal variables connected to the design that are generally unknown to the planners.

[30] Ibid, p.129-137

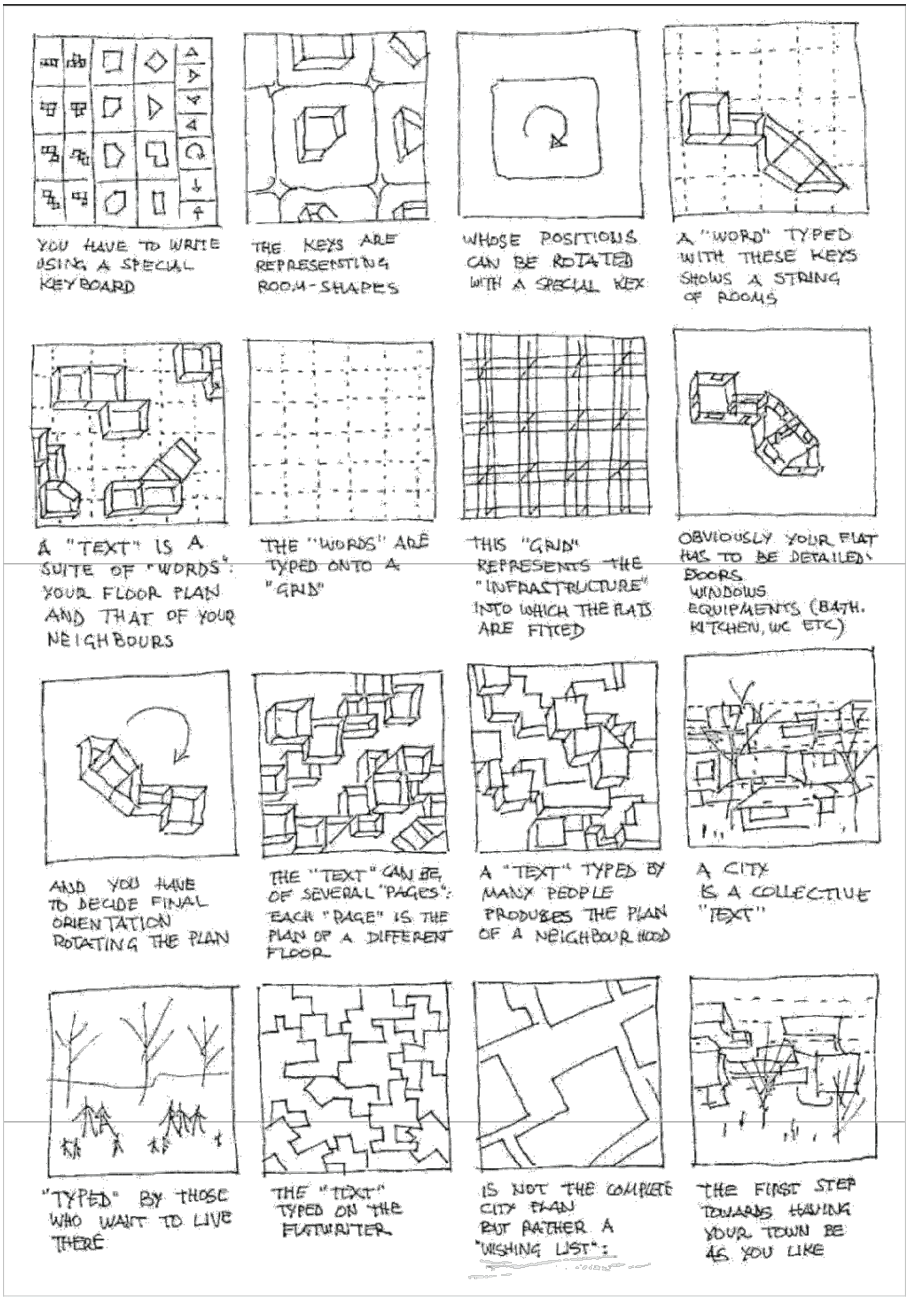

Fig. 9 Flat writer, explained through Yona Friedman drawings. Source: Friedman, Y., Pro Domo, Actar Junta de Andalucia, Consejeria de Cultura, anno 2010.

The questionnaires that have been conducted had the intention to collect the private knowledge that is normally lacking in the renovation process and base the Add-on proposal upon the sociological features that could be derived from the survey. Yet in the future this approach could become highly inter-active and be translated in visual language (reason why Friedman also decided to use comics and drawings to illustrate his theories to the users).

The main experimental design that followed the ideas and principles illustrated above and tries to re-interpret the Flat writer software into more contemporary definitions are:

- TheWhyFactory and VerticalCity carried by MVRDV as examples of possible applications of the design process in an interactive computer interface
- The Wikihouse project, which shows the potential of globalization and mass production when applied to the construction and design process.

These contemporary on-going projects and experiences are trying to apply and translate the idea of the multiple-design and open form into design experiments. The Vertical Village is a vision of bottom-up residential development, which evolutionary grows and changes over time. It aims to combine the freedom of suburban architecture and the social coherence of village life with the density of the city, especially in Asia where it was first launched. The DAP3 group in collaboration with the architects of MVRDV, have thus developed a grasshopper definition that stands at the base of the HouseMaker application and allows the users to insert different parameters and to design their own house that gets inserted into a broader scale and envisages a new urban landscape for the city. It is a tool that allows individualization of one's own private space offering a set of pre-defined shapes and objects. This actually means a seemingly infinite number of combinations. The other tool of the project is the VillageMaker, an interactive, dynamic planning software, which replaces master plans and safeguards the qualities of each house in the growing and changing vertical city.[31] The two scales and dimensions reproduce the two loop-levels of the Flatwrier, first on the private dimension and second as a means of controlling the entire urban system and the interaction among the different 'boxes'. For the first time, the theories of Yona Friedman and the idea of the Flatwriter, meet the current technology of parametrically controlled data and Grasshopper codes a definition to control the variability and allow inhabitants to take part in a new interpretation of computer-aided participatory design. The methodology and the application of these software bring this experience very close to the here presented research but still, as realized probably also by the architects themselves looking at step 5, the current state of the project results in a chaotic output that fails in being convincing, especially if considering to apply such a system to the existing built environment in a renovation process. There is an extremely high degree of variability and very little rules to govern and drive the process, which leads to randomness and if on the theoretical side it is interesting to explore the potential of the suggested openness, on the other practical side it is highly inefficient in terms of production and extremely complex as formal outcome. This remains the main observation against the project and the aspect that is expected to be overcome with this research offering a way out of this methodology from being merely illusive towards signing a turning point for the mass production of design elements and components, specifically conceived for energy renovation interventions.

Examples like the Vertical City project have suggested that there is a need of controlling the process not only from a procedural point of view but also from a design side. The innovation stands in the capability of finding the set of rules that can control the process and its outcome, guaranteeing a formal coherency of the system and of the architectural result as well. The task of the architect is therefore that of drawing the pieces of the mosaic and the rules for the possible combination. The final output, unforeseeable until the completion of the choices of the inhabitants, has to be determined by the inhabitants.

[31] MVRDV, The Why Factory (t?f), The Vertical Village, Nai Publisher, Amsterdam 2012.

The Wikihouse is presented as an interesting reference regarding the production methodology and it proves that architecture is shifting from being a product for few in becoming a mass industrialization product governed by the logic of the mass customization. Wikihouse is an open source construction set, available online, and constantly growing. The aim is to allow anyone to design, download and ‘print’ CNC-milled houses (digitally printed) and components, which can be assembled with minimal formal skill or training. The last prototype has been just built in September 2014 for the design week in London. The Wikihouse phenomena and its success prove that the future tendency is leaning towards the customization of the products where the (inter)net bridges between users and digitally printable products. This strategy has been envisaged to be applied to the façade renovation components and would enable the inhabitants to control the possible design option through their application via phone and by means of the software on their personal computers used to directly communicate to the planners their wishes sending the façade component to CNC machines. The system would represent a real revolution in the renovation market and could significantly enrich the attractiveness of this type of intervention by increasing the participation of the users, minimizing the conflicts in the negotiation table between planners and users. Moreover the proposed technology has proved to be highly efficient in terms of cost and time savings, to be capable of improving the energy performances of the building and at the same time reducing the payback of the intervention by possibly incorporating volumetric addition and leaving space for possible architectural reinterpretation. The next step is to make this technology applicable to all the existing buildings and affordable to all the users, reachable and simple.

4.4 Multi-variable design

Defining the main design principles and parameters according to their variability leads to the possibility of understanding and controlling a genotype that incorporates multiple design solutions in itself. The single components (the phenotypes) can be interwoven, changed or transformed, still guaranteeing the coherence of the final composition as an open and *in-fieri* composition. By iteratively changing the parameters used to generate models one can create multiple possibilities for consideration. Variations can be produced in the geometry without disturbing the underlying topology. Variations in topology and formal composition of the façade can also be arranged by changing the number of parts or underlying relationships between parts.

As already mentioned in chapter 3, the design is divided in three stages each corresponding to a different scale in a reiterate design that foreseen the possibility of combining a large number of possibilities for the façade renovation. It is possible to determine the '*Alfa*' element that can define the façade basic unit. The variation of the *Alfa* component will generate all the other different components that constitute the envelope. Dividing and partitioning the façade in sub-components allows conceiving the envelope as an inter-exchangeable skin, a puzzle that can be deconstructed and reconstructed to reach the best combination of functionality and performance. The secondary phase consists in the definition of a secondary scale of design looking at the architectural span, intended as the space between two staircases or breaking elements in the facade after which, generally, the facade components are repeated identically. The third design scale unit is determined by the entire building. The possible design solutions are studied from the primary cell; according to the suggestions of the planners and the inhabitants a first set of options is produced. The variability of the different elements of the new façade are numerous and can be increased or changed according to the specific case study. The division in phases allows the designers, planners and the used algorithm to control the results of a design with multiple possible configurations at all the scales, from the components variations defined by the inhabitants up to the overall building where coherence shall be guarantee.

The division in several base modules allows the planner to control the façade composition and assemblage at all the scales, but how is it possible to combine the different façade elements leaving the possibility to the inhabitants to choose and at the same time prevent the chaos to govern the entire façade system? The question is strictly related to the idea of defining a set of rules and combinations that are possible and let the final outcome open. Housing discourse has not only to cope with the exclusion from the dominant practice and the myths of 'Architecture' but also find its way in the hostile territories of political and economical challenges. The revolution that the approach could bring in the renovation method offers benefits in the interaction of all the spheres involved in the Housing discourse, yet bringing the inhabitants back at the centre and enhancing the capability of the building to change and alter thus answer to the social variables and inputs through physical features. This approach, named *multi-variant design*, wants to define a new way of approaching the energy renovation practice by seeking for the definition of a design method that could lead to multiple design outcomes and not one pre-fixed and over imposed result. The variability of the different elements of the new façade are numerous: the above variables are only the primary one, a broader range can be implemented in the process and can be increased or changed according to the specific case study.

In fact all the possible design solutions can be studied and tested on the primary module; according to the suggestions of the planners and the inhabitants a first set of options is produced and the abacus can work as a catalogue of possible solutions among which the inhabitant can choose. The privilege of the first inhabitants that engage in the process and take part by expressing their choice consist in having the entire range of possibilities among which to select. The later inhabitants that take part will instead have a restricted number of choices since the planners will have discard those options that would collide with the previously chosen one. The idea is to govern the mechanism and the rules of the game but leave to the users the power to choose.

The presented methodology is thus based on the assumption that it is possible to develop multi-variant design and multiple criteria analysis of a building refurbishment in order to enabled one to form up to 100,000 alternative versions. *Architecture is an unfinished work of art and structure, a* *support, which leaves to the user blank spaces for participation in the decision-design process.*[32] Since a formal design is necessary to guarantee a structured and organized process that is called to respond coherently with current energy and safety regulations and requirements, fixed components (structural and functional invariants) need to be applied in the (re-) design processes of the buildings. On the other hand, a degree of flexibility and the adoption of processes engaging directly the inhabitants could offer a real solution both to the anonymity and standardization of these housing complexes.

The rules among which the inhabitants can choose and act have to be set by the architects but the final decision has to be taken by the users. Since the 'letters' of this alphabet have been studied as a modular system and can be joined together in multiple combinations, the 'discourse' that it will produce from inhabitants will have a positive result.[33] Disorder reveals the conflicts and highlights the contradictions of living and inhabiting, thus returning to users an architecture on a human scale. Given the fact that is possible to measure the validity of results – especially when dealing with Housing - by the degree to which they satisfy their civil commitment, the truth is that in order there is the frustrating boredom of imposition, while in disorder there is the exciting imagination of participation[34].

The possible solutions and the formal suggestions for the façade transformation and extensions, should anyway come from the architect that sets the pattern and the series of proposals collected in the Abacus, together with the rules that stand behind the computer aided program that is then used as an inter-active interface to handle the dialogue with many final users. This ensures the coherency of the final outcome, proposing only fitting solutions and re-iterating the trial and error loop narrowing down the choice among the possible choices, still defined by the architect, that

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[32] Habraken, J., Supports: an alternative to Mass Housing, ed. by Jonathan Teicher, Urban International Press UK, 1999.
[33] Cattani, E., A. Ferrante, A 'Learning from Informality' approach for socio-oriented and sustainable built environments, Conference in Sao Paolo, SASBE 2012
[34] Marini, S., Giancarlo De Carlo. L'architettura della partecipazione, Quodlibet Abitare: 2013.

therefore plays the role of moderator and definitions' controller. It is once again the architect that sets the rules of the game, the formal guidelines and guarantees the correspondence of the project with the general needs, requirements and pre-existent context. Within this open form (Hansen) and supports (Habraken) scheme, the inhabitants can chose what is the most fitting option among the possible defined by the planner.

Inter-action and clashing between choices from one inhabitant and the other are also controlled and handled by the program: the options proposed to one inhabitant are influenced by and different to the wishes and decisions taken by an another inhabitant that, for example, lives next door or above; the neighbouring options in the façade will not collide and the risk of turning into a chaotic mosaic of non-controlled design is avoided. The current design research experiences of this kind[35] have in fact shown a great potential and interesting aspects on the theoretical side but showed also a high degree of chaos in the formal and final outcome. The rules and the style have to be set and defined in order to avoid a deconstructionism ruled only by disorder and randomness, within which, the author disagrees with Friedman and Price, there is little architectural style and definition of beauty.

The application of the proposed methodology and utilisation of the abacus as design tool has been tested in the Corticella design workshop carried out in Bologna.[36] The district of Corticella is a neighbourhood located in the northern suburban area of Bologna; it has been built from 1970 up until 1980. The main building typology is residential blocks of 6 to 7 storeys and tower buildings for a total of about 104.000 m^2. The consortium "PEEP Corticella" is a cooperative society that manages the district heating system whose members are the owners of buildings served by the same district heating network: members elect the board of directors that has its own statute and

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[35] For example the Vertical City Project

[36] For more details about the project and the student workshop carried in Corticella (Bologna, 2012) see: Cattani, E., A. Ferrante, N. Bartolini, G. Semprini, Energy retrofitting on existing building. The case of social housing district in Bologna, Corticella., Conservazione vs Innovazione, InBo rivista online, Vol. 3, n. 5, Bologna, 2012.

was admitted to the chamber of commerce. The project is on going and the Architecture Department of Bologna University is working together with the Sociology Department to set up a direct and active cooperation with the inhabitants of the neighbourhood. The main focus of the architectural experiment has been driven towards the urban scale and the possibilities of renewal action for the ground floor level. The majority of the blocks are currently characterised by the presence of pillars and a basement level narrow and dark. Cars are everywhere and block a possible fruition of the street/garden/park level from the pedestrian's perspective. The renewal action has therefore been developed to guarantee a higher degree of freedom to the inhabitants that will be able to choose the best fitting solution according to their needs.

This approach has been applied also to the ground floor level, incorporating different levels of privacy of the collective areas, thus starting from a direct and active participation of the inhabitants. Fences, borders and limits have been drawn according to the systematic analysis carried on site and the specific desires of the population. As Gehl points out, the majority of social residential areas have been built according to principles and ideologies that give very low priority to outdoor activities, to the connection between distance, intensity, to the closeness in various contact settings has an interesting parallel in decoding and experiencing cities and city spaces[37]. The proposed design scenario has proved to be effective and replicable within the same compound and neighbourhood.

The comparison between the results of the design researches show a very high degree of possible combinations: the design solutions have not been constrained to a simple prefabricated structure, indeed the need of developing modular and variable solutions has lead to a wide set of possible architectural, technical and structural configurations. The different façade abacuses that have been produced for these case studies represent the base for the development of a new construction

[37] Gehl J, Cities for people, Island Press, Washington, 2010.

system for the façade production. The design becomes a game with no specific rule[38] between technicians and inhabitants. Ethnographic and cultural differences can be considered in the development of customized solutions to revision the envelope towards a more culturally responsive skin, keeping into account not only the performance aspects but also the cultural background of the inhabitants.

The flexibility and inter-active character of the proposed system shows the high potential impact on the social housing renovation market: through the application of one process, the revision of millions of buildings would be possible, not through standardized intervention but with a user-driven and tailored solution, different for each building and each user. The next research step is to analyse the possible application in a larger scheme, considering different urban contexts, geographical and ethnographic contexts, which have been approached in the three chosen case study and illustrated in the next chapter.

[38] Di Sivo M., Angelucci F., Il mass customization process per l'Housing Sociale. Potenzialità, nodi critici e line di ricerca, ISSN online 2239-0243, Firenze University Press, 2011

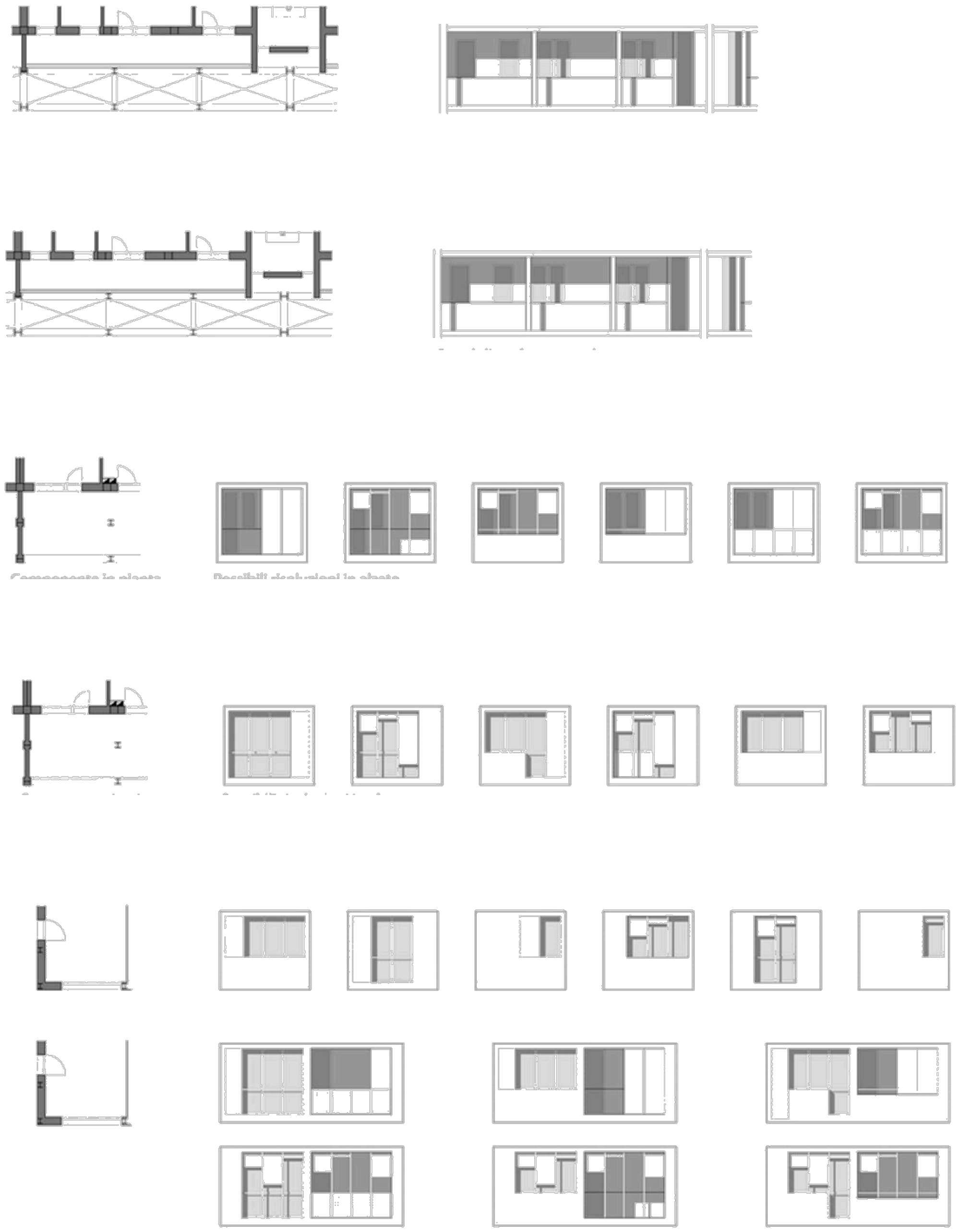


Fig. 10 Possible façade elements collected in the abacus of solutions. Inhabitants can chose among balconies, loggia, façade stransformation, room enalrgment different type of shutters, materials and colors under the guidance of the planners that coordinate the work. The reference building is located in via Byron Corticella (Bo).

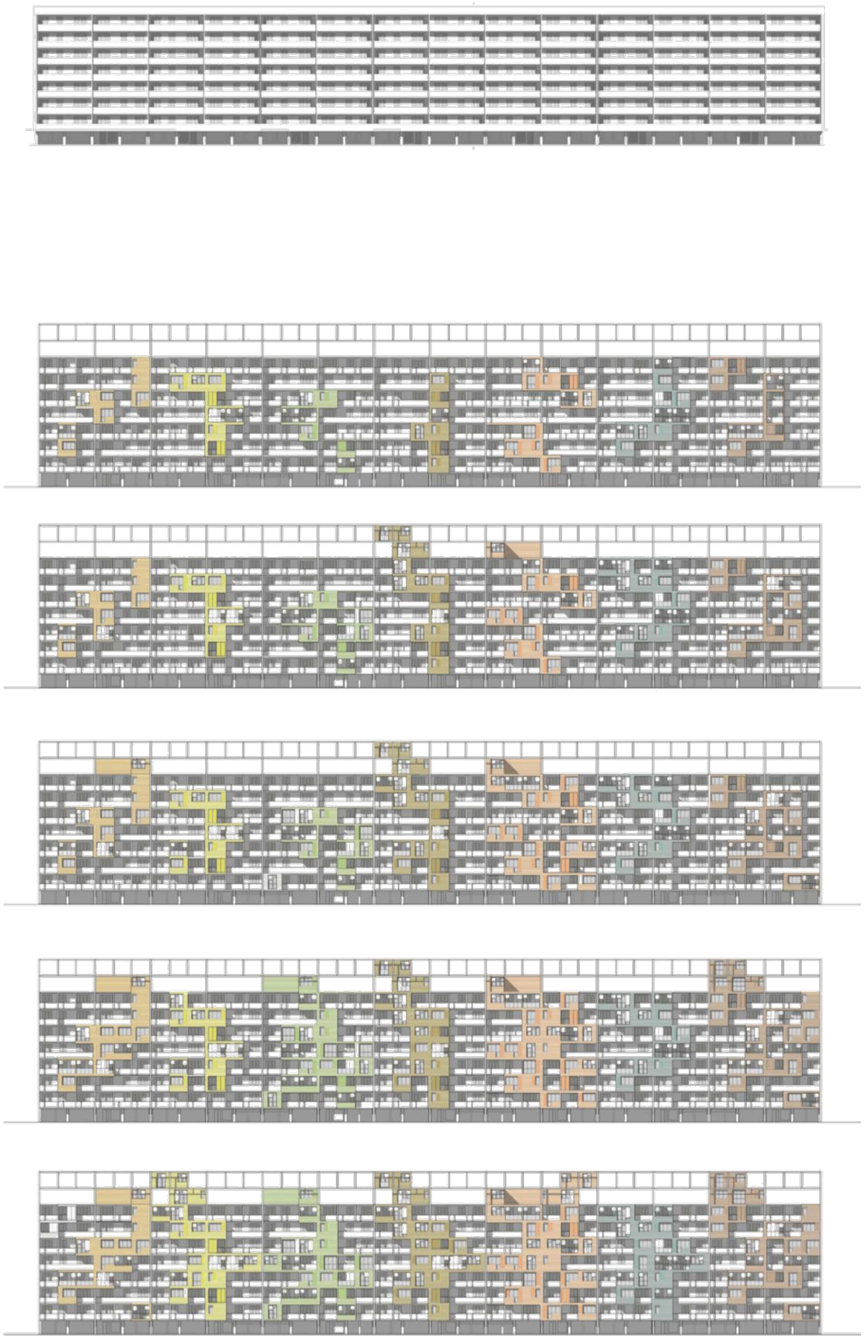


Fig. 11 Possible façade combination for the line building block located in via Byron Corticella (Bo). The images shows the simulations run by students during the Architettura Tecnica workshop held in Bologna in 2014 illustrating the possible façade combination resulting by the choices made by inhabitants among the offer proposed in Fig. 7

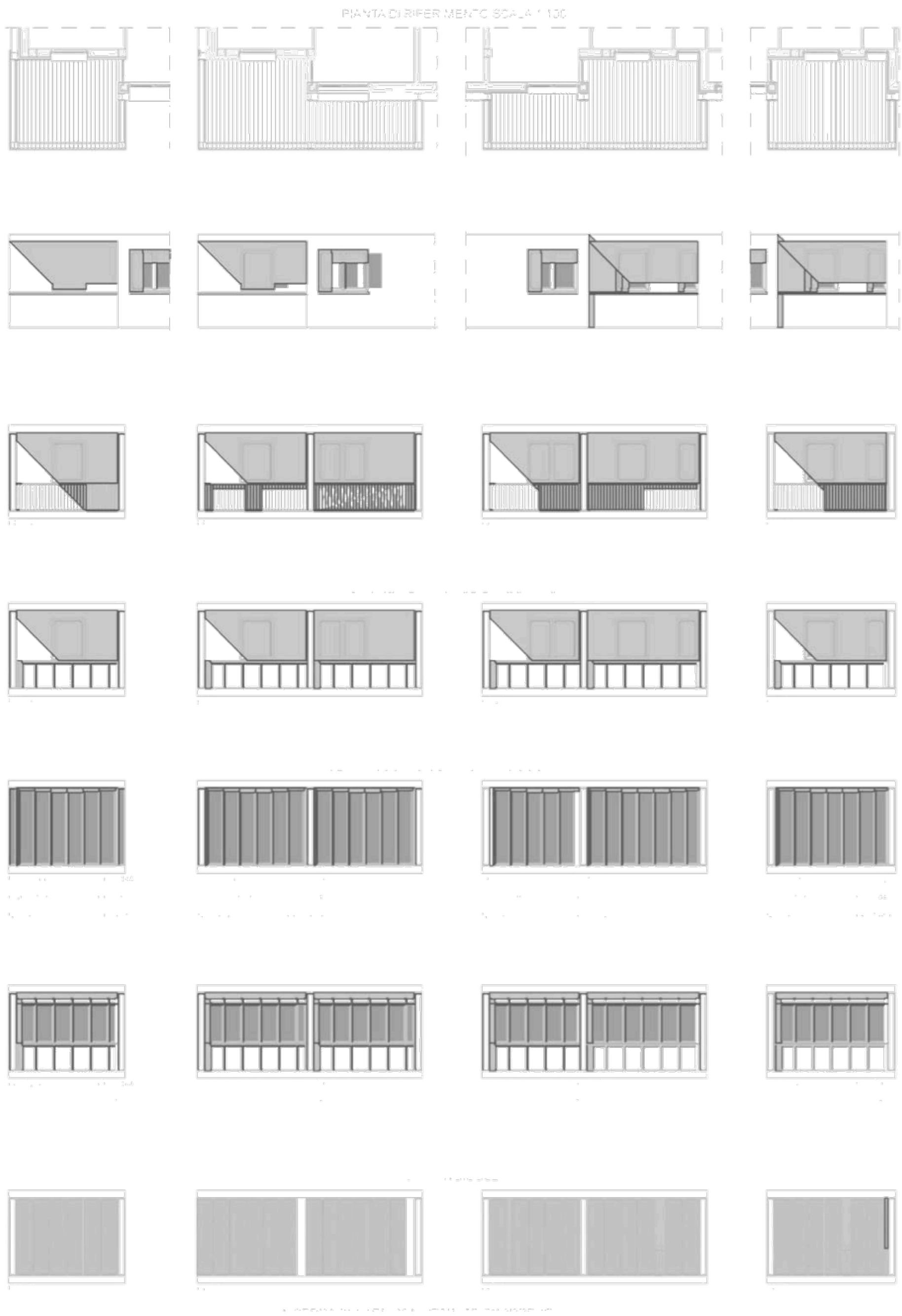


Fig. 12 Possible façade elements collected in the abacus of solutions. Inhabitants can chose among balconies, loggia, façade stransformation, room enalrgment different type of shutters, materials and colors under the guidance of the planners that coordinate the work. The reference building is located in via Byron Corticella (Bo).

Fig. 13 Possible façade combination for the tower building located in via Byron Corticella (Bo). The images shows the simulations run by students during the Architettura Tecnica workshop held in Bologna in 2014 illustrating the possible façade combination resulting by the choices made by inhabitants among the offer proposed in Fig. 9

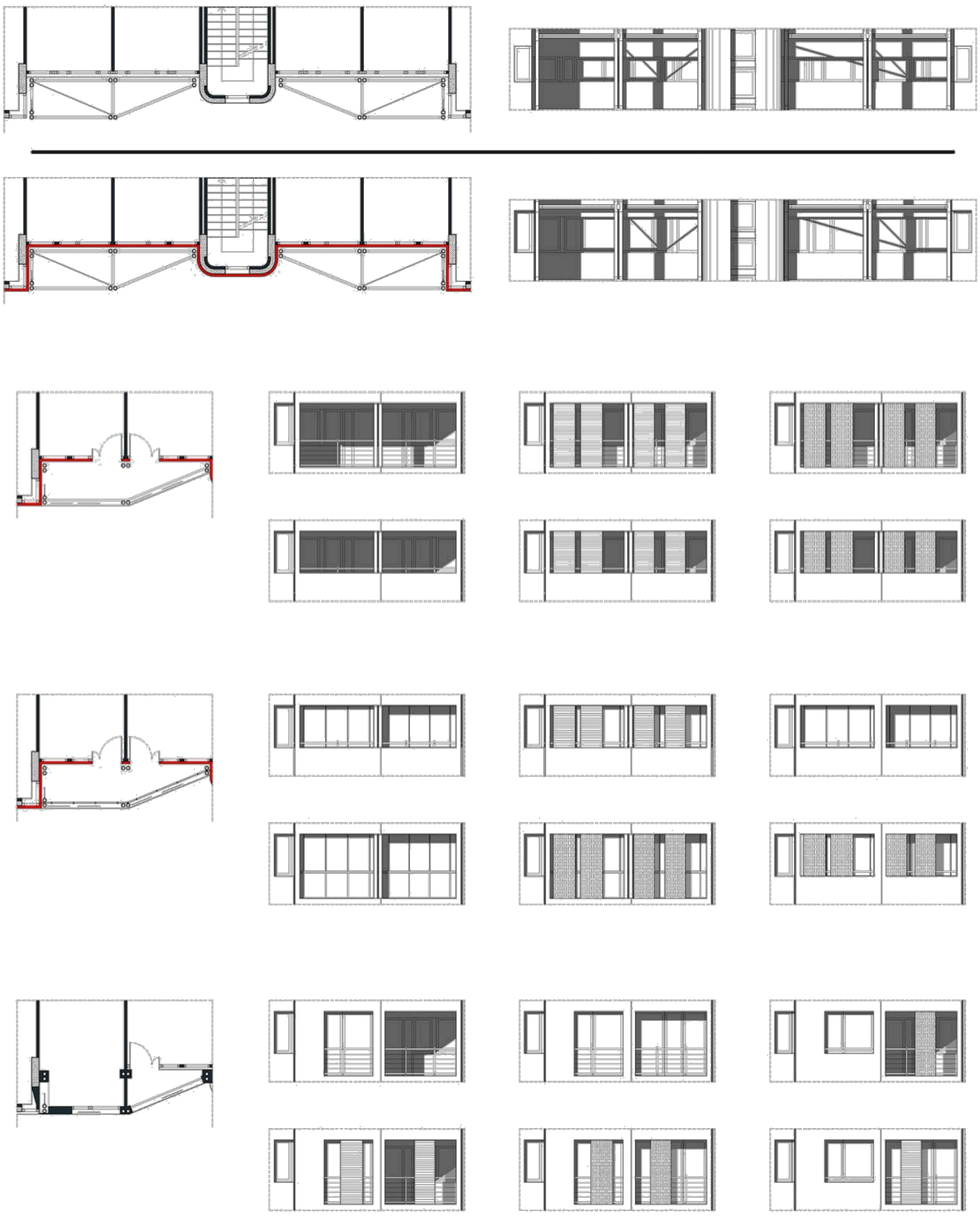


Fig. 14 Possible façade elements collected in the abacus of solutions. Inhabitants can chose among balconies, loggia, façade stransformation, room enalrgment different type of shutters, materials and colors under the guidance of the planners that coordinate the work. The reference building is located in via Goethe Corticella (Bo).

Fig. 15 Possible façade combination for the tower building located in via Goethe Corticella (Bo). The images shows the simulations run by students during the Architettura Tecnica workshop held in Bologna in 2014 illustrating the possible façade combination resulting by the choices made by inhabitants among the offer proposed in Fig. 11

As the above-illustrated experiments will show, the abacus of limited possibilities for the façade, leads to a system that can generate infinite number of façade configuration. The rule behind the process has to be set by the planner that is the director of the 'game' within which the inhabitants can personalise their own apartment. Still, in each of the above illustrated projects, there is a character, a concept a driving idea that remains and guides the elevation composition.

Whether the new façade will be based upon a contraposition relationship with the previous one or rather mime the pre-existence trying to reproduce its order, or it is playing on the chromatic transition between one architecture span and the other or rather is based on one mono-chromatic colour it is defined *antes* by the architect. The Abacus is the instrument to achieve the purpose and the method ensures the possibility by the inhabitants to act and choose, decide and personalise their own façade ambit, within a certain set of rules.

The following chapter will validate and test the proposed methodology in a European context facing and combining the three main aspects presented as core topic of the research for integrated deep renovation interventions through Add-ons:

- The social aspect: through the social survey conducted, which has lead to the collection of social factors and data to determine a socially sustainable line of intervention guaranteeing the consensus of the majority of the inhabitants;
- The technical aspect: proposing the integration of prefabricated façade elements offered in a variety of possible configuration in a multi-variant design. The design will be an open formed that could evolve in time and shape according to the inhabitants wishes and needs in a non-deterministic manner.
- The economical aspect: proving the beneficial effect of the add on strategy in the payback of the renovation both as energy reduction and as real estate profit tool to counter-balance the initial investment

PART 3

CHAPTER 5_ VALIDATION BY DESIGN ON THREE DIFFERENT SCENARIOS

The methodological approach towards the knowledge of urban context can be seen as the typological process of the buildings, at the different scalar correlations among building types, pathways and textures forming the overall urban structure[1]. The idea of intervening in the renovation practice through volumetric addition that could overcome the economical, social and procedural existing barriers is also strictly connected to the urban potential of our cities. The densification policies here proposed would open up a new perspective in the already actual dialogue regarding the saving agricultural soil policies. In Italy, still today, we consume 8 m^2 of agricultural land every second, since 1990 we have consumed a total of over 2 million hectares of land, a surface equal to the Emilia Romagna region. Countries like Germany and England introduce already before the year 2000 very strict regulation on the maximum of new soil that can be used for building purposes. Yet the total amount of new buildings per year in Europe doubles the number of the total refurbished buildings. The Add-on strategy is a densification strategy before even becoming a renovation strategy.

The discourse is thus connected to the potential of densification of the areas where the infill will happen. It is suggested as a turn around in territorial regulation to develop urban maps that study and mark those areas where the infrastructures and the urban net is developed enough to support a densification resulting in an increased number of inhabitant and extra services need. These residual and potential maps could support the Public Administrations in planning the transferability of edification rights and index from areas currently advocated to new construction towards already urbanised areas where the Add-ons could support the renovation of existing building. Already today urban density, in its various and different definitions, is the basic tool used to develop urban zoning; it is conceived as the most diffuse and necessary tool to shape cities, imposing an order on the urban development, and regulating future growth, determining in other words if it would be possible and in which areas to increase the volume of the existing

[1] Caniggia, G., G. L. Maffei, Lettura dell'edilizia di base, in: Composizione architettonica e tipologia edilizia ,Saggi Marsilio, Venezia, 1983.

building. In large cities and metropolitan areas, zoning provides specifications on end-use and size of buildings, contributing to the characterization of diversity of the many neighbourhoods that constitute the city[2]

What are then the factors and indexes that could support the definition of these maps and how can the urban density be measured? The urban density in a residential area can be calculated in different ways, but the most common indexes are essentially three (iii):

i) The ratio between the number of residential units and the urban horizontal surface;
ii) The ratio between the number of inhabitants and the urban horizontal surface;
iii) The ratio between the residential surfaces and the urban horizontal surface.

Although the first method is the most commonly used from urban planners in new developments[3], it presents the disadvantage to be strictly dependent from the actual destination and use of the specific buildings. The second ratio index is used by landscape designers, geographers and infrastructures' engineers, since it is extremely useful in the calculation of the environmental urban load in a specific built context and the consequent dimensioning of its infrastructural network systems.

The third indicator, called Floor Area Ratio, F.A.R., is a measurement to identify the density of a Region[4]. This index can be calculated by dividing the sum of all the built surfaces by the square metres of the total urban open area. F.A.R. is one of the more commonly used indexes by urban

[2] Different classes can be based on the discrete values (strong, medium, weak) of three parameters in urban planning: building continuity (continuous, medium, discontinuous), surface density (strong, medium, weak), building height (low, medium, high). The surface density is the ratio between the surface of the buildings at the ground level and the surface of the concerned area. A strong building continuity indicates that buildings predominantly structure urban spaces. Adjacent buildings, streets and artificial pavements cover more than 80% of the area. A building discontinuity indicates that buildings and artificial pavements covers with discontinuity large spaces. The use of discrete values implies to get threshold values. Main used parameters are: BUILDING CONTINUITY (Discontinuous: isolated buildings; Means: some group of adjacent buildings; Continuous: linear or block arrangement); SURFACE DENSITY (Weak: less than 15%; Means: from 15% to 30%; Strong: more than 30%); BUILDING HEIGHT (Low: from one to four floors; Means: from five to 10 floors; High: more than 10 floors). Threshold values may be adjusted or modified to take into account various urban contexts.

[3] It is especially used from Spanish urban planners and architects (Mozas and Fernandez, 2002).

[4] Reale L., Densità, città, residenza. Tecniche di densificazione e strategie anti-sprawl. Gangemi Editore: Roma 2008.

planners and designers. In fact, in the zoning resolution, the Floor Area is defined as the sum of the gross areas of the several floors of a building or buildings, measured from exterior faces of exterior walls or from the centre lines of walls separating two buildings. Even if it does not provide information of the functional use of the urban surfaces (public spaces, services, real occupied dwellings, etc.) it represents the more effective ratio to express the numerical incidence of the existing volumetric forms in the built environment. In particular, F.A.R. below 1 represents a low density, 1-2 medium and above 2 it indicates a high/very high urban density[5]; F.A.R. around 3 or more is considered extremely high. In other terms, the Floor Area Ratio (FAR) is the total floor area on a zoning lot, divided by the lot area of the same zoning lot. Floor area ratio (FAR) is also named floor space ratio (FSR), floor space index (FSI), site ratio and plot ratio); it is the ratio of a building's total floor area (gross floor area) to the size of the piece of land upon which it is built. This value is often used in the zoning regulative tool for the different zoning district and it can also refer to limits imposed on such a ratio.

The floor area ratio can be used in zoning to limit the amount of construction in a specific area.[6] For example, if the relevant zoning ordinance permits construction on a parcel, and if construction must adhere to a 0.10 FAR, then the total area of all floors in all buildings constructed on the parcel must be no more than one-tenth the area of the parcel itself. The correspondent formula is:

$$\mathrm{FAR} = \frac{\text{Total area of all the buildings' floor or total gross floor area}}{\text{Area of the urban plot}}$$

[5] A FAR of 1.5 is quite high, although this density is not unusual in historical city centres like Florence, Venice or central Paris, and is considerably exceeded in most of Manhattan. It requires 4-story buildings and narrow streets with limited interior courtyards. Higher buildings would leave more room for streets and gardens, but they are hardly present in the old historical centres of the cities.

[6] Ferrante A., Towards Nearly Zero Energy. Urban Settings in the Mediterranean Climate. Elsevier, 2016

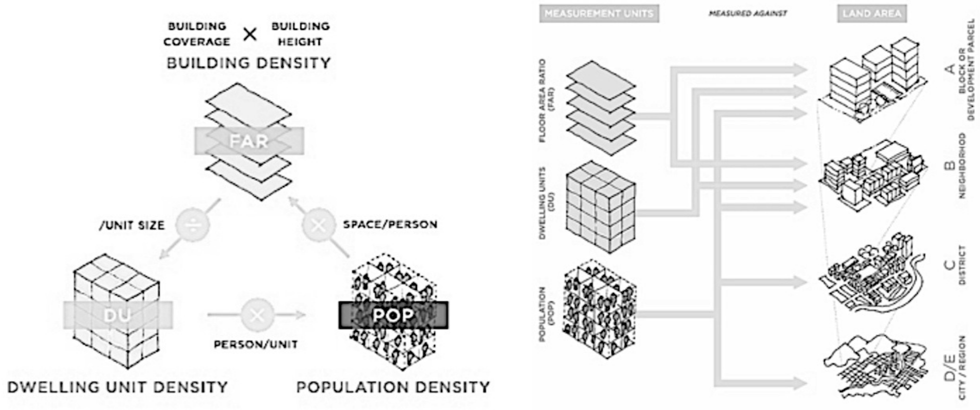


Fig. 1 The relationship between building, dwelling unit and population density. Different levels and scale of the density calculation. (source: 2011 Density Atlas, available online at http://densityatlas.org)

The floor area of a building usually does not include: cellar spaces; elevator or stair bulkheads, accessory water tanks or cooling towers, attic space providing structural headroom, floor space in open or roofed terraces, bridges, breeze ways or porches, floor space used for mechanical equipment, the lowest story of a residential building, floor space in exterior not enclosed balconies, etc.. If the area of the plot is 100 square meters, then 100 square meters of gross floor area has been built on the plot. In this case four floors of 25 square meters each are built on a site of 100 square meters, with a resulting FAR 1.0. Thus, the same FAR could have been obtained in the different following options:

- A 1-story building on 100% of the site (1 x 1 = 1.0)
- A 2-story building on 50% of the site (2 x 0.50 = 1.0)
- A 4-story building on 25% of the site (4 x 0,25 = 1.0)

Thus, the same FAR can express either a single-story building consuming the entire allowable area in one floor, or a multi-stories building that rises higher above the plane of the land. In this second case, the building will consequently result in a smaller footprint with respect to a single-story building of the same total floor area. Notwithstanding the manifest degree of approximation of the FAR, which disregards important other parameters, like height, width, or length, it is important to notice that the floor area ratio well correlates with other factors relevant to zoning regulation, such as the total parking area that would be required for an office building, the total number of units that might be available for residential use, total load on municipal infrastructural services, etc. In fact, the amounts of these other important urban parameters are nearly constant for a given total floor area, regardless of how total gross floor area is distributed in parallel and/or perpendicularly with respect to the ground level.

The F.A.R. as been used to identify three different case study within Europe that could cover the three different urban density in order to investigate the potential of the volumetric addition strategy in the different contexts. It could be one of the possible index that also the public administrations could use to develop thematic maps to indicate the different degrees if *residual density*[7] that could be used by planners as design trigger. The evaluation on the density and urban potential has been carried not only at the big scale of the city chosen but also at the district level. In order to evaluate the strategy and test in regarding a broader range of scenario, the choice of the building type and reference neighbourhoods has lead to the definition of different degree of implementation of the strategy increasing the replicability on European level.

The case studies have been therefore chosen upon evaluation concerning the urban and densification potential. There is however broader list of parameters that has lead to the choice of the case study upon which the strategy has been tested. The following chart illustrates the set of variables that have been taken into consideration. Trying to cover a wide range of different cases, three countries have been chosen with different economical and political conditions but also geographical and therefore climatic conditions: Greece, Italy and Germany. Within the chosen target countries the cities have been chosen upon the data availability but also the search for an heterogeneous collection of different density conditions, low medium and high density. Therefore the city chosen are Reggio Emilia in Italy with an average FAR of 0,5, Frankfurt in Germany with FAR 1,15 and Athens in Greece with a high-density value of 1,70.

AMBIT	CRITERIA	SCALE
Urban	• Floor Area Ration • Dwelling Unit Density • Infrastructure • Population	→ 0 – 2 → 10 – 200 per block → 0 – 5 car park per unit → 100 – 20.000 ab/km^2
Energetic	• Energy Consumptions • Energy costs	→ 100 – 180 Kwh/m^2*y → 15-30 thousand per year
Geographical	• Climate • Welfare	→ Warm – Temperate - Cold → Unstable – Fluctuant – Stable economical/political context
Architecture	• Year of construction • Materials • Structure	→ 1930 – 1980 → Bricks – Prefabrication – Concrete → Loadbearing walls – Loadbearing panels – Concrete scheleton
Social	• Inhabitants' mixture • Ethnographic analysis	→ Low – Middle – High Age → Low – Middle – High Education → Low – Middle – High Income → Original residents - immigrants
Real Estate	• Price per m^2 • Renovation cost per m^2	→ 1000 - 6000 Euro/m^2 → 600 - 2000 Euro/m^2

Tab. 1 The considered ambits and related criteria that have guided the case study selection

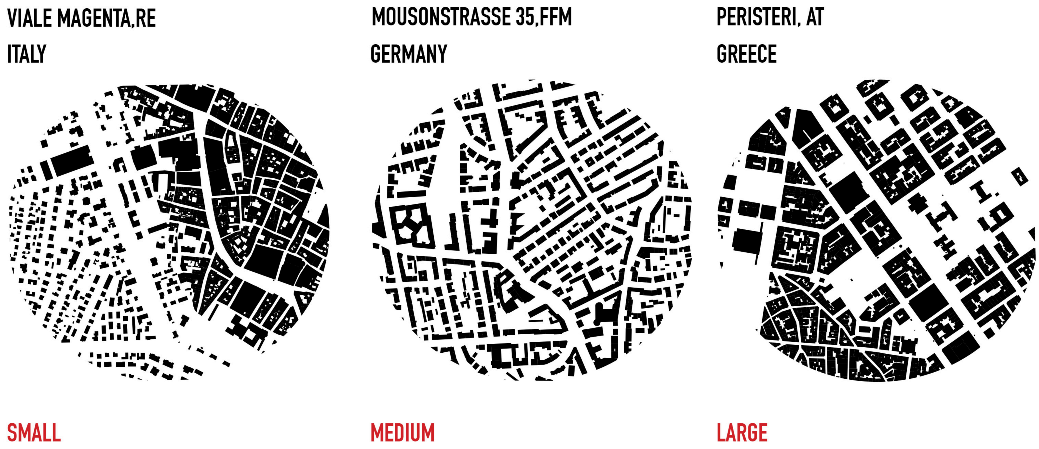


Fig. 2 The different urban characteristic of the district chosen as pilot case study to test the proposed strategy

It shall be underlined however that the FAR of the cities not always represents the specificity of the areas that have then been chosen has case study. The value varies in face according the different areas and neighbourhood of the city and the building chosen not always respect well represent the average condition and the values above mentioned. Having realised the discrepancy, a FAR value at the scale of the plot has been evaluated and the Reggio Emilia case study is located in an area with average 0,79 fairly in line wit the rest of the city while the Frankfurt case study has a FAR of 2,68, considerably above the average and the building chosen in Athens has a FAR of 0,45, considerably below the average. It became then later evident that the reference value should be the FAR of the specific plot, showing a high potential for densification and additions both in Reggio Emilia (where also the present services could allow an increase of population living in the area) and in Peristeri, where contrary from many other areas of Athens, the density of the area chosen is not above the average. On the other hand, the medium density case study, in Frankfurt, has shown a very strict urban tissue and the high value of FAR, already in the preliminary phase, has underline the difficulties in expanding the existing volume of the building, unless creating the necessary service upgrade and considering an addition on the rooftop. Together with the various climatic and density data, also the population mixture and the social aspects are different. The questionnaire has been run and collected in all the three case studies and has return a very variegated and different social/ethnographical answer opening up to different design scenarios for Add-ons.

Finally, also the architecture of the building chosen is characterised by different characteristics: starting from the age of construction (the building in Italy is the oldest and has historical preservation value, 1936, the one in Germany was built after the Second World War in 1958 and the one in Athens, despite the bad conservation condition is the most recent, built in 1970) continuing with the envelope and construction system and look of the buildings. The next chapter will illustrate the data collected on the urban, architectural and sociological level for each of the case study together with the drawings developed for each building. The annex panels summarise the information and simulate the applicability of the proposed methodology for each case study. A different abacus has been developed for each building, envisaging a possible architectural strategy and approach for each case. The different abacus has been then tested upon the existing elevation simulating the possible choices of the different inhabitants for each dwelling units.

The methodology has been tested for each case providing an abacus of variation for the envelope and suggesting the most appropriate volumetric addition coherently with the results of the questionnaires and the open dialogue with the inhabitants. The project is an open-process wit no fixed result and at the same time the program in terms of cost and benefit has shown great potential. The possible development of the research could lead to the definition of an interactive platform through which the inhabitants could act and inter-act, simulate and test the possible variables proposed by the designers (the abacus) and decide also upon specific information related to the functional potential of each choice and its cost. The social process, now conducted in experimental manner through human direct contact, could become an open source network with related application and software, the inhabitants to directly communicate their wishes and decide upon the definition of their own cell, thus contributing in the generation of façade totality. The general cost-benefit analysis that have been undertaken in Chapter 3 for sample building have here been conducted on the three chosen markets and contexts (Italy, Germany, Athens) underlining important factors that influence the effect of Add-ons on the financial and economical feasibility of Deep Renovation.

5.1 The Italian case study. Viale Magenta, Reggio Emilia (IT)

At the beginning of the XX century the housing condition in Italy was characterized by very poor hygienic and safety condition; as a consequence of the economical crisis most of the workers and immigrants from the rural areas could not afford adequate living conditions within the city boundaries. In 1920, the IACP - Istituto Autonomo Case Popolari – was created in Reggio Emilia as an answer to this housing emergency. The primary goal of the new-born public organism consisted in developing and renewing social housing compounds to ensure decent dwellings to the low income classes. The chosen Italian case study was built from IACP in 1936, as a direct consequence of several demolition of decaying buildings run from the fascist regime. The promise made to the inhabitants of the “Popolo Giusto” (Fair Community) was to be relocated in new modern houses planned according to the fascist sobriety and architectural style: the new housing districted was built in Viale Magenta. Many of the original inhabitants were indeed members of the partisan movement and the building has retained up until now an important memorial value for the city of Reggio Emilia. All the ‘Case Popolari’ settlement is unified by the same architectural fascist style reproducing the neat and the order that the political system was pursuing.

Only the different colours of the original façade characterized the building in three portions: the so-called white houses were the units facing Viale Magenta, the yellow houses were facing the internal courtyard and the green houses were facing the river[8]. The quality of the buildings was substantially higher then the average level of the time.

[8] Mariotti, G., Successe alle case popolari, cronache di guerra, iStoreco in collaboration with Comune di Reggio Emilia, 2005, Reggio Emilia, 2005.

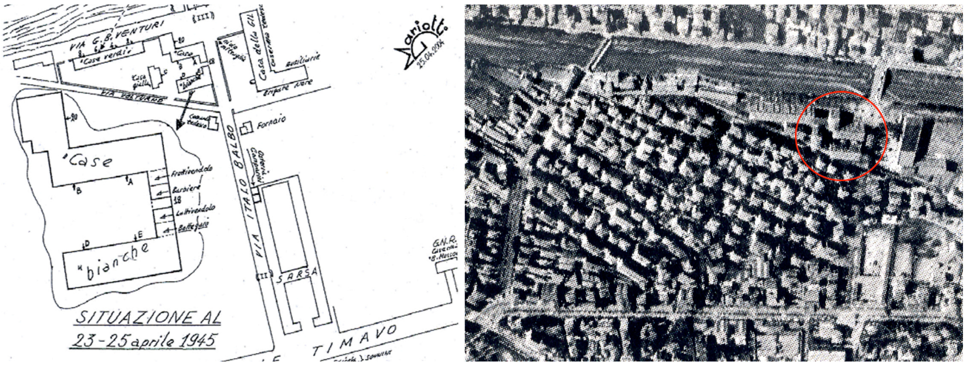


Fig. 3 Historical map of the situation as it was in April 1945 with the original functions (left). Aerial photo immediately after the war, the building - where several fire shootings took place between the Germans and the patricians - is marked in red. Source: Mariotti, G., Successe alle case popolari, cronache di guerra, iStoreco in collaboration with Comune di Reggio Emilia, 2005, Reggio Emilia, 2005.

Significant was the promise of the *podestà* with the black shirt to deliver the houses to directly transfer the property of the apartments to those who were chosen as assignees. Considering the current state of the building, it looks evident that it is necessary to investigate possible strategies towards renovation: the painting and the plaster are crumbling, the facade presents significant signs of deterioration, the main concrete structure is exposed, thermal bridges and old window frames contribute to the low quality of the envelope. The heating system is currently de-centralized and each unit is equipped with old boilers. It is clear that the historical value of the building needs to be preserved and this results in both a valuable characteristic of the case study and at the same time a barrier for the standard energy renovation actions (window change, external coating, plant renewal...).

Also, the home property regime of the building is mixed: almost two third of the dwelling units are rented by ACER -the housing association currently in charge of the management of the building- and the other one third of the units is privately owned.

This condition requires a general consensus of the inhabitants in order to be able to intervene on the building, thus a direct engagement of the population becomes fundamental within the definition of the most appropriate renovation strategy. Moreover the majority of the inhabitants are elderly people (some are still the original inhabitants) and only a few are immigrants. The social mix of the community living in the building represents an interesting opportunity to test engaging experiments for participation to define a multi-disciplinary approach that goes beyond the standardized intervention of energy renovation. In order to overcome the economical barriers that often slow down the renovation of social housing buildings, it would be possible to test on the pilot case study the effect of extending the building through a volumetric addition as infill on the street front.

The location and proximity to the city centre, in fact, offer a great potential for the real estate investments and could pay off the energy renovation of the entire building. The development of several architectural and technological solutions on the pilot case study would increase the adaptability of the proposal and support the definition a broader strategy applicable also in other contexts.

The Municipality of Reggio Emilia together with ACER have already undertaken several preliminary surveys and engaged an open dialogue with the inhabitants to investigate the possible actions.

Pilot case	IACP HOUSES IN VIALE MAGENTA (REGGIO EMILIA, ITALY)
Year of construction	1936
Number of units	48
Main building typology	Block building disposed in a court shape (U shape)
Construction system	Concrete skeleton
Dimension of units	About 100m^2
Technical Data	Residential surface: about 4400m^2 Structure: concrete skeleton, concrete slabs and brick external walls Window: aluminium or wood with single/double glass Plants: decentralized plant, boiler in each unit
Last refurbished	1985
Energy performance	About 180 Kwh/m^2*y (class G of the EPC)
Energy management	Owners and ACER
Property regime	Mixed: owners and tenants from ACER (Social Housing)
Adaptability degree (1-5)	2,17 (calculated according to the method presented in chapter 2)
Social Mixture	31 % foreigners (Nigeria, Egypt, Tunisia, Morocco, Ethiopia, Ghana, Poland)
Average rental cost	150 euros/month
Critical points	Owners: barriers to decision processes (condominium approval is necessary) Old building with historical memory value Street front
Possible additions	Possible additions on the attic (currently used as deposit) and at the street front

Tab. 2 Italian case study description sheet

5.1.1 Adaptability assessment, densification potential

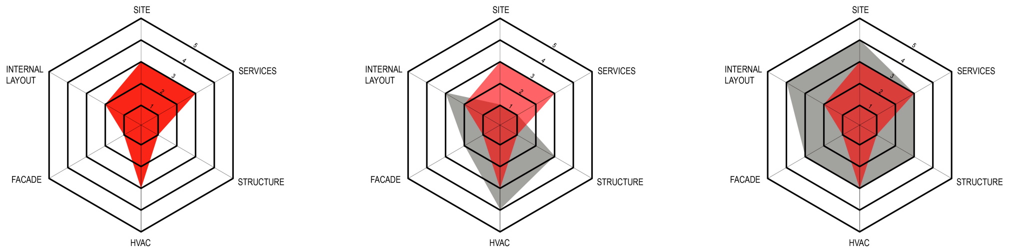


Fig. 4 Adaptability study for the case study of Reggio Emilia (left) and comparison between the adaptability status of Viale Magenta and Mousonstrasse (DE) case study (in the centre) and between Viale Magenta and Peristeri (GR) (right)

The historical character of the building and the rigid facade layout allow little transformation in general terms. The heritage protection constrains pendent on the buildings requests that the interventions respect the original characters of the pre-existence. The adaptability diagram visualises the aspects where the case study has more potential for transformation, which is mainly on the installation systems and on the site since there are enough services to support an enlargement of the community.

The volumetric addition should therefore not interfere with the pre-existence in architectural terms and the transformation on the facade should respect the current facade drawing. The survey on the building has shown that the attic, currently used as deposit and storage room has a clear high of about 2.4 meters, offering an interesting opportunity for Add-on without having to consistently increase the urban configuration of the area. The current status of the building shows severe external damages to the structure and the envelope.

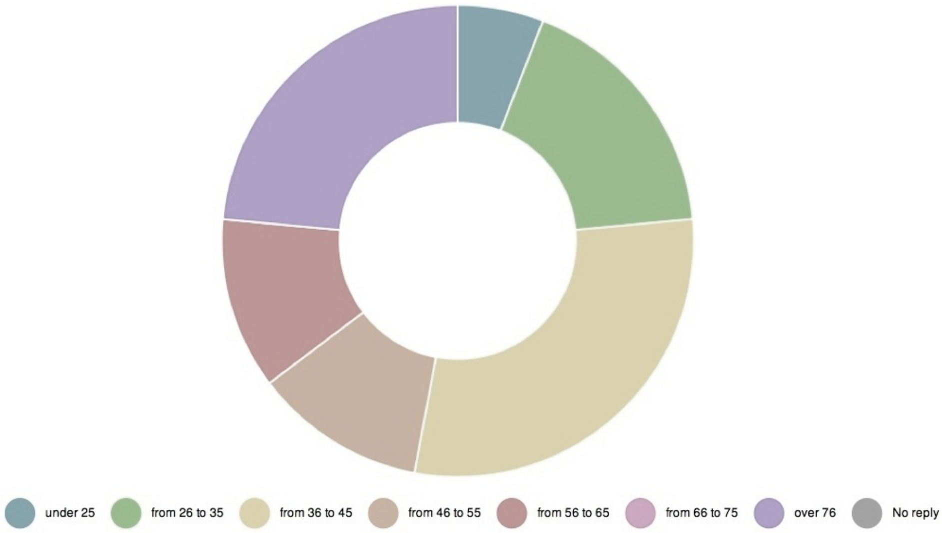
The parking situation offers an external parking space for 22 cars, considering that the building hosts over 48 units it is reasonable to imagine that measures to empower the infrastructure and service of the area shall be included in case of densification. In front of the building and along the street that is adjacent to the river Crostolo, the possibility of creating new and extra parking spot has been evaluated and discussed with the Municipality, which has expressed positive opinion in regards. Moreover it is important to underline that more than 30% of the inhabitants are unemployed and often do not posses a car, the urgency of the building according to their inhabitants are not much related to traffic or parking space but rather to the obsolescent condition of the buildings.

Political and administrative parties involved have stated the urgency for renovation and a financial support has already been made eligible to Acer Reggio Emilia, which is managing the building as public Social Housing institution. The existing structure of the building (mixed of a concrete skeleton and load bearing masonry) does not allow consistent intervention unless structural security measures will be undertaken, especially considering that Italy is a highly seismic territory.

5.1.2 Data results of the questionnaires

The aim of the research is to overcome the existing social, economical and technical barriers to renovation. Therefore the first step after the preliminary analysis of the building has consisted in conducting the sociological survey, testing the questionnaire tool developed directly on the case study. As mentioned the sociological investigations has been used to understand the crucial opinion of the inhabitants related to the possibility of renovation. Which are the emergencies that the building has according to the users and which could become the trigger and negotiation points to convince the inhabitants of the positive effect of an energy renovation.

Considering the Viale Magenta neighbourhood, about thirty questionnaires have been collected. The following graphics show the most significant statistic results related to the questions that have been considered central in the survey. Other considerations, inferred from informal behaviours or by the course of the research and the non-structured interviews have been summarized in the text.



Place of Birth

Text Responses

Tunisia
Tunisia
Palermo
Morocco
Reggio Emilia
Reggio Emilia
Reggio Emilia
Reggio Emilia
Polonia
Correggio, RE, Italy
Treviso, Italy
Rome, Italy
Marocco

Fig. 5 Age groups that took part in the survey

A significant percentage of immigrants are occupying the building and it has been recorded by the interviews that there is an on-going conflict between the original inhabitants and the new comers, generally not from Italian roots. While the area and the building have the historical reputations of memorial importance and has been reported by several adults that have lived their childhood in the building playing in the surroundings and the internal courtyard, the current limitations and restrictions imposed by a group of inhabitants to the kids of the immigrants family are consistently different. The little tolerance and perhaps the prejudge towards ‘foreigners’ led to a policy of severe rules and regulations, kids can play only after 16.00 and until 18.00. It is hard to coexist with different cultural habits in an atmosphere of non-tolerance and continual fights and it is even harder to witness such conflict in a context of general poverty, where one would imagine there should be room for understanding and community feeling. For this case study it has been conducted one singular survey but indeed the results testimony how two different groups are inhabiting the same building and perceiving the physical and social conditions in two opposite ways. As priority measures it is important to evaluate the possibility of introducing social mediators or create a balanced social mix that could improve the integration of disadvantaged groups in the community.

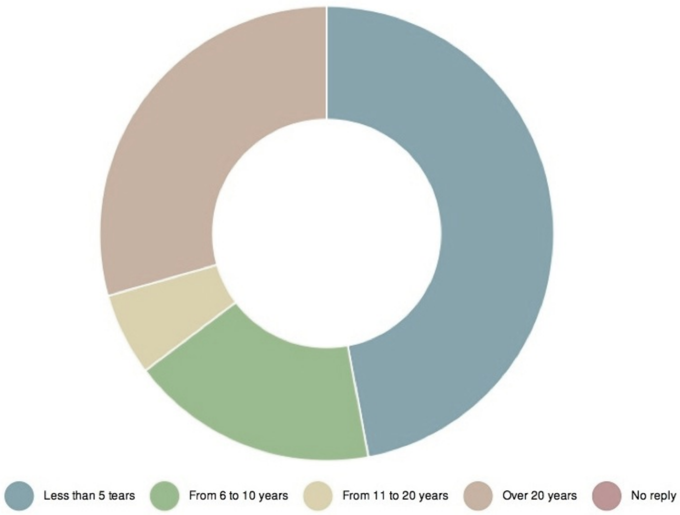


Fig. 6 Answers regarding the time of permanence in the neighbourhood

The division between Italians and non-Italians has reflected also the level of attachment to the building and to the neighbourhood: half of the users have been living in the are for longer than 20 years whereas the other half for less then 5 years. This has effects also on the property regime that is mixed between tenants from Social Housing institutions and homeowners that have bought the houses after the war. The internal layout, furniture and condition of the apartment is also reflecting this differentiation since a good part of the dwelling unit is in obsolescent condition while another few dwellings have been privately renovated and refurbished, looking completely different when compared with the rest. The unemployment rate in the building is fairly high and it has been registered that a large number of families in disadvantaged condition have to face high maintenance and cleaning costs.

The Social Housing ACER is offering the apartment for lower rent calculated according to the income of the families living under social housing care. The average rental cost is around 150 euros varying from a minimum of 30 euros/month to a maximum of 300 euros per month. It is however true that cleaning and gardening costs are fairly high and the inhabitants who do not have a job would gladly offer themselves to do the jobs rather than increasing their debts to pay for these services.

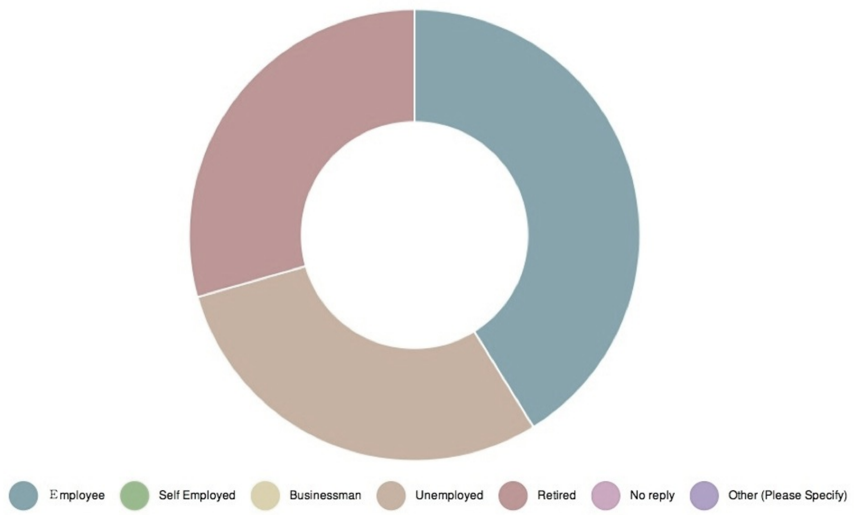
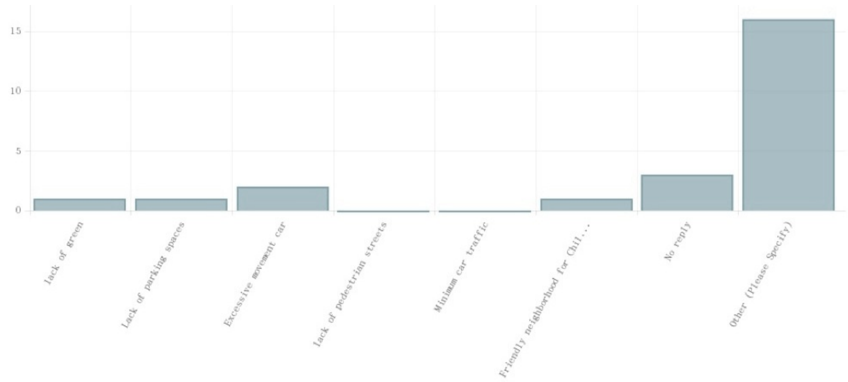


Fig. 7 Employment type

Overall there is a general consensus in complains regarding the neighbourhood. On one hand the original inhabitants and homeowners are complaining about the increased immigration rate and they feel unsafe in the building. On the other hand the new comers, who are living in disadvantaged situation and could not afford a renovation of the dwelling live in conditions that are extreme considering safety and hygienic standards and are victim of racist and segregation from the other member of the community. The creation of a mixed system that could help overcoming the existing racial and social conflict is one of the priorities registered. It is also urgent to intervene with basic measures to prevent water infiltrations, moulding in the walls and proper insulation together with structural safety measures to guarantee the security of the building in case of earthquake.

Balconies and external areas such as the internal courtyard are not consistently used. The birds and animals that are surrounding the building are generating dirt and noise, which discourages the inhabitants, especially those living at the top floor, to use their balconies. An overhanging roof needs to be provided to protect the building from the dirt produced by birds and at the same time a more open policy has to be undertaken to activate the use of the internal garden for the children living in the building without them having to be object of racism and limitations from the other inhabitants.



Text Responses

Unfriendly neighborhood, racist. Too expensive and low quality of the houses
Unfriendly neighborhood for my children, they can not play
Old people, too strict. No community feeling
Nice area
Too much smog and pollution
It became worse on a social level, too many immigrants and poor people
Left alone, no mantainance
I don't like the neighborhood
I don't like it at all, expecially in the last years because of the neighborhood
getting worst
absolute deterioration
unfriendly neighborhood
close to the city center
it got worst during the years
close to the city center but it's negletted
not clean, robberies

Fig. 8 Answers to the request of expressing an opinion regarding the current condition in the Magenta neighbourhood

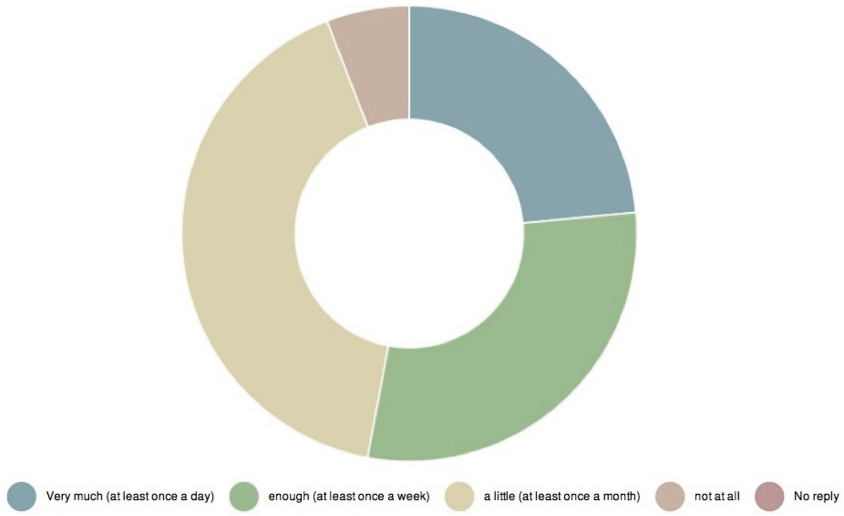


Fig. 9 Answers regarding the current use of the balconies

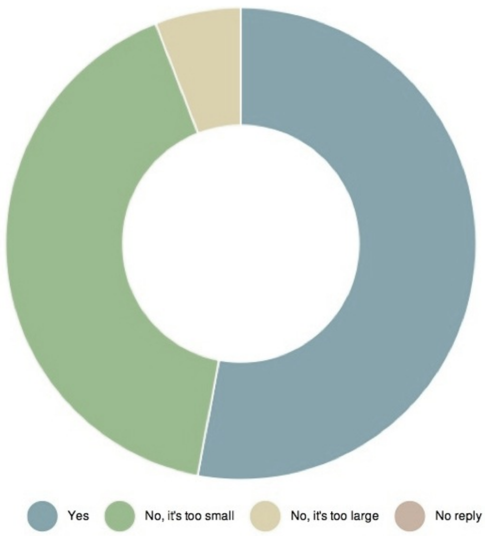


Fig. 10 Answers regarding the satisfaction with the size of the apartment units

The dwelling units are divided in three different typologies, one smaller than 50 m^2, one around 60 m^2, and one bigger than 70 m^2. This explains the various reply received during the survey regarding the size of the apartments. It is also important to underline that the majority of the original inhabitants, currently homeowners, are elderly people, mostly living alone in fairly big dwellings. The new comers, on social housing protection are generally numerous families of 4-5 components and having to share a two-bedroom apartment.

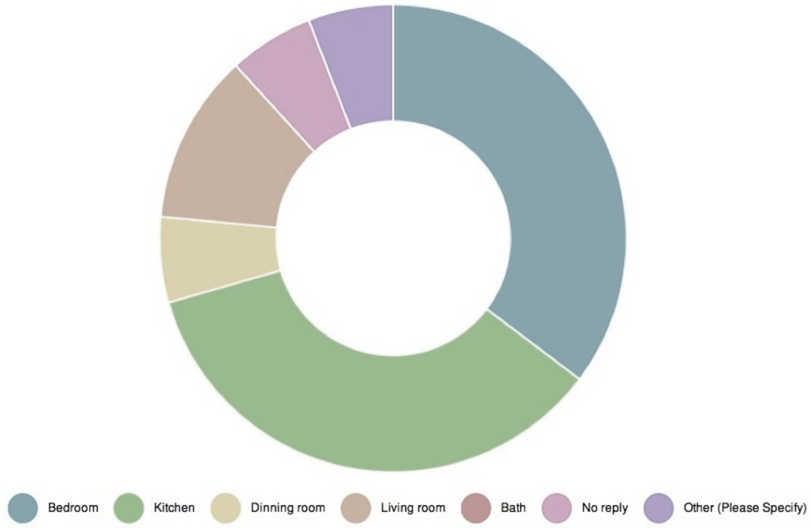


Fig. 11 Answers to the question: what room of your apartment would you like to renovate

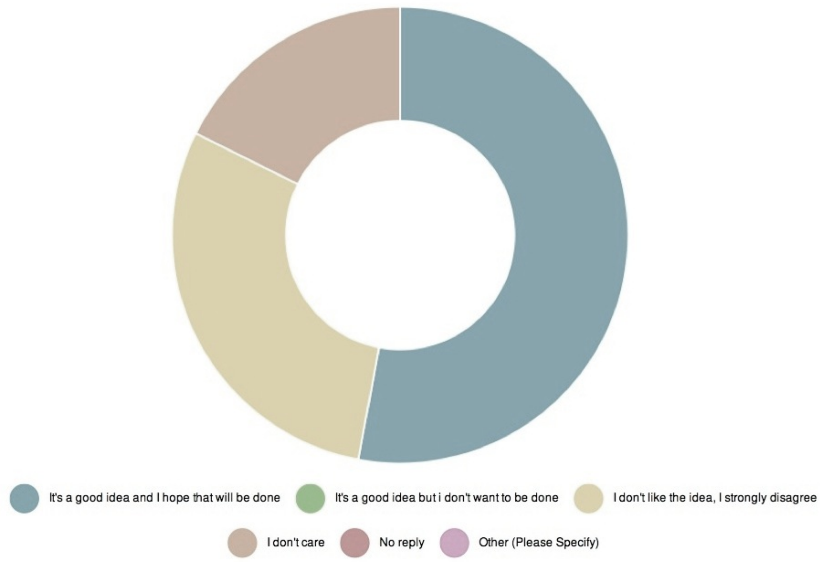


Fig. 12 Answers regarding the possibility of building extra volume on the roofs

The majority of the interviewed has expressed the need of renovating the kitchen and bathrooms, possible creating an extra room for the kitchen, which is currently integrated in the living room with a small portable electric plate. The possibility of creating an extra room for the kitchen can be translated in enclosing part of the existing dwelling when reported to be too big and create an Add-on that includes the services and kitchen allowing an internal re-arrangement of the apartment layout.

A volumetric addition on the rooftop is not seen positively since the attic is currently used for storage purpose. Moreover the inhabitants have expressed worries regarding the structural safety of the building and it is indeed highly complicated and expensive to consider to intervene increasing the building load without substantially have to improve the structure performances of the building. On the other hand, the possibility of filling the current volumetric void through an Add-on on the street elevation has collected positive opinion. With particular attention the survey has been conducted on those units that have currently an outside view and would lose one of the windows from the kitchen in case of intervention with this addition of space.

Fig. 13 Answers regarding the possibility of filling the volumetric void t the street front with extra apartment units that could contribute in paying off the energy renovation intervention

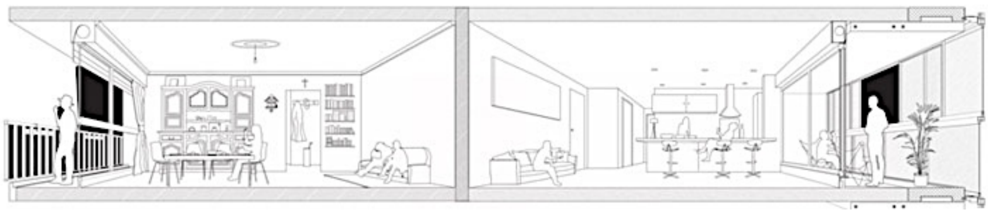


Fig. 14 before and after, example of possible interior re-organisation. Source: LAN Architecture

The existing dwelling facing the urban void are extremely small and have agreed with the possibility of losing one of the two windows in the kitchen spaces in favor of an extra room and a consistent re-arrangement of the internal space.

The majority of the inhabitants use external tends or rollers to shade in summer, mostly ineffective as internal shading systems, providing shade when already the heat has 'entered' the apartment. There is no cooling system in the majority of the apartment but yet it is crucial and urgent to intervene on the architecturally and energetically relevant aspects, creating an insulation layer and providing proper external shading systems.

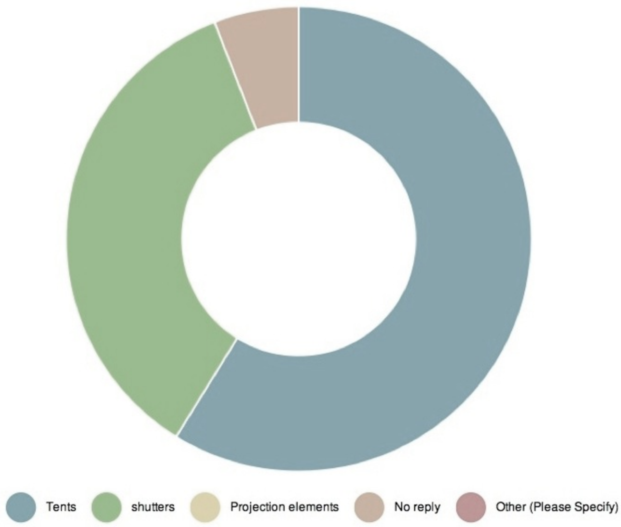
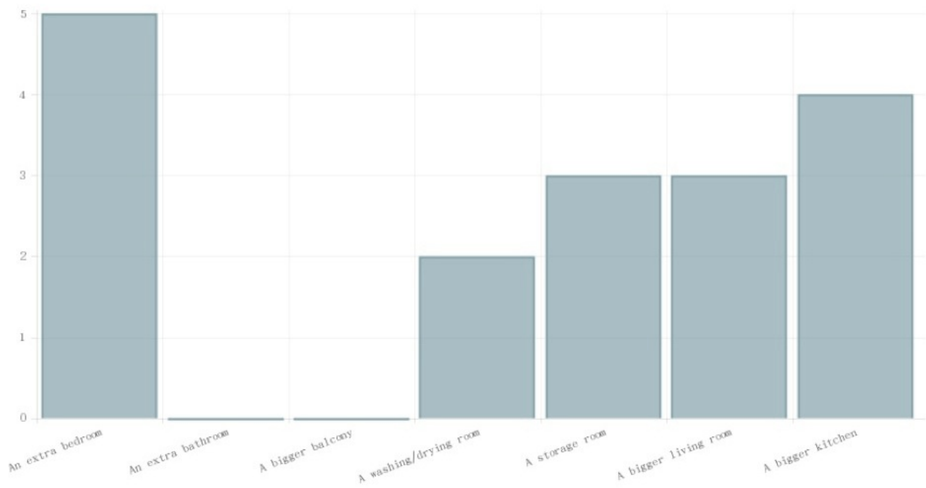


Fig. 15 Current oscuration and shading devices



Is there some comment or advice or suggestion regarding the improvement of your apartment/building that you would like to share with our team?

Text Responses

During the ramadan we cook and go out during the night. The neighborhood complain for the noise. There is no privacy and no community. We only have one bedroom and I have three kids, the house is too small

The common garden mantainance is too expensive and we are unemployed with experience in gardening. We could take care of it ourselves. The comdominum costs are too high. The cellars are full of rats and too dirty can not be used.

Need of intervention on the staircases and in the public area.

More freedom on the common areas

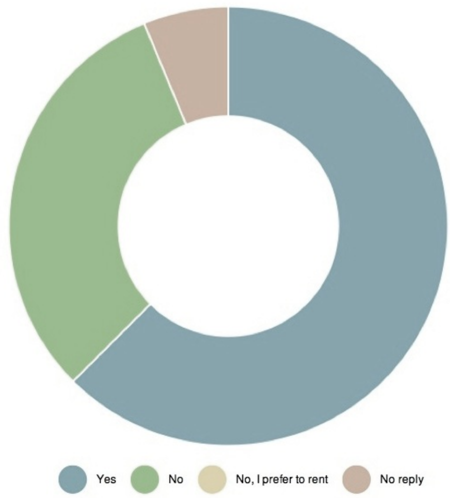
The living and dining room is open space and too little. There is no service room to be use for storage.
The basement and the under-roof storage are not usable because of security and hygenic reasons

I would like to have more space for storage such as an extra storage room

The problem of the pigeons on the roof is sever, I can not open the windows and use the back balcony because it is dirty and there are pigeons everywhere. The top cornice of the roof is falling off which is dangerous and is not protecting from rain.

There is a need of increasing security in the access of the building, a guardian at the front door and security doors. The neighborhood is not safe

Fig. 16 Advices ad suggestions made by the inhabitants spontaneously



Can you specify the amount of money that you would give to buy the apartment?

Text Responses

This is the first answer choice	50.000 with a loan
This is the first answer choice	I have not yet thought about it
This is the first answer choice	80000
This is the first answer choice	50000 euro
No reply	no reply
No reply	no reply

Fig. 17 Answers regarding the possibility of buying the apartment after renovation, how much would the interviewee be willing to pay for it?

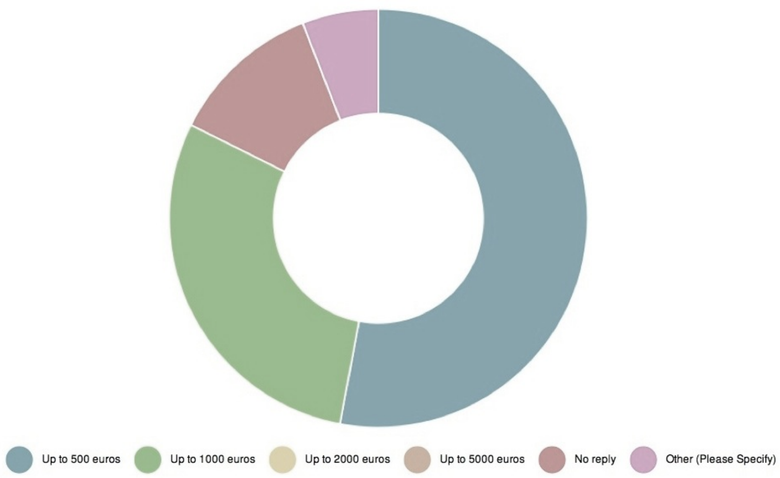


Fig. 18 Answers regarding the amount of money that the inhabitants would be willing to co-invest to finance the renovation intervention

Analysing the investment possibilities and scheme, the questionnaire included several questions regarding possibility of exchange floor surface for money, investment for the renovation and intention from the tenants to buy the apartments. To the question 'If you would be asked to place a financial contribution for the energy renovation intervention in exchange of a convenient loan rate to buy the apartment you are currently renting, would you be interested?' More than 50 % showed interest and suggested a total sum of about 50.000 euros to buy the entire apartments with a loan (it would mean an average of 1.000 Euros/m^2). The market price for buying new apartments in the area is currently 1.860 Euros/m^2[9] so it can be said that the possibility and estimation made by the inhabitants who would be willing to pay is fair.

When asked if they would be willing to support the renovation costs with a contribution in euros, the inhabitants have mostly agreed a sum of less than 1.000 euros.

The research group has considered important to proceed the investigation and analysis upon the collected data through cross analysis. The three questions that have been further investigated are:

1. Which is your opinion about apartment construction on the roof of the building? Please keep in mind that this would allow the installation of solar panel, improve the energy performance and consequently reduce both the energy and the renovation costs

2. If you would be given the opportunity to renovate your apartment, would you be in favour of a volumetric extension? What type of intervention would you like to suggest?

3. Have you ever heard of energy efficiency?

In relation to questions number 1 and 2, the research aimed at understanding the level of education and the social position of the interviewees that have answered positively, e.g. in favour to the volumetric addition strategy. In relation to the awareness on the subject of energy

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[9] Tecnocasa report 2014 for the Gattaglio area where the building is located.

efficiency, question 3, the cross analysis has been carried together with the investment-related questions.

In other words, the research team tried to evaluate if it exists a direct relations between the level of knowledge on the subject and the willingness of the inhabitants to contribute, also financially, to the energy renovation intervention. In the following diagrams, the column in blue represents the interviewees that are in favour of rooftop and volumetric extensions, the green one represents the ones that are in favour of the idea but would not support its application in Peristeri whereas the yellow one represents the interviewee that are against the idea and its application.

The cross-analysis has shown that the majority of the interviewees that have express their disapproval to the volumetric addition strategy are retired person, mostly with only a primary education. On the other hand, the subjects that have supported the proposal both as an idea and for its application in Reggio Emilia have a Lyceum diploma or a university degree and are employed or retired. The following graph shows the relationship between the knowledge on energy efficiency and the support to the proposal. The majority of the ones that are in favour (blue column) are also the majority of the subjects that are interested in energy efficiency and are informed on the subject. A significant part of the yellow ones, subjects against the volumetric addition, are also in the groups that are never been interested in the topic or have never heard of the term energy efficiency.

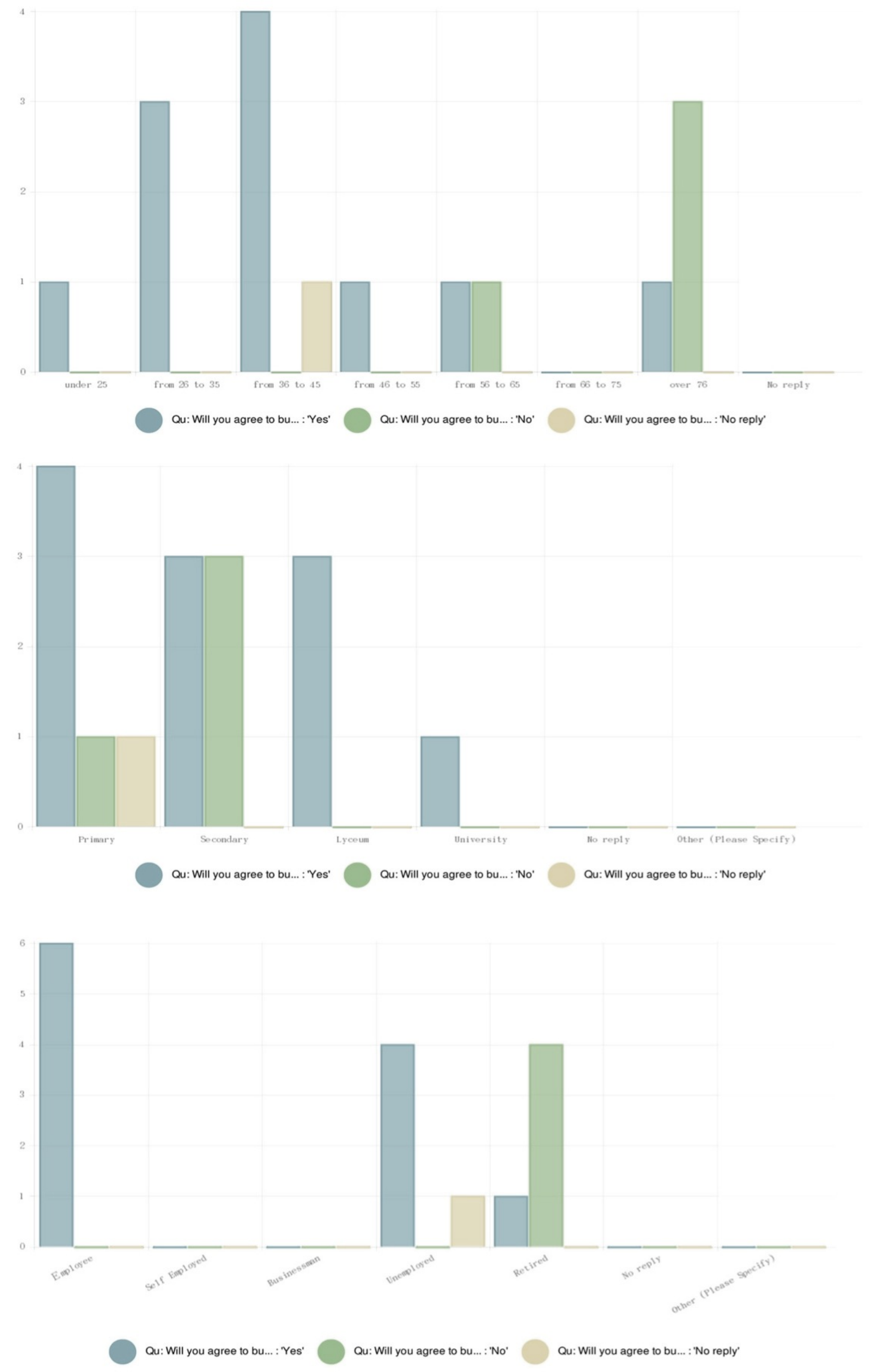


Fig. 19 Comparison among the opinion on the volumetric addition strategy and (from above): a. the age of the interviewees, b. the level of education of the interviewees, c. the type of occupation (social level) of the interviewees

From the considerations above and the results of the survey, it is clear that, in order to increase the support and commitment of the inhabitants in this type of intervention, it would be necessary to develop a communication policy and create a sufficient common knowledge on the energy efficiency subject, on the pay-back potentials and on the techniques that could be applied on the buildings. This would consistently contribute to shift some of the sceptical inhabitants towards supporting the renovation action. Intervention on the existing buildings not only on the outside envelope but also offering a better kitchen and renovation in the toilet would also represent a key leverage to convince the inhabitants in supporting the Deep Renovation.

In conclusion, the evaluation and dialogue with the inhabitants of the Viale Magenta neighbourhood has lead to important conclusions that will be implemented in the design proposal. The volumetric addition, as will be tested in this case study will be addressed more towards the creation of punctual intervention on the façade of the existing building without interfering with the original layout of the building and creating additional space on the street font. The intention is also to renovate the commercial activity at the street level in order to improve the social mix and attract also more visitors from the near-by city centre. Moreover the new apartment units will introduce in the social mix, middle class and young people that could act as mediator in the on-going conflict between the elderly and the immigrant groups and hopefully improve the living condition of the community. These scenarios could contribute in to balancing the investment and increase the satisfaction of the existing inhabitants by improving the quality of their dwelling.

The inhabitants will propose micro-scale intervention, at the unit level, as negotiation leverages to gain the consensus in the renovation. Shading systems will be provided and integrated in the façade and envelope systems. Storage space should be created in the balcony or in the apartments, since the users need it. An improvement in the layout could be offered for the living room and kitchens, which are the preferred areas of the apartments.

The majority of the inhabitants does not support rooftop additions, there is a need to increase the safety and static conditions of the buildings' structure. This aspect could be integrated in the renovation proposal acting therefore again as a trigger node to overcome the disadvantages and problems that inhabitants will face in case of renovation (noise, dirt, disturbance). As for the ground floor, it is important to propose a new organization of the external areas and the internal courtyard to favour the access and the fruition of those communal spaces. A consistent number of car parks shall be created in order to provide for the current inhabitants that yet do not have enough paring spaces and for the new inhabitants.

The following image shows in red the extra-volumes that could be created as part of the renovation. In summery, from the results of the questionnaires the strategy will keep account of:

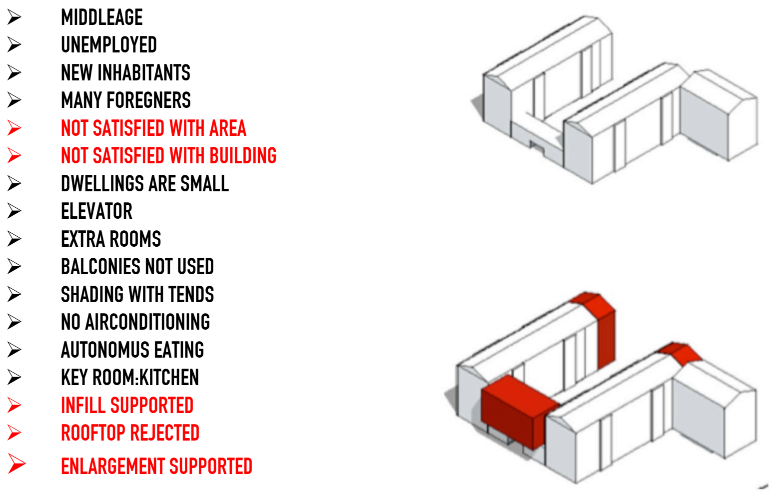


Fig. 20 Urban and architectural strategy layout, red volumes represent the potential volumetric addition that would foster the renovation intervention by decreasing the pay-back time

The next step consists in revising the scenarios that came out of the sociological feasibility study according to technical, urban and architectural feasibility. In the next paragraph a schematic draft of project has been carried to illustrate the potential of introducing the volumetric addition and the façade renovation through the multi-variant design strategy. Ultimately a cost-benefit analysis brings to a better definition of the project according to its payback and real technical potential considering the real cost of the renovation intervention combined with the cost for Add-on construction and the energy reduction resulting from the renovation.

5.1.3 Project summary

The building chosen as Italian case study is characterised by an internal courtyard and two identical building blocks creating a U shape. The street front is only one storey high while the other parts of the building are four storeys high. The front part of the building is dedicated since the origin of the construction to commercial activities while the rest is residential. Each staircase serves eight apartment units facing mainly east and west. The dwellings are distributed to have mostly cross ventilation and good exposures. The original loggias have been transformed by several inhabitants in serras and winter gardens with economical and various solutions. The elevations are currently not homogeneous and vary in different shading and enclosure systems. The building remission of 1985 (*condono edilizio*) authorised the inhabitants to legalise these informal actions by paying a fee and the majority agreed in officially registering the transformation by the ACER.

The renovation intervention has been structured in three main actions:

- Window replacement (triple glazing with obscurant panels for shading) and the application of an insulation layer. The areas around the transparent opening could be underlined by the application of a metal panel that supports the sliding obscurant systems
- Renovation of the cellars and the attic, which are currently in critical conditions in terms of hygiene and structural safety. Roof renovation with insulation and the addition of overhanging elements to protect the façade from rain and external agents.
- Add-on on the street elevation. The possibility of creating extra dwelling units on the rooftop has been considered and discussed with the inhabitants who have rejected the proposal. The attic will be given as renovated and additional surface to the current inhabitants as bonus to balance the disadvantage and disturbances to the inhabitants created by the renovation.

The Add-on will enclose the side windows of six apartments. The inhabitants living in these dwellings have been questioned about the matter and have expressed their interest in the renovation. The enclosure of the window will be compensated by the addition of a glazed winter garden-balcony facing both the courtyard and the street front and increasing the Usable Living Area of the current apartments. Moreover, as requested by the users, a reorganisation of the internal layout will be offered to create a separate space for the kitchens (currently organised as corner space in the living room). As already mentioned the research does not intend to enter the composition and formal aspects related to the Add-on strategy, the images and panels attached are indicative to illustrate the potential of the approach and prove its feasibility. The additional volume of this case study and also of the following ones has not been defined in materiality and colour, red has been used in the schemes to indicate and underline the additional portion. However, for this specific case study it is recommended to use a contemporary language for the Add-on, in clear respect of the pre-existence, not interfering on the formal level and preserving the typical character of the original building and its historical value. To engage the inhabitants and offer the multi-variant design an abacus of possibilities for the façade has also been studied. The aim is to re-define the functionality of the façade through the façade components as illustrated in Chapter 3 without creating further horizontal extensions. The existing balconies and loggia could be enclosed and become extra rooms or winter gardens or simply be refurbished according to the inhabitants' wishes. The abacus (P.it. presented in the attached panel is an example of the possible collection of façade elements that can be offered as a catalogue to the users. The combination of different façade component will result in a coherent composition defined according upon the desires of the single. The final images and three-dimensional visualisations (P.it.2) illustrate the potential in volumetric terms of the strategy and show a possible combination of the façade abacus elements.

Fig. 21 Main elevation of the building in Viale Magenta. The current situation (before) shows a discontinuity and urban void that has been 'filled' with an Add-on on the street front (after).

5.1.4 Cost-benefit analysis

The scenario and design experiment carried on the Italian case study has been further evaluated from an economical point of view to investigate the real benefit of the Add-on in reducing the excessive up-front costs that generally represent the main barrier to deep renovation in Europe.

Table 3 illustrates the unit cost for each of the renovation intervention foreseen for the case study 1. The object is to define a specific cost per square meter of the renovation intervention in the specific Italian market, which in this case resulted 545,00 euro/m^2. The intervention included insulation, window replacement, basic substitution of plant, thermostat devices in all the apartment and the application of new windows, finishing and balconies as presented in the panels (P.it3-5). In parallel, the cost of the Add-on has been estimated. The case study has proven the feasibility of an overall Add-on of 558 m^2. Considering the schematic design presented in the project experiment carried the overall cost per square meter to construct the Add-on would be 634,00 euro/m^2. A Photovoltaic plant has been planned on the portion of the roof facing west to integrate RES in the renovation, for an overall of 634 m^2 for a power plant of 91,50 kWp (solar panel yield 15%).

Tab. 4 collects the energy savings and consumptions data. Energy related aspects are the results of the calculations and simulations carried instead on a series of dwelling, located at different levels and with different exposure, of the buildings with energy simulations programs (Design Builder and MC Impianti). The overall energy consumptions have been compared with the bills and the real data provided by ACER; this made possible to quantify the possible energy savings generated by a Deep renovation and include the economical benefit in the analysis. As for the cost evaluation, the current situation of the Italian market has been analysed searching for the unit cost of the Add-on and the real estate value of the Add-on according to the area the case study is located. The energy prices have been collected from the Italian and local energy provider (Iren). As for the electrical production, the PV plant evaluated and included in the project simulation has been counted and inserted in the evaluation accounting its potential energy production.

	UoM	Quantity	Unitarian cost	Total cost
Renovation Interventions	**mq**	**(Case study 01)**	**(Italian market)**	**545,57 €**
Window replacement (triple glazing)	mq	568,52	700,00 €	397.964,00 €
Rooftop insulation	mq	1.335,00	40,00 €	53.400,00 €
Facade insulation	mq	3.302,48	100,00 €	330.248,00 €
Ground Floor slab insulation (against earth)	mq	1.162,00	65,00 €	75.530,00 €
Insulation of floor slabs adjacent to cold spaces (parkings, pilotis etc.)	mq	-	65,00 €	- €
Insulation of balconies, bow-windows, frames	mq	336,00	140,00 €	47.040,00 €
New balconies and finishing	mq	656,00	40,00 €	26.240,00 €
New heating system with heat pump	cad		40.000,00 €	40.000,00 €
Thermostat for consumptions check	cad	40,00	290,00 €	11.600,00 €
				982.022,00 €
			With extra costs	**1.080.224,20 €**
Add-on construction cost	**mq**			**634,00 €**
New windows in the addition	mq	66,00	700,00 €	46.200,00 €
Add-on construction cost (1)	mq	558,00	600,00 €	334.800,00 €
				381.000,00 €
			With extra costs	**419.100,00 €**
PV plant	kWp	91,50	450,00 €	**41.175,00 €**
Total Investment				**1.499.324,20 €**

Tab. 3 Cost overview for the renovation intervention, the Add-on construction and for the installation of a PV plant on the roof of the building. The data here presented are collected also in Tab.5 and will be the base for the cost-benefit analysis carried in Tab. 6-7.

Energy consumptions (1)			
170,36	kWh/mq per year	Before	DB simulations
25,00	kWh/mq per year	After	SET point
470.197,50	kWh per year	Before	
69.000,00	kWh per year	After	
Energy prices (2)			
0,95	€/mc	Natural gas price	(Iren, 2015)
0,18	€/kWh	Electricity price	(Iren, 2015)
Energy savings (thermal)			
40.119,75	mc per year	Gas savings after intervention	
6.900,00	mc per year	Gas consumptions after intervention	
38.113,76	**€ per year**	**Energy Savings after intervention**	
6.555,00	**€ per year**	**Energy Costs after intervention**	
Energy production (electrical)			
24.004,16	kWh per year	Electrical energy production from PV	
91,50	kWh peak	Total power of the plant	
4.320,75	**€ per year**	**Energy Savings after intervention**	

Tab. 4 Energy consumptions and production as for the Italian market and the considered case study. (1) The energy consumptions have been derived by the simulations carried with Design Builder on the case study. Thermal and electrical benefit in economical terms has then been calculated. The energy prices (2) have been collected from the Italian and local energy provider (Iren). The data here presented are collected also in Tab.5 and will be the base for the cost-benefit analysis carried in Tab. 6-7.

Table 2 collects all the main data and calculations related to the case study that have been then used as a basis to run the cost-benefit calculations on the case study. The location and geometrical data have been derived by the original drawings (see Annex 1) and the surveys conducted during the research time. Architecture technology aspects have been assumed by comparison with similar case study, the different transmittance value have been calculated according to the information available on the original maps and the tests carried on the building by ACER.

Energy related data and cost data are derived by the previews calculations as illustrated in Tab. 3-4. In order to run the cost-benefit simulation the costs of the intervention have been compared with the benefit given by the energy reduction, the energy production from PV and also the profit given by the sale of the Add-on which could significantly reduce the pay-back as already discussed. By applying the formula presented in Chapter 3, it has been possible to also preliminary calculate the minimum Add-on required to significantly impact on the renovation balance by reducing the payback time below the five years threshold. The formula does not take into account the financial aspects related to the renovation such as the interest rate and the investment rate, which has been here raised to 5% considering the possibility of an Esco interested in the investment.

Moreover the possibility of including in the survey the fiscal incentives offered by the Italian government in these type of renovation is also not included in the preliminary and qualitative analysis. It is thus interesting to consider the evaluation of Add-on necessary surface to compare in an initial stage the intervention and set a threshold between intervention that surely will have a payback time lower of 5 years (without incentives) and those that will result in longer pay-back times. This data has then been compared with the feasible Add-on that could be realised according to the different results of the sociological survey and the analysis on the potential adaptability of each context. In specific, for the Italian case study it has not been possible to reach the level of Add-on required and preliminary calculated to the formula therefore it has been expected to have higher pay-back times that could easily be reduced considering the favourable incentive scheme present in the region.

GEOMETRY		
Total net Surface	**2.760**	**mq**
Total gross Surface	3.105	mq
Total gross Volume	8.694	mc
S/V (1)	0,36	
Average gross Unit Surface	78	mq
Number of units	40	dwellings
Dwellings involved in the sociological survey	16	dwellers
Number of car parks	27	parkings
Area Lotto	4.211	mq
FAR Density (2)	0,18	-
ARCHITECTURE TECHNOLOGY		
Year of construction	1936	-
Restoration intervention	1975	-
Structure	Loadbearing walls	-
Roof construction type	Span-roof with attic	-
Facade	Bricks	-
Shading system	Rolling shutters	-
Add-on typology (3)	**Infill – Autonomous Structure**	-
ENERGY RELATED ASPECTS		
Energy consumptions heating and cooling (4)	170	kWh/mq
Envelope transmittance (average)	0,943	W/mq°K
Yearly energy consumptions	**376.158**	**kWh/y**
Energy savings by retrofitting (5)	332.198	kWh/y
Unit Energy reduction by retrofitting	102	euro/mq
Co2 reduction	29	t/CO2
Available PV surface	634	mq
Renewable energy production (6)	**24.004**	**kWh/y**
COST EVALUATIONS		
Real estate value (7)	1.860	Euro/mq
Renovation cost (8)	545	Euro/mq
Total renovation cost	**1.080.224,20**	**Euro**
Energy savings (thermal) after renovation	38.113,76	Euro
Add-On construction cost (9)	535	Euro/mq
Incentives (10)	65	%
Gas cost (11)	0,95	Euro/mq
Electricity cost (11)	0,12	Euro/kWh
PV plant cost	**41.175**	**Euro**
Energy savings through solar energy	2.880	Euro
ADD-ON NECESSARY TO SET THE PAYBACK BELOW 5 YEARS (12)	**904**	**mq**
ADD-ON FEASIBLE AS DEMONSTRATION PROJECT	**558**	**mq**

Tab. 5 (1) The surface area to volume (S/V) ratio defines the heat loss and gain.The greater the surface area the more the heat gain/loss through it. (2) FAR denisty is calculated as the ration between the total liveable surface and the plot area. (3) The Add-on typology is defined according to the categorisation made in Chapter 2 (Tab.2.2). In this case it is a *completing-authonomous Add-on* by infill (4) Energy consumptions and EP average values have been calulated through simulation run by Design Builder considering both the summer and the winter regime (5) The value of energy savings has been calculated considering to reduce the current consumptions down to 25 kWh/m^2 per year which has been set as target (see Tab. 4) (6) The renewable energy production given by the proposed PV plant has been supposed to be installed on an overall surface of 634 mq with a power of 91,5 kWp. (7) The real estate value is intended as the potential selling value of new real estate units as derived by the market situation in Reggio Emilia as well as the unitarian construction cost (Source: Tecnocasa report 2014) (8,9) The renoavion and Add-on construction cst per square meter have been calculated on the specific case study as showed in Tab. 3 (10) The incentives provided by the Italian government is calculated upon the 65% of the total investment for those interventions that are related to the energy renovation, it is divided into 10 rates and accounted as fiscal reduction as established by the Conto Energia 2015 (11) The data is derived by Eurostat statistics from 2015 and the current prices of Iren as local energy provider (12) The volumetric addition calulcated accoding to the formula presented in Chapter 3 to reduce the payback time below the 5 years threshold

Renovation investment	1.080.224,20	€
PV investment	41.175,00	
Add-Ons investment	419.100,00	€
Total Investment (Renovation + PV + Add-Ons)	**1.540.499,20**	€
Savings (non weighted, thermal)	38.113,76	€ /year
Profit from Add-ons' sale	**1.179.240,00**	€
Savings (non weighted, electrical)	4.320,75	€ /year
Fiscal incentive (65%)	728.909,48	€
Fiscal incentive rate (10 years plan)	72.890,95	€ /year
Interest rate (5%)	0,050	
Energy inflation rate (3%)	0,030	

Incoming				Outgoing			
Year	Savings	PV Production	Incentive	Consumptions	Cash flow	NPV	Sum
0	0,00		0,00	0,00	-1.540.499,20	-1.540.499,20	-1.540.499,20
0	1.179.240,00		0,00	0,00	1.179.240,00	1.179.240,00	-361.259,20
1	38.113,76	4.320,75	72.890,95	6.555,00	115.325,46	109.833,77	-251.425,43
2	39.257,18	4.450,37	72.890,95	6.751,65	116.598,49	105.758,27	-145.667,16
3	40.434,89	4.583,88	72.890,95	6.954,20	117.909,72	101.854,85	-43.812,31
4	41.647,94	4.721,40	72.890,95	7.162,83	119.260,28	98.115,73	54.303,42
5	42.897,38	4.863,04	72.890,95	7.377,71	120.651,36	94.533,50	148.836,92
6	44.184,30	5.008,93	72.890,95	7.599,04	122.084,18	91.101,09	239.938,02
7	45.509,83	5.159,20	72.890,95	7.827,01	123.559,97	87.811,77	327.749,78
8	46.875,12	5.313,98	72.890,95	8.061,82	125.080,04	84.659,10	412.408,88
9	48.281,37	5.473,40	72.890,95	8.303,68	126.645,72	81.636,96	494.045,84
10	49.729,82	5.637,60	72.890,95	8.552,79	128.258,36	78.739,51	572.785,34
11	51.221,71	5.806,72		8.809,37	57.028,43	33.343,34	606.128,69
12	52.758,36	5.980,93		9.073,65	58.739,29	32.708,23	638.836,92
13	54.341,11	6.160,35		9.345,86	60.501,47	32.085,22	670.922,14
14	55.971,35	6.345,16		9.626,24	62.316,51	31.474,07	702.396,21
15	57.650,49	6.535,52		9.915,03	64.186,01	30.874,57	733.270,78
16	59.380,00	6.731,59		10.212,48	66.111,59	30.286,48	763.557,26
17	61.161,40	6.933,53		10.518,85	68.094,93	29.709,59	793.266,85
18	62.996,24	7.141,54		10.834,42	70.137,78	29.143,70	822.410,55
19	64.886,13	7.355,79		11.159,45	72.241,91	28.588,58	850.999,13
20	66.832,71	7.576,46		11.494,23	74.409,17	28.044,03	879.043,16
21	68.837,69	7.803,75		11.839,06	76.641,45	27.509,86	906.553,03
22	70.902,83	8.037,87		12.194,23	78.940,69	26.985,86	933.538,89
23	73.029,91	8.279,00		12.560,06	81.308,91	26.471,85	960.010,74
24	75.220,81	8.527,37		12.936,86	83.748,18	25.967,62	985.978,36
25	77.477,43	8.783,19		13.324,97	86.260,62	25.473,00	1.011.451,36
26	79.801,75	9.046,69		13.724,71	88.848,44	24.987,80	1.036.439,16
27	82.195,81	9.318,09		14.136,46	91.513,90	24.511,84	1.060.951,01
28	84.661,68	9.597,63		14.560,55	94.259,31	24.044,95	1.084.995,96
29	87.201,53	9.885,56		14.997,37	97.087,09	23.586,95	1.108.582,91
30	89.817,58	10.182,13		15.447,29	99.999,71	23.137,68	1.131.720,59
				NPV	30 years	2.672.219,79	
				IRR	30 years	0,17276	
				PAY-BACK TIME	4 years		

Tab. 6 Cost-benefit analysis carried for deep renovation with Add-Ons of 558 m^2 considering the current incentive scheme which in Italy covers up to 65% of the initial investment as fiscal reduction. The payback time resulting from the NPV (2.672.220 euro) is 4 years and the IRR is 17,3 %

Renovation investment	1.080.224,20	€
PV investment	41.175,00	
Add-Ons investment	419.100,00	€
Total investment (Renovation+PV+Add-Ons)	**1.540.499,20**	€
Savings (non weighted)	38.113,76	€ per year
Profit from Add-ons' sale	**1.179.240,00**	€
Savings (non weighted,electrical)	4.320,75	€ per year
Interest rate (5%)	0,0500	
Energy inflation rate (3%)	0,0300	

	Incoming		Outgoing			
Year	Savings	En.Production PV	Consumptions	Cashflow	NPV	Sum
0	0,00		0,00	-1.540.499,20	-1.540.499,20	-1.540.499,20
0	1.179.240,00		0,00	1.179.240,00	1.179.240,00	-361.259,20
1	38.113,76	4.320,75	6.555,00	42.434,51	40.413,82	-320.845,38
2	39.257,18	4.450,37	6.751,65	43.707,55	39.644,03	-281.201,35
3	40.434,89	4.583,88	6.954,20	45.018,77	38.888,91	-242.312,44
4	41.647,94	4.721,40	7.162,83	46.369,34	38.148,17	-204.164,27
5	42.897,38	4.863,04	7.377,71	47.760,42	37.421,54	-166.742,74
6	44.184,30	5.008,93	7.599,04	49.193,23	36.708,74	-130.033,99
7	45.509,83	5.159,20	7.827,01	50.669,03	36.009,53	-94.024,46
8	46.875,12	5.313,98	8.061,82	52.189,10	35.323,63	-58.700,83
9	48.281,37	5.473,40	8.303,68	53.754,77	34.650,80	-24.050,02
10	49.729,82	5.637,60	8.552,79	55.367,41	33.990,79	9.940,77
11	51.221,71	5.806,72	8.809,37	57.028,43	33.343,34	43.284,11
12	52.758,36	5.980,93	9.073,65	58.739,29	32.708,23	75.992,34
13	54.341,11	6.160,35	9.345,86	60.501,47	32.085,22	108.077,56
14	55.971,35	6.345,16	9.626,24	62.316,51	31.474,07	139.551,63
15	57.650,49	6.535,52	9.915,03	64.186,01	30.874,57	170.426,20
16	59.380,00	6.731,59	10.212,48	66.111,59	30.286,48	200.712,68
17	61.161,40	6.933,53	10.518,85	68.094,93	29.709,59	230.422,27
18	62.996,24	7.141,54	10.834,42	70.137,78	29.143,70	259.565,97
19	64.886,13	7.355,79	11.159,45	72.241,91	28.588,58	288.154,55
20	66.832,71	7.576,46	11.494,23	74.409,17	28.044,03	316.198,58
21	68.837,69	7.803,75	11.839,06	76.641,45	27.509,86	343.708,45
22	70.902,83	8.037,87	12.194,23	78.940,69	26.985,86	370.694,31
23	73.029,91	8.279,00	12.560,06	81.308,91	26.471,85	397.166,16
24	75.220,81	8.527,37	12.936,86	83.748,18	25.967,62	423.133,78
25	77.477,43	8.783,19	13.324,97	86.260,62	25.473,00	448.606,78
26	79.801,75	9.046,69	13.724,71	88.848,44	24.987,80	473.594,58
27	82.195,81	9.318,09	14.136,46	91.513,90	24.511,84	498.106,43
28	84.661,68	9.597,63	14.560,55	94.259,31	24.044,95	522.151,38
29	87.201,53	9.885,56	14.997,37	97.087,09	23.586,95	545.738,33
30	89.817,58	10.182,13	15.447,29	99.999,71	23.137,68	568.876,01
			NPV	30 years	2.109.375,21	
			IRR	30 years	0,10099	
			PAY-BACK TIME	10 years		

Tab. 7 Cost-benefit analysis carried for deep renovation with Add-Ons of 558 m^2 . The payback time resulting from the NPV (2.109.375 euro) is 10 years and the IRR is 10,1 %

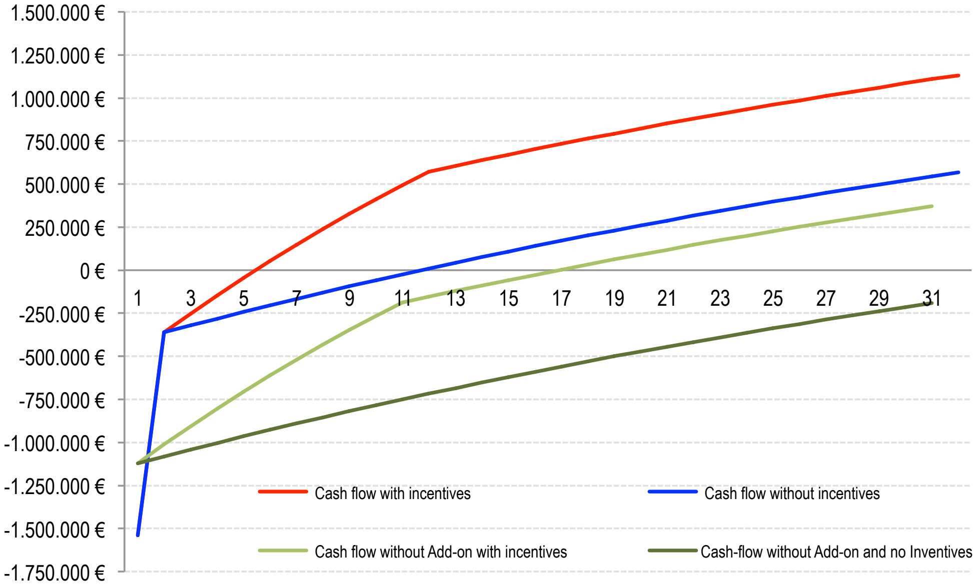
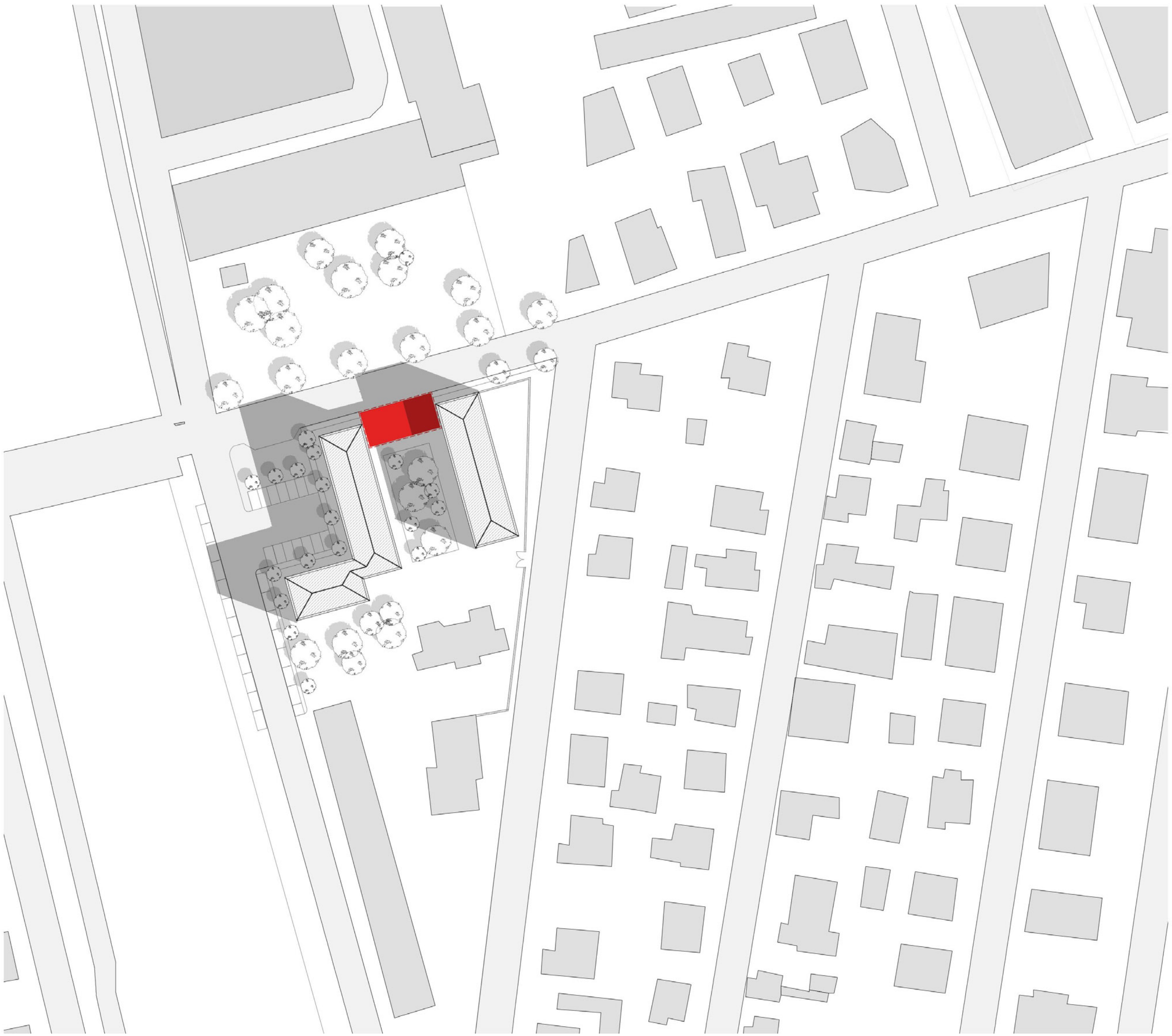


Fig. 22 The graphic shows the comparison between the two cost-benefit analysis carried for deep renovation with Add-On as the design experiment for the case study 01. Deep renovation with Add-Ons' investments without incentives (blue in the graphic), can reach a pay-back time of 10 years whereas the pay-back time of Deep renovation with Add-ons, with incentive - for the Italian legislative framework accounting for 65% of the initial investment - (red in the graphic) is about 4 years. The graphic shows the comparison between the Deep Renovation with Add-on as above illustrated and the case of no Add-on (in green in the graphic) both with and without incentives.

The graphic in Fig. 21 illustrated the cashflow and cost-benefit analysis as carried for the case study 01. It is clear that the current real estate and construction market condition in Italy is not significantly favourable, the Add-on profit compared to the construction cost and the increase in the upfront cost is not contributing significantly but it is anyway signing an important change in the overflow of the inverstement by reducing the risks and brining an initial reduction of the costs. The first uprise of the cashflow is represented by the Add-on profit which is determine a crucial change in the investment trend when compared to the standard cost-benefit analysis of Deep Renovation as illustrated in Chapter 3. The green lines of the graphic show the investment cash flow in case for the building in via Magenta the deep renovation would have been carried without Add-on. It is clear that the upfront cost would have been minor in case of no additional construction costs for the Add-on but is also clear that there would have been no profit from the sale and the pay-back time would have been significantly extended beyond the 15 years also in case of incentives (light green) and beyond the 30 years in case of no incentives.

5.1.5 TABLE AND DRAWINGS, CASE STUDY 01



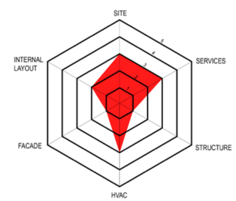
CASE STUDY

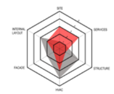
Viale Magenta, Reggio Emilia (IT)

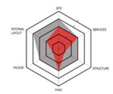
RELEVANT DATA

Total net Surface	2.760
Total gross Surface	3.105
Total gross Volume	8.694
S/V (1)	0,36
Average gross Unit Surface	78
Number of units	40
Dwellings involved in the survey	16
Number of car parks	27
Area Lotto	4.211
FAR Density (2)	0,18

ADDITIONAL INFORMATION







VIALE MAGENTA.RE
ITALY

SMALL

Current state, urban scale
1.1000

P. it.01

Floorplan _ Typical

Section

North-West Elevation

West Elevation

CASE STUDY

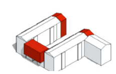
Viale Magenta, Reggio Emilia (IT)

RELEVANT DATA

Year of construction	1936
Restoration intervention	1975
Structure	Loadbearing walls
Roof construction type	Span-roof with attic
Facade	Bricks
Shading system	Rolling shutters
Add-on typology (3)	Infill – Autonomous

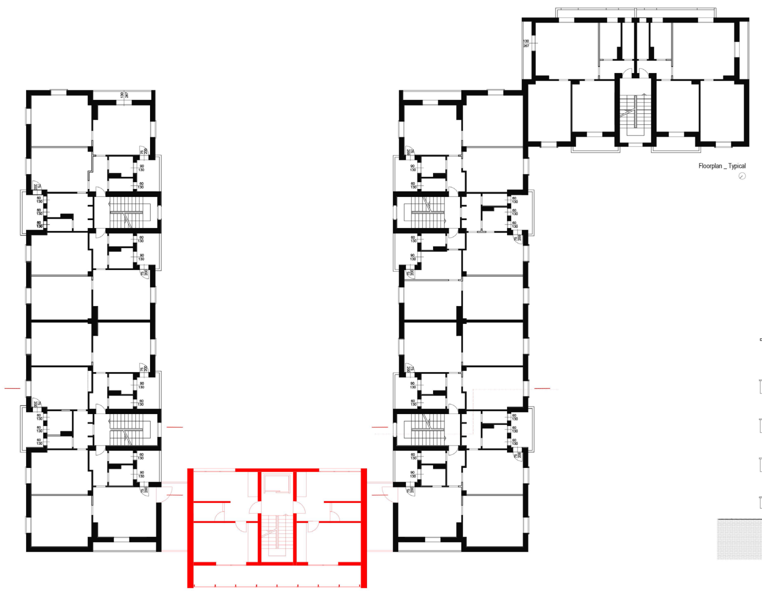
ADDITIONAL INFORMATION

Energy consumptions, heating and cooling	170	kWh/mq
Envelope transmittance	0,943	W/mq°K
Total primary energy consumptions	376.158	kWh/y
Energy savings by retrofitting (3)	332.198	kWh/y
Unit Energy reduction by retrofitting	102	euro/mq
Co2 reduction	29	t/CO2
Available PV surface	634	mq
Renewable energy production	24.004	kWh/y



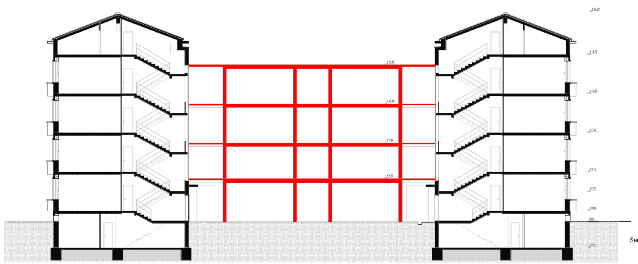
Current State, building scale
1:200

P. it.02



Floorplan _ Typical

North-West Elevation



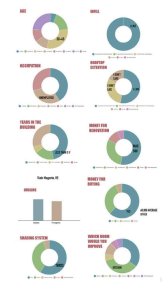
Section

CASE STUDY

Viale Magenta, Reggio Emilia (IT)

RELEVANT DATA

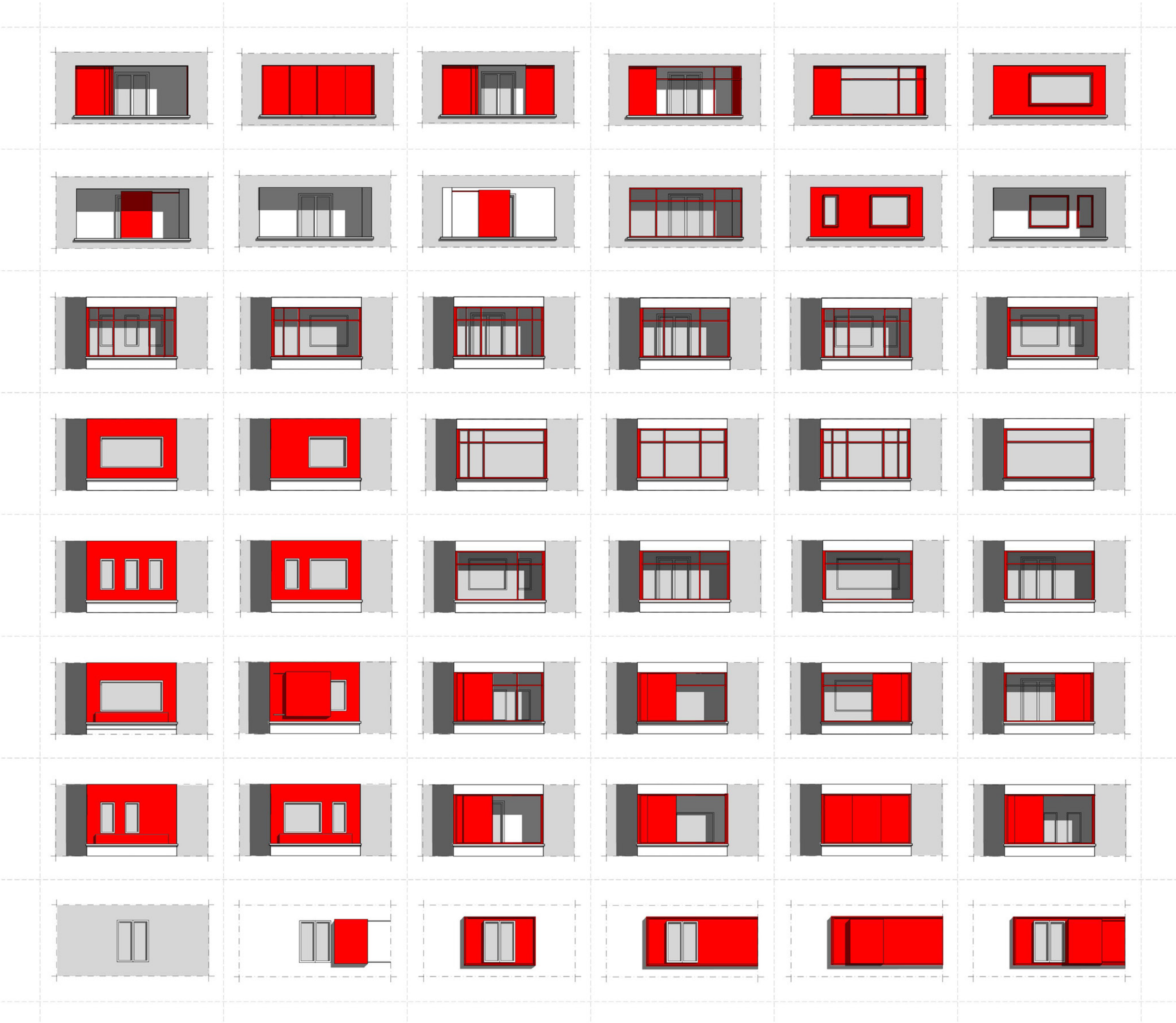
Window replacement (triple glazing)	397.964,00 €
Rooftop insulation	53.400,00 €
Facade insulation	330.248,00 €
Ground Floor slab insulation (against earth)	75.530,00 €
Insulation of floor slabs adjacent to cold spaces (parkings, pilotis etc.)	-
Insulation of balconies, bow-windows,	47.040,00 €
frames	26.240,00 €
New balconies and finishing	40.000,00 €
New heating system with heat pump	11.600,00 €
Thermostat for consumptions check	1.080.224,20 €
Total renovation cost	46.200,00 €
New windows in the addition	46.200,00 €
Addition construction cost	419.100,00 €
PV plant	41.175,00 €
Total Investment	1.499.324,20 €



Possible outcome,
multi-variable design

1:200

P. it.03



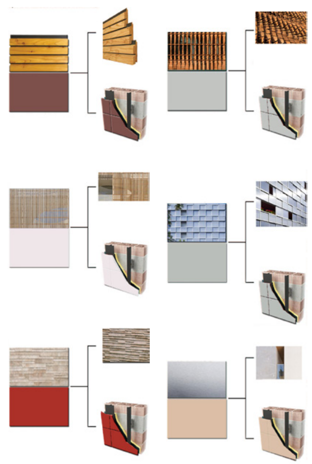
CASE STUDY

Viale Magenta, Reggio Emilia (IT)

RELEVANT DATA

MIDDLEAGE
UNEMPLOYED
NEW INHABITANTS
MANY FOREGNERS
NOT SATISFIED WITH AREA
NOT SATISFIED WITH BUILDING
DWELLINGS ARE SMALL
ELEVATOR
EXTRA ROOMS
BALCONIES NOT USED
SHADING WITH TENDS
NO AIRCONDITIONING
AUTONOMUS EATING
KEY ROOM:KITCHEN
INFILL SUPPORTED
ROOFTOP REJECTED
ENLARGEMENT SUPPORTED

POSSIBLE MATERIALS



Typological Façade Abacus

1.200

P. it.05

5.2 The German case study. Mousonstrasse 53, Frankfurt am Main (DE)

The existing building chosen for pilot case 2 is located in the Mousonstrasse, in Bornheim: a north-eastern district of 47 districts in Frankfurt am Main / Germany. Most buildings are arranged in perimeter blocks and therefore close to each other. Some of the houses are historic buildings descended from the founding period in Germany. The streets are rather narrow, never the less enough parking lots are provided. The place is also famous for its post-war architecture and art noveau buildings, which can be found in many European cities. The social housing association Nassauische Heimstädte (NH) provided the five floors building, constructed in 1958, which is not under monumental protection. The five-story building includes a basement floor, five floors of apartments up to three rooms and a drying loft. The existing building with a slightly curved shape facing the south, is connected to the neighbouring building with a mansard rooftop in the east, while the west side of the building ends in a higher levelled building, the 'Kopfbau' with a flat rooftop. Currently, the building has a pent roof and a dry basement, which serves only small stowage place for residents. It was typical to establish buildings with a dry loft in the 50s/60s in Germany.

Access to the apartments is available by a vertical staircase, leading to open access balconies in the north. The access to the apartments in the higher building is given directly from the vertical staircase (one apartment per floor). Further the open access balcony leads to four apartments per floor in the lower building. The floor plan of those apartments is traditional and typical in combination with the usage of access pergolas. The functional rooms as kitchens, bathrooms, and office rooms are arranged in the northern part facing the access balcony; the more private rooms are arranged to the south. To improve the habitable surface, balconies have been attached during rehabilitation in 2004; the intervention consisted also in an insulation (EPS - 14 cm) coating that was placed on the south-eastern and western facades of the building. The north-western facade has not been insulated, windows and doors have not been replaced. The original construction system is made of five different types of blocks to improve the static behaviour of the building. In its current state the building is not easily accessible for its residents, especially those, who are living in the upper floors of the building.

Pilot case	MOUSONSTRASSE 53 (FRANKFURTAM MAIN, GERMANY)
Year of construction:	1958
Number of units:	25
Main building typology:	Block building
Construction system	Loadbearing wall
Dimension of units:	About 60m^2
Technical Data	Residential surface: about 2300m^2 Structure: concrete slabs and load bearing walls constructed with different type of bricks produce through recycled construction material from the post war period Window: aluminium with single/double glass Plants: currently, the gas boilers renewed in 2008 and located in each apartment unit
Last refurbished	2004
Energy performance:	About 150 Kwh/m^2*y
Energy management:	NH
Property regime:	Mixed: tenants from NH (Social Housing)
Adaptability degree (1-5)	2
Social Mixture	25% (Poland, Russia, Ukraine, Scotland)
Average rental cost	420-520 euros
Critical points:	Owners: scarce parking lots, difficult densification Current condition of the building relatively good, no apparent emergency Street front
Possible additions	Rooftop addition, façade extrusion from both sides

A lift to the vertical staircases in the north will be installed in order to provide for all residents, especially for the elderly ones, a low-barrier access. The main part of the building is covered with a white plaster, the higher part of the existing building is coloured in red plaster. The access balconies, as well as the private balconies are covered with a grey corrugated metal sheet. Moreover the south side got heat insulated and later on in 2008 the heating system was renewed with a new condensing boiler.

5.2.1 Adaptability assessment, densification potential

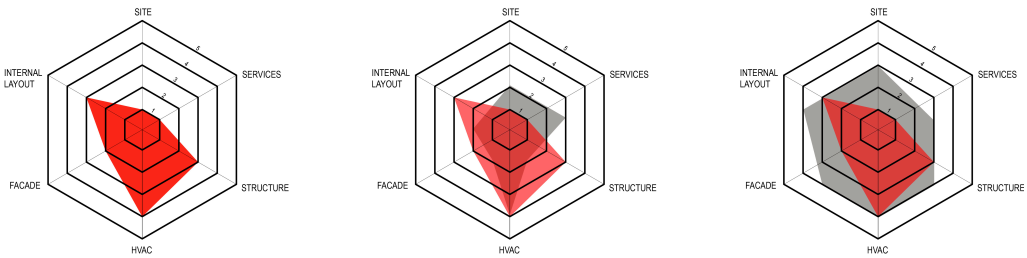


Fig. 23 Adaptability study for the case study of Frankfurt am Main (left) and comparison between the adaptability status of Mousonstrasse (DE) and viale Magenta (IT) (in the centre) and between Moussonstrasse (DE) and Peristeri (GR) (right)

The adaptability assessment on the German case study shows an overall fairly rigid profile and the urban context is not flexible enough to allow extensions or transformations at the ground level. Also the lack of services, already not sufficient to answer to the current status is not favouring the increase of load and density of the area. The Frankfurt turban area is extremely densely populated and Bornheim as a district is a prime location within the first urban periphery. The particular situation, characterised by a rigid framework that allows few transformations is counterbalanced by an extremely favourable real estate market that could show the entire potential of the Add-on strategy. Contrary from the previously illustrated case study, the construction market in Germany is still flourishing and the real estate value of Add-on especially in this area would significantly benefit on the Deep Renovation. On the other hand, the building has a potential for transformation on the layout, facade and structure allowing the planners to evaluate the option of a rooftop addition.

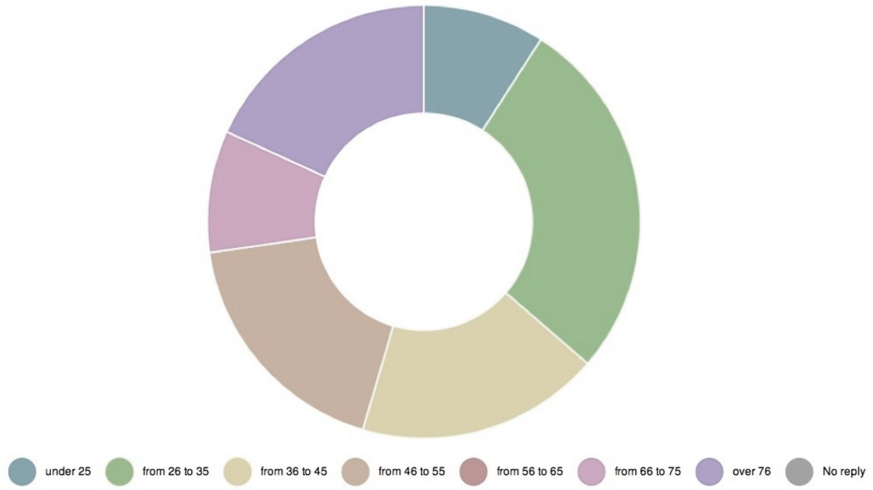
5.2.2 Data results of the questionnaires

Considering the Building in Mousonsstrasse neighbourhood, about fifteen questionnaires have been collected. A consistent percentage of inhabitants are old and requested not to be part in the survey. It must be underlined that a cultural difference has been recorded between the southern European case studies and the northern one. The percentage of immigrant living in the neighbourhood is significantly low, all of the dwellers have middle or good economical status whereas in the Italian and Greek case study the living conditions are often complicated and the buildings are inadequate. This pushes the inhabitants to complain and open up to the survey.

The foreigners living in the building are completely already integrated in the German society, speak the language and know the culture and habits to an extent that they are part of the community. The relative comfort given by the current status and the cultural privacy characterising the German case study explains the reduced participation in the survey.

The age and employment status in this second case study are evenly distributed characterising the building with a fair heterogeneity of sociological and ethnographical groups. Most of the inhabitants have been living in the area for longer than 20 years and are accustomed to the neighbourhood.

The inhabitants are mainly social tenants renting from the Nassauische Heimstädte, the rental price (7 euro/m^2) is lower than the normal rental market of the area (11 euro/m^2). The following graphics show the most significant statistic results related to the questions that have been considered central in the survey.



Place of Birth

Text Responses

Frankfurt am Main
Germany
Sudetenland
Scottland
Ucraine
Poland
Russia
Frankfurt am Main
Frankfurt am Main
Hilden
Frankfurt am Main

Fig. 24 Age groups that took part in the survey

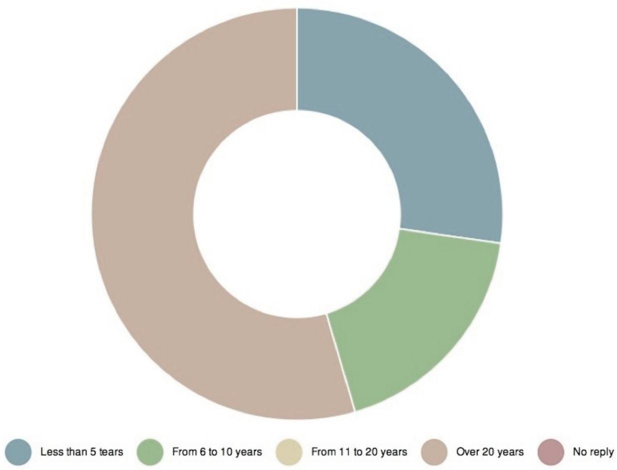


Fig. 25 Answers regarding the time of permanence in the neighbourhood

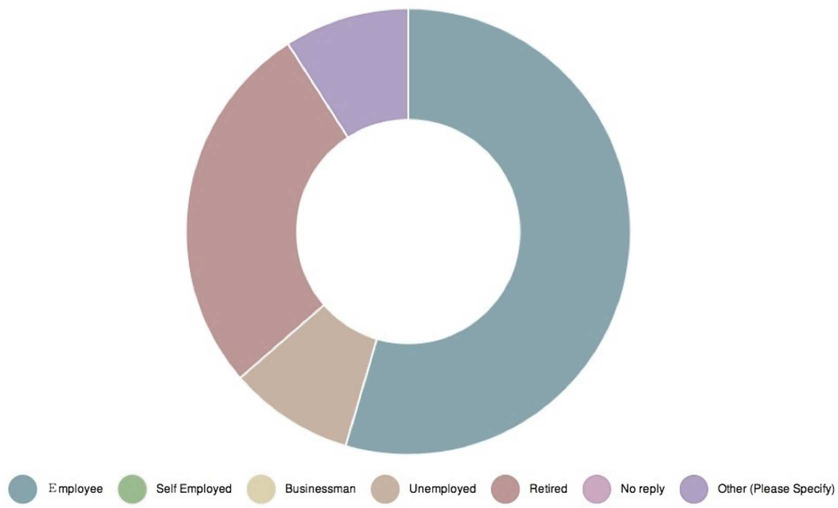
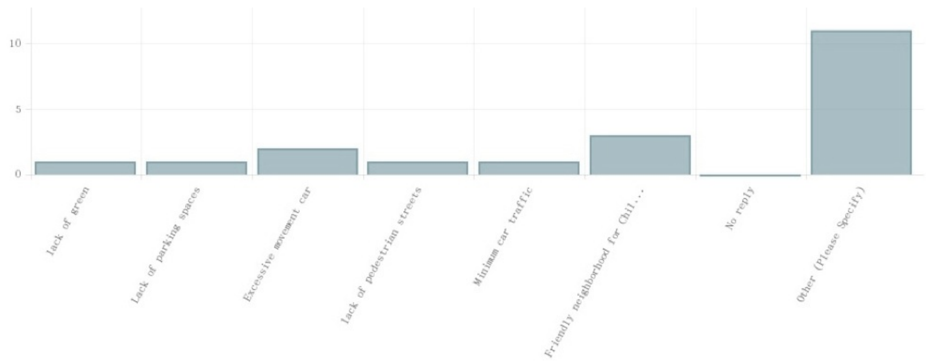


Fig. 26 Employment type



Text Responses

We are satisfied with the neighborhood but not with the neighbours. No one takes care of the communal space, to clean and to maintain the building

I like the area

Quite

Good

I like it

Neighborhous are tolerant and nice. The position is perfect and well connected

No problem, no real community and contact with the neighbors but it is quite and peacefull

All good

It is dirty and no one takes care of the neighborhood. There are too many immigrants. The walkway is always full of shoes and private things. The front ground floor space is always used for rubbish and there is no possibility of communal use

The neighbors and the location is too trafficked. It is a dangerous are with drugs exchange, kids can not play in the playground which is indeed used as rubbish and general storage. There are too many autos and it is too noisy.

I am satisfied but there is no community, no relationship with the neighbors

Fig. 27 Opinion of the interviewee regarding the neighborhood

Complains from the inhabitant regard mainly the participation from the community in cleaning and taking care of the areas surrounding the building. As for the building itself there have been no real complain, the status of the construction is good and there has been a refurbishment intervention in 2004 8although only the southern facade has been insulated). The general feeling among the users is the lack of a real community, the persons living the building are considering it as individual dwellings and there are no communal spaces or gathering.

Balconies are often used mainly to dry cloths and enjoy the sun, the current size of the balconies does not allow eating outside or using them for activities that require a longer stay. Also the existing balconies have been added in a second stage, a record with dating has not been found but the construction details and type of the substructure of the balconies has been added probably in the ‘80s.

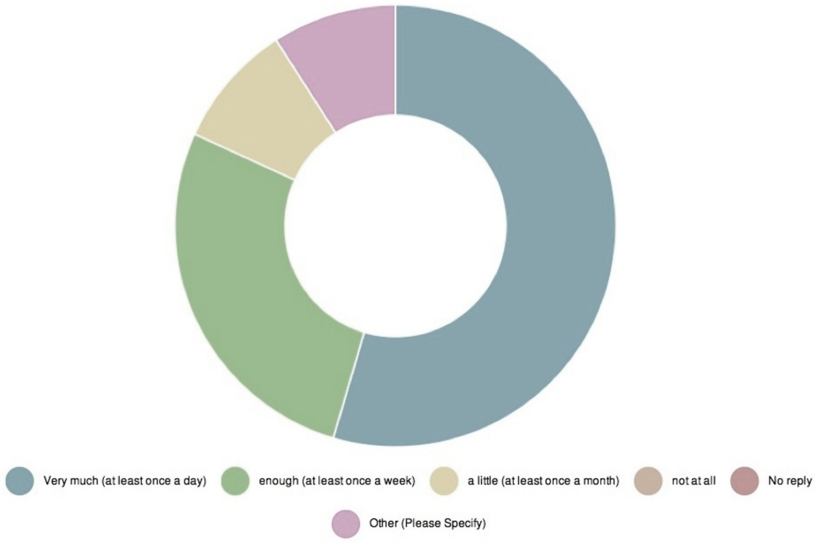


Fig. 28 Answers regarding the current use of the balconies

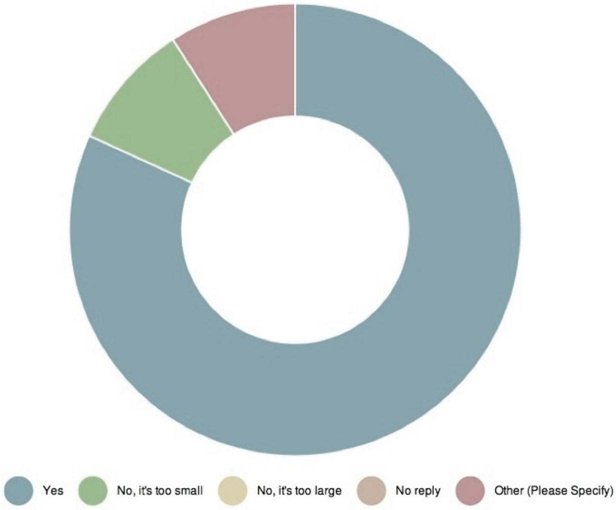


Fig. 29 Answers regarding the satisfaction with the size of the apartment units

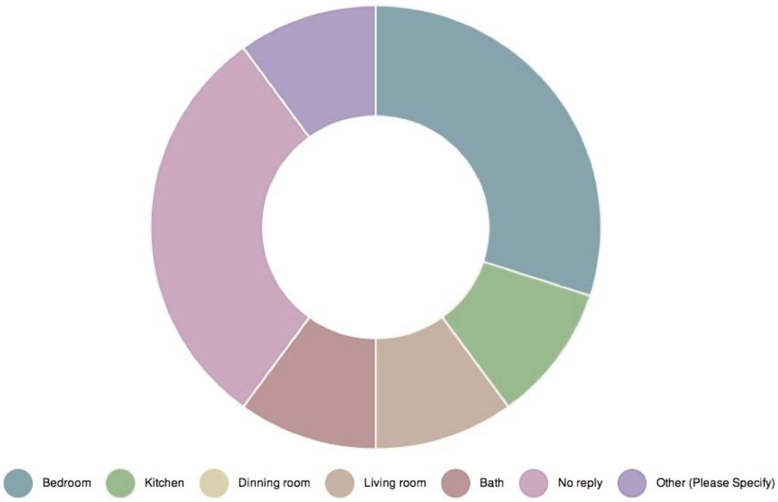


Fig. 30 Answers to the question: what room of your apartment would you like to renovate

As already mentioned the users are satisfied with their dwellings, the size is appropriate and fairly big compare to the German standards in the same area. The wish of the users that would like to improve the inside layout are directed towards intervention on the bedroom. The current apartment would require an extra bedroom or an extra room that could be used as studio. Only few of the interviewee expressed interest in interventions on the living room (enlargement), kitchen or bathroom (renovated).

When directly asked regarding the possibility of creating extra volume on the roof to support financially the renovation of the entire buildings, half of the inhabitants expressed interest and support to the idea; the other half stated a lack of interest but inferring they would not oppose to it. Compared to the Italian case study, the awareness regarding Energy Efficient topic has been registered to be higher therefore also the support encountered in the renovation has been more consistent from those dwellers that had already knowledge on the topic.

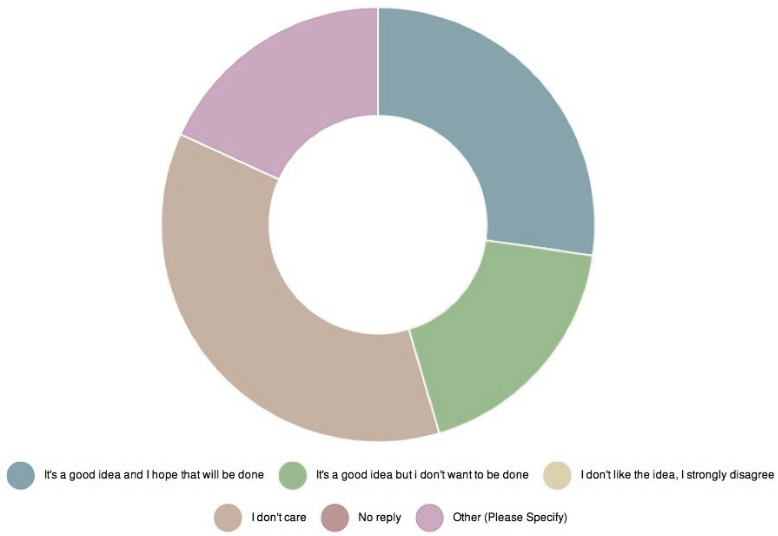
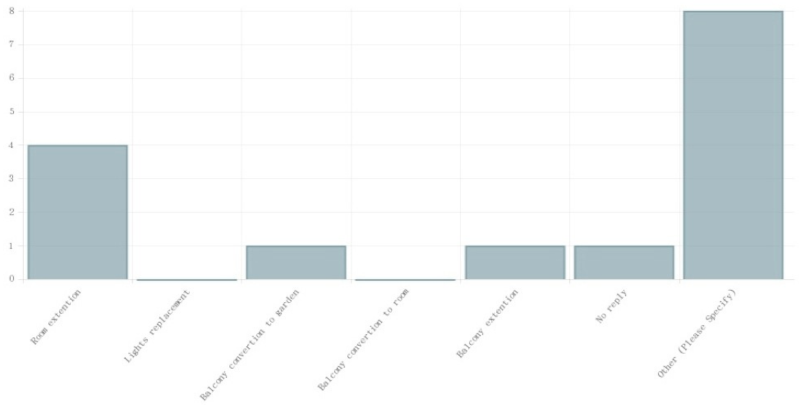


Fig. 31 Answers regarding the possibility of building extra volume on the roofs

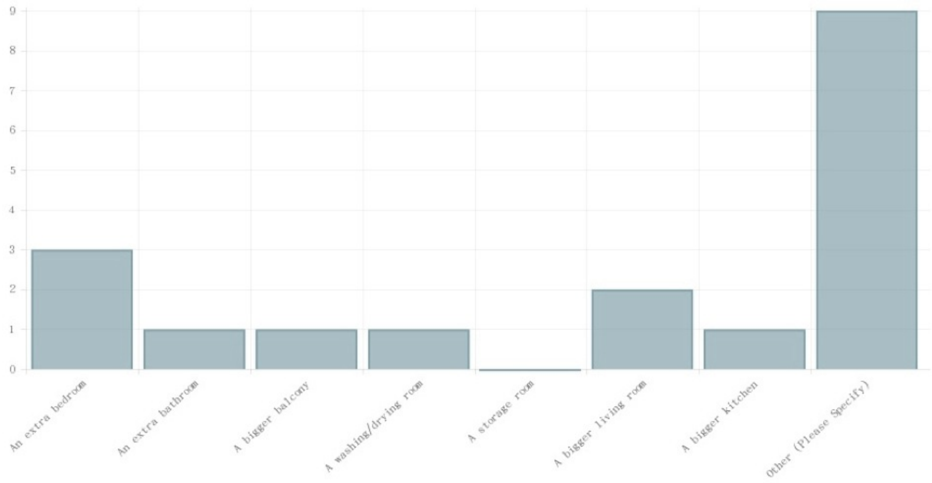


Text Responses

I would like to have a bigger bedroom and renovate the bathroom
Nothing
Would not change anything
Nothing
Bedroom enlargement, sound insultaion
The living room and the bathroom
I would like to have a balcony. The corridor and the kitchen are too big.
I would like to have an external elevator

Fig. 32 Answers regarding the possibility of changing the layout or size of some rooms or portions of the apartments

Together with the request of enlargement of the bedrooms, a large group of interviewee expressed the desire that the renovation would include the installation of an elevator, today still missing in the building although it is a six storeys building. The distribution scheme to access the units is located on the northern facade through walkways that are directed along the facade and guide towards the different front doors. It is possible to include an external elevator on the rear of the building and integrate it in the current distribution and circulation system without having to proceed with major renovation works.



Text Responses

Nothing

Nothing

Nothing

Bigger bedroom. Sound insulation, windows need to be changed

An elevator

Nothing

Better ventilation and better water plant. Less noise

A balcony

An elevator

Is there some comment or advice or suggestion regarding the improvement of your apartment/building that you would like to share with our team?

Text Responses

Ask the housing association

No

I am happy and satisfied

No

No

tends for the balcony, coverage for the bicycle stall. An elevator is needed

Elevator and renovation of the surroundings

No

More privacy, there is no sound insulation in the toilets. When I am in the kitchen the neighbors always can see me. Same from the sleeping room all the other people from the close buildings can look inside

More safety, a better entrance and park organisation. If possible I would like to hae a garden or a balcony

We would need an extra elevator. The heating system needs to be renewed and I would like to have it autonoumously

Fig. 33 Advices ad suggestions made by the inhabitants spontaneously

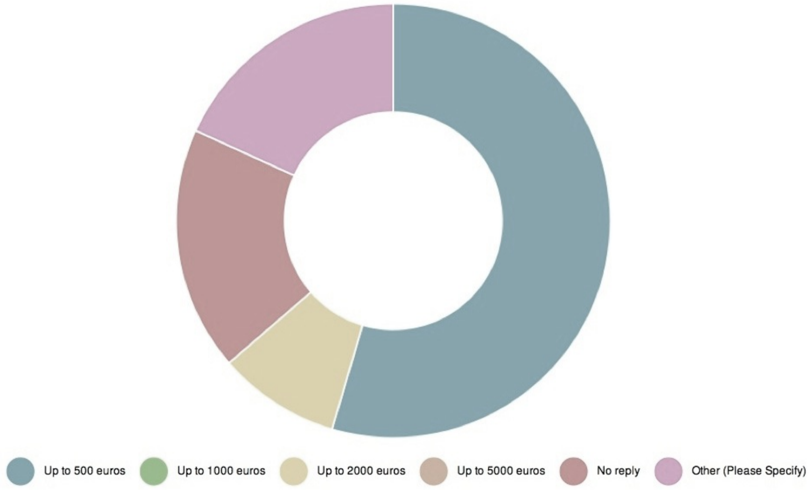


Fig. 34 Answers regarding the amount of money that the inhabitants would be willing to co-invest to finance the renovation intervention

Can you specify the amount of money that you would give to buy the apartment?

Text Responses

This is the first answer choice	70.000 euros
This is the first answer choice	I would not know
This is the first answer choice	100.000 euros
This is the first answer choice	Can not be estimated but there is interest in buying the apartment

Fig. 35 Answers regarding the possibility of buying the apartment after renovation, how much would you be willing to pay for it?

The questionnaire included several questions regarding possibility of exchange floor surface for money; they also included question to investigate the interest from the inhabitants to take active part in a portion of the investment for the renovation and also the intention from the tenants to buy the apartments. To the question 'If you would be asked to place a financial contribution for the energy renovation intervention in exchange of a convenient loan rate to buy the apartment you are currently renting, would you be interested?' More than 50 % showed interest and suggested a total sum of about 70.000-100.000 euros to buy the entire apartments with a loan. The market price for buying new apartments in the area is currently 4.200 Euros/m^2[10] so it can be said that the possibility and estimation made by the inhabitants who would be willing to pay is below the market expectation also considering the good state of the building.

When asked if they would be willing to support the renovation costs with a contribution in euros, the inhabitants have mostly agreed a sum of less than 1.000 euros.

The research group has considered important to proceed the investigation and analysis upon the collected data through cross analysis. The three questions that have been further investigated are:

1. Which is your opinion about apartment construction on the roof of the building? Please keep in mind that this would allow the installation of solar panel, improve the energy performance and consequently reduce both the energy and the renovation costs

2. If you would be given the opportunity to renovate your apartment, would you be in favour of a volumetric extension? What type of intervention would you like to suggest?

3. Have you ever heard of energy efficiency?

In relation to questions number 1 and 2, the research aimed at understanding the level of education and the social position of the interviewees that have answered positively, e.g. in

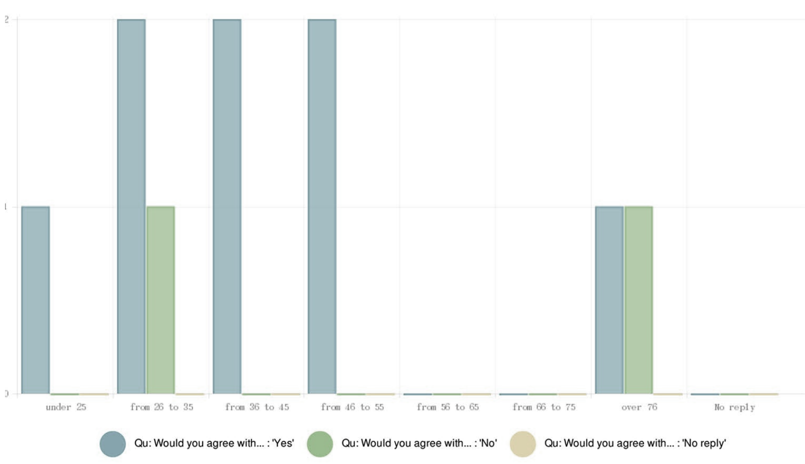
[10] Tecnocasa report 2014 for the Gattaglio area where the building is located.

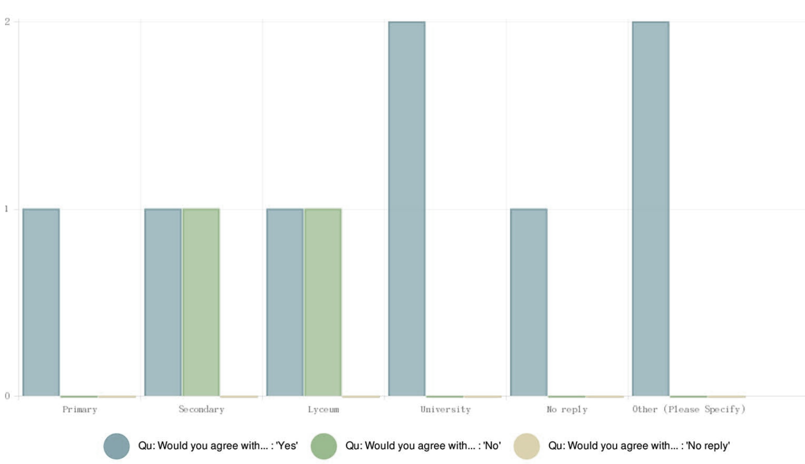
favour to the Add-on strategy. In relation to the awareness on the subject of energy efficiency, question 3, the cross analysis has been carried together with the investment-related questions.

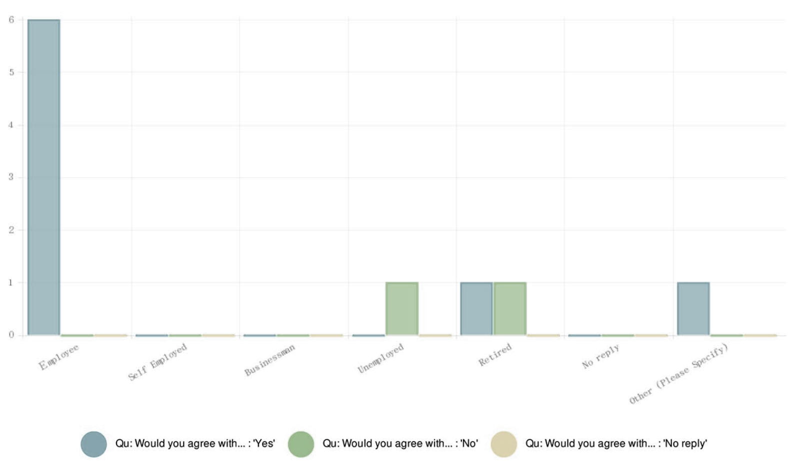
In other words, the research team tried to evaluate if it exists a direct relations between the level of knowledge on the subject and the willingness of the inhabitants to contribute, also financially, to the energy renovation intervention. In the following diagrams, the column in blue represents the interviewees that are in favour of rooftop and volumetric extensions, the green one represents the ones that are in favour of the idea but would not support its application in Peristeri whereas the yellow one represents the interviewee that are against the idea and its application.

The cross-analysis has shown, also in this second case study, that the majority of the interviewees that have express their disapproval to the Add-on strategy are retired person, mostly with only a primary education. On the other hand, the subjects that have supported the proposal both as an idea and for its application in Mousonstrasse have a Lyceum diploma or a university degree and are employed or retired.

The following graphs show the relationship between the knowledge on energy efficiency and the support to the proposal. The majority of the ones that are in favour (blue column) are also the majority of the subjects that are interested in energy efficiency and are informed on the subject. The green column in the graphs represents the users that are indifferent to the suggested intervention. The yellow column instead represents the subjects against the volumetric addition, mainly the groups that have never been interested in the topic or have never heard of the term ‘energy efficiency’ , In this case study the yellow portion is extremely limited.


2
1
0
under 25
from 26 to 35
from 36 to 45
from 46 to 55
from 56 to 65
from 66 to 75
over 76
No reply
Qu: Would you agree with... : 'Yes'
Qu: Would you agree with... : 'No'
Qu: Would you agree with... : 'No reply'


2
1
0
Primary
Secondary
Lyceum
University
No reply
Other (Please Specify)
Qu: Would you agree with... : 'Yes'
Qu: Would you agree with... : 'No'
Qu: Would you agree with... : 'No reply'


6
5
4
3
2
1
0
Employee
Self Employed
Businessman
Unemployed
Retired
No reply
Other (Please Specify)
Qu: Would you agree with... : 'Yes'
Qu: Would you agree with... : 'No'
Qu: Would you agree with... : 'No reply'

In conclusion, the evaluation and dialogue with the inhabitants of Mousonsstrasse has lead to important conclusions that will be implemented in the design proposal. The Add-on, as will be tested in this case study will be addressed towards the creation of punctual intervention on the façade that would allow the enlargement of the existing bedrooms or the creation of winter gardens or rather the increase in size of the existing balconies.

These scenarios could contribute in balancing the investment and increase the satisfaction of the existing inhabitants by also improving the quality of their dwellings. The new apartments on the rooftop could be using partially the high of the existing unused attic and integrate PV panels for the production of green energy. Synergies between the existing building and the new portions of the prefabricated housing units that will be located on the roof could be including also virtuous plant systems. The inhabitants will be proposed micro-scale intervention, at the unit level, as negotiation leverages to gain the consensus in the renovation. The non-seismic context of this case study allows us, together with the positive response received by the inhabitants, to use the German case study to test the Rooftop addition typology. A module for the prototype that will be located on the roof has been produce in accordance with Bien Zencker and the FH Frankfurt, in the framework of the Solar Decathlon 2014. Fig.35 shows in red the extra-volumes that could be created as part of the renovation.

- YOUNG USERS
- EMPLOYED
- OLD INHABITANTS
- MANY FOREGNERS
- SATISFIED WITH THE AREA
- SATISFIED WITH THE BUILDING
- DWELLINGS ARE GOOD SIZE
- ELEVATOR
- NO EXTRA ROOM
- BALCONIES ARE USED
- SHAIDNG WITH TENDS
- NO AIRCONDITIONING
- CENTRALISED HEATING
- KEY ROOM: BATHROOM
- INFILL NOT POSSIBLE
- ROOFTOP SUPPORTED
- EXTRA BUILDING NOT POSSIBLE

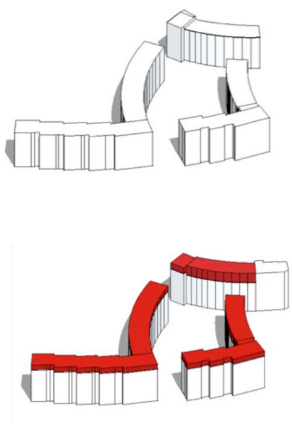


Fig. 36 Urban and architectural strategy layout, red volumes represent the potential volumetric addition that would foster the renovation intervention by decreasing the pay-back time

5.2.3 Project summary

The Add-on proposed for the German case study consists in the creation of five new dwelling units on the rooftop of the existing building. Therefore the existing roof will be removed and the dry basement will be stalled up to create new living space as well as to launch the basis for the new roof with an integrated second floor. The new roof is modelled with an overhang on top of the existing building to emphases the Add-on and to extend the surface available to install the PV plants. In occasion of the Solar Decathlon 2014 has been possible to test the construction of a real scale prototype for the Add-on and also collect data regarding the consumptions and possible energy balance between the prototype in Versailles and the existing building in Mousonstrasse (simulated in the prototype). The new residential units have been conceived as lightweight wooden structure with the intension to not overstrain the structure of the existing building. The wood panel construction is composed of individual modular flat wooden panels that can be assembled at the building site within a short time and make a building envelope which is immediately wind protected and waterproof. The assembly phase has been considered to be efficient and rapid to reduce the residents' disturbance unduly during construction. In Germany, the number of houses constructed of wood continues to rise and has many positive properties.

Dwelling will be adapted to the building of the existing housing by duplication, which leads to the fact that several housing units can be placed. Moreover, the new built roof will be placed according to the best solar energy efficiency, allowing the complete supply of energy in the house. The Symbiont, as the prefabricated dwelling unit has been called for the Solar Decathlon competition, connects with the existing building by using the drying loft as additional living space. This action is revealing the melting point between old and new. Benefit is that the height of the roof expansion will be pleasant to the surrounding buildings.

To create a relationship between the old and the new, the supporting walls of the lower units are transferred to the upper volumetric addition, thus, four Add-on with the dimensions of 8.77 m x 7.36 m can be placed on the roof.

Fig. 37 Main elevation of the building in Moussonstrasse. The current situation (before) shows that the overall high of the building chosen as case study is lower compared to the adjacent building on the left and the majority of the buildings in the compound. The Topping Add-on (after) increases the high of the building by the construction of fve new dwelling units, as tested and prefabricated for the Solar Decathlon 2014, by FH Frankfurt and Bien Zenker

Access to the new apartments will be provided by the existing vertical staircase, which will be upgraded too, a new access balcony, as already existing in the north will be attached to the Add-on by a hanging construction.[11] To fulfil the different inhabitant needs and to provide the building with the necessary flexibility to increase its durability also in future possible inhabitant changes the abacus for multi-variant design has been produced. The façade variation has been studied to offer the possibility of creating extra rooms or enlarge the existing one, transform the opened balconies in winter gardens and to also enlarge or shade part of the existing balconies directly.

The original dry ground windows are not only for exposure to light, but also extended for the purpose of communication between the access and the new dwelling units. By the overhang on the first floor above the access balcony, the ability is given to arrange individual rooms to this site. A detailed bio-climatic concept has been developed for the prototype. The bioclimatic strategy for the Symbiont has been thought to be able to effectively control heat losses and solar gains through out all the year. In winter the solar gain is optimized by the possibility of removing the designed shading system, offering large glazing surfaces towards south.

[11] OnTop Team Project Manual, Solar Decathlon research, Fach Hoch Schuele Frankfurt, Frankfurt am Main, 2014

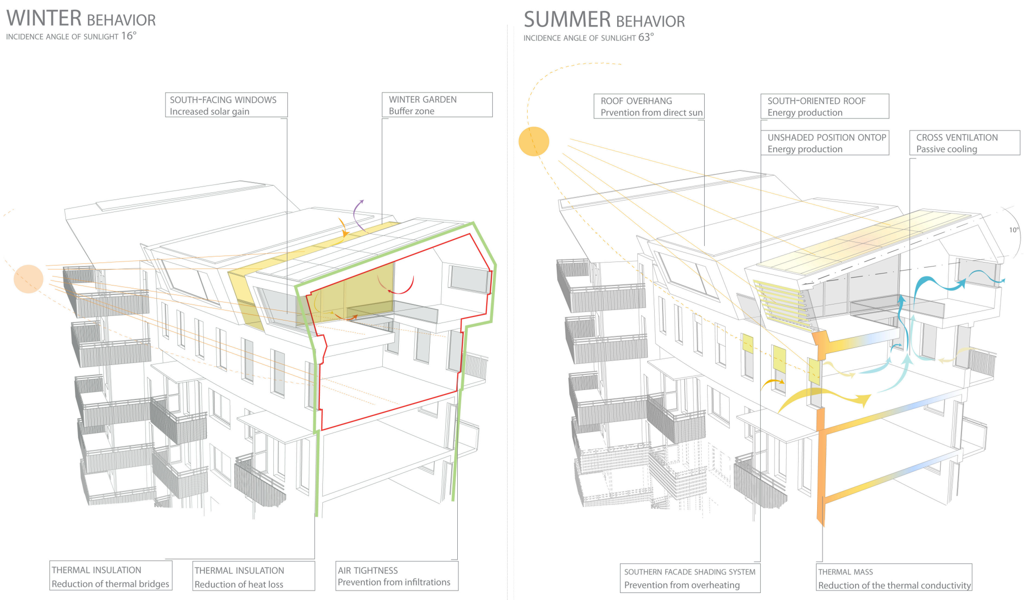


Fig. 38 Bioclimatic concept for the Add-on of Case study 02. The schemes illustrate the bioclimatic behaviour of the Add-on both in winter and in summer regime underlining the main passive features that have been planned and included in the Add-on.

The inclusion of the winter garden provides a buffer area that can store the heat during the day and slowly heat the new apartment units during the night. Vice versa during the day the presence of the winter garden between two adjacent Add-ons, significantly reduces the energy losses. The envelope as been thought to be highly thermally insulated and guarantee the air tightness of the entire system, preventing any infiltrations or losses.

Thermal bridges will be avoided and specific attention has been placed in the connections between the existing building and the Add-on. In summer the shading system will prevent direct sun to access the building, especially on the south facades. Together with this shading system, the roof overhang has been designed to reduce the direct sun exposure. One again the geometry that has been chosen for the Add-on offers a higher roof surface available for the installation of PV panels. Coherently with the layout of the existing building and its apartment units, cross ventilation has been made possible also in the new dwellings and helps in strengthening the passive cooling strategy in summer.

The double volume staircase connects the two floors of the prefabricated apartment unit, increasing the cross ventilation not only through out the first floor but also on the top floor. The existing building with its massive construction fabric provides the additional thermal mass that in summer can reduce the thermal conductivity of the Add-on.

In particular in this case study, the innovation of the Add-on proposal has been stretched to the plant and energetic aspects. The energy connection between the existing building and the Add-on is representing the innovation incorporating directly the existing energy losses of the existing building back in the energy balance. At the moment this losses increase the building consumptions but it would be possible to reuse these energy losses and give them as a benefit of the renovation through Add-on.

Another point of the synergy created by adding the new volumes on the existing building is the combination between older technique in the existing building and newer technique in the Add-on. This provides the older technique (radiators, gas condensing boiler and electrical installation) in the existing building with new intelligence (building systems, controlling systems) from the Add-on. The result is a more efficient overall system that has not required the substitution or change of the distribution parts of the plant.

5.2.4 Cost-benefit analysis

Table 8 illustrates the unit cost for each of the renovation intervention foreseen for the case study 2. The object is to define a specific cost per square meter of the renovation intervention in the specific German market, which in this case resulted 814 euro/m^2. The intervention included insulation (excluding the northern façade which has already been insulated in 2004), window replacement, basic substitution of plant (not the distribution installation but the central heating system), thermostat devices in all the apartments and the application of new windows, finishing and balconies as presented in the panels (P.de3-5). In parallel, the cost of the Add-on has been estimated. The case study has proven the feasibility of an overall Add-on of 470 m^2 also considering the cost evaluations carried with the inhabitants and the construction partners Bien Zenker partner during the SD2014. Considering the schematic design presented in the project experiment carried the overall cost per square meter to construct the Add-on would be 1.245 euro/m^2. A Photovoltaic plant has been planned on the portion of the roof facing west to integrate RES in the renovation, for an overall of 115 m^2 for a power plant of 13,7 kWp (solar panel yield 10%).

Tab. 9 collects the energy savings and consumptions data. Energy related aspects are the results of the calculations and simulations carried instead on a series of dwelling, located at different levels and with different exposure, of the buildings with energy simulations programs (Design Builder and IDA Ice). The overall energy consumptions have been compared with the bills and the real data provided by NH; this made possible to quantify the possible energy savings generated by a Deep renovation and include the economical benefit in the analysis.

As for the cost evaluation, the current situation of the German market has been analysed searching for the unit cost of the Add-on and the real estate value of the Add-on according to the area the case study is located (Wohnimmobilienbericht Frankfurt 2014). The housing market in Frankfurt for rented flats and condominiums saw a price increase in recent years. Despite 20,480 new homes since 2002, the population density rose from 2,591 to 2,785 inhabitants per square meter. New construction cannot meet the demand. In Ostend, Bornheim and the downtown area rents of € 14-15 per square meter and sales prices of about € 4000-5700 per square meter can be realized for newly built housing.[12]

The energy prices have been collected from the Italian and local energy provider (Mainova). As for the electrical production, the PV plant evaluated and included in the project simulation has been counted and inserted in the evaluation accounting its potential energy production.

[12] Project Manual, Solar Decathlon research, Fach Hoch Schuele Frankfurt, Frankfurt am Main, 2014

	UoM	Quantity	Unitarian cost	Total cost
Renovation Interventions	**mq**	**(Case study 01)**	**(Italian market)**	**814 €**
Window replacement (triple glazing)	mq	289,00	800,00 €	944.000,00 €
Rooftop insulation	mq	402,00	60,00 €	24.120,00 €
Facade insulation	mq	1.180,00	130,00 €	153.400,00 €
Ground Floor slab insulation (against earth)	mq	402,00	80,00 €	32.160,00 €
Insulation of floor slabs adjacent to cold spaces (parking, pilotis etc.)	mq	-	70,00 €	- €
Insulation of balconies, bow-windows, frames	mq	120,00	150,00 €	22.500,00 €
New balconies and finishing	mq	150,00	50,00 €	7.500,00 €
New heating system with heat pump	cad		80.000,00 €	80.000,00 €
Thermostat for consumptions check	cad	25,00	400,00 €	10.000,00 €
				1.273.680,00 €
			With extra costs	**1.464.732,00 €**
Add-on construction cost	**mq**			**1.250,00 €**
New windows in the addition	mq	156,00	700,00 €	109.200,00 €
Add-on construction cost (1)	mq	470,00	900,00 €	423.000,00 €
				532.200,00 €
			With extra costs	**585.420,00 €**
PV plant	kWp	**17,25**	**800,00 €**	**13.800,00 €**
Total Investment				**2.050.152,00 €**

Tab. 8 Cost overview for the renovation intervention, the Add-on construction and for the installation of a PV plant on the roof of the building. The data here presented are collected also in Tab.10 and will be the base for the cost-benefit analysis carried in Tab. 11-12.

Energy consumptions (1)			
219,00	kWh/mq per year	Before	DB simulations
25,00	kWh/mq per year	After	SET point
354.123,00	kWh per year	Before	
40.425,00	kWh per year	After	
Energy prices (2)			
0,65	€/mc	Natural gas price	(Mainova, 2015)
0,28	€/kWh	Electricity price	(Mainova, 2015)
Energy savings (thermal)			
31.369,80	mc per year	Gas savings after intervention	
4.042,50	mc per year	Gas consumptions after intervention	
20.390,37	**€ per year**	**Energy Savings after intervention**	
2.627,63	**€ per year**	**Energy Costs after intervention**	
Energy production (electrical)			
1.954,96	kWh per year	Electrical energy production from PV	
17,25	kWh peak	Total power of the plant	
547,39	**€ per year**	**Energy Savings after intervention**	

Tab. 9 Energy consumptions and production as for the German market and the considered case study. (1) The energy consumptions have been derived by the simulations carried with Design Builder and IDA ice on the case study. Thermal and electrical benefit in economical terms has then been calculated. The energy prices (2) have been collected from the German and local energy provider (Mainova). The data here presented are collected also in Tab.10 and will be the base for the cost-benefit analysis carried in Tab. 11-12.

GEOMETRY		
Total net Surface	**1.617**	**mq**
Total gross Surface	2.470	mq
Total gross Volume	7.180	mc
S/V (1)	0,34	
Average gross Unit Surface	99	mq
Number of units	25	dwellings
Dwellings involved in the sociological survey	10	dwellings
Number of car parks	12	parkings
Area Lotto	1.014	mq
FAR Density (2)	0,41	-
ARCHITECTURE TECHNOLOGY		
Year of construction	1958	-
Restoration intervention	2004	-
Structure	loadbearing walls	-
Roof construction type	Flat roof with attic	-
Facade	reused bricks	-
Shading system	tends	-
Add-on typology (3)	**Topping – Parasitic Add-on**	-
ENERGY RELATED ASPECTS		
Energy consumptions heating and cooling (4)	219	kWh/mq
Envelope transmittance (average)	0,854	W/mq°K
Yearly energy consumptions	**354.123**	**kWh/y**
Energy savings by retrofitting (5)	401.198	kWh/y
Unit Energy reduction by retrofitting	106	euro/mq
Co2 reduction	34	t/CO2
Available PV surface	115	mq
Renewable energy production (6)	**2.715**	**kWh/y**
COST EVALUATIONS		
Real estate value (7)	4.200	Euro/mq
Renovation cost (8)	814	Euro/mq
Total renovation cost	**2.050.188**	**Euro**
Energy savings (thermal) after renovation	26.078	Euro
Add-On construction cost (9)	1.246	Euro/mq
Incentives (10)	30	%
Gas cost (11)	0,65	Euro/mq
Electricity cost (11)	0,28	Euro/kWh
PV plant cost	13.800	**Euro**
Energy savings through solar energy	550	Euro
ADD-ON NECESSARY TO SET THE PAYBACK BELOW 5 YEARS (12)	**649**	**mq**
ADD-ON FEASIBLE AS DEMONSTRATION PROJECT	**470**	**mq**

Tab. 10 (1) The surface area to volume (S/V) ratio defines the heat loss and gain.The greater the surface area the more the heat gain/loss through it. (2) FAR denisty is calculated as the ration between the total liveable surface and the plot area. (3) The Add-on typology is defined according to the categorisation made in Chapter 2 (Tab.2.2). In this case it is a *parastic Add-on by topping* (4) Energy consumptions and EP average values have been calulated through simulation run by Design Builder considering both the summer and the winter regime (5) The value of energy savings has been calculated considering to reduce the current consumptions down to 25 kWh/m^2 per year which has been set as target (see Tab. 4) (6) The renewable energy production given by the proposed PV plant has been supposed to be installed on an overall surface of 115 mq with a power of 17,5 kWp. (7) The real estate value is intended as the potential selling value of new real estate units as derived by the market situation in Reggio Emilia as well as the unitarian construction cost (Source: Wohnimmobilienbericht Frankfurt 2014) (8,9) The renoavion and Add-on construction cst per square meter have been calculated on the specific case study as showed in Tab. 3 (10) The incentives provided by the Italian government is calculated upon the 30% of the total investment for those interventions that are related to the energy renovation as established by the KfW 2015 (11) The data is derived by Eurostat statistics from 2015 and the current prices of Mainova as local energy provider (12) The volumetric addition calulcated accoding to the formula presented in Chapter 3 to reduce the payback time below the 5 years threshold

Renovation investment			1.464.732,00	€			
Renovation investment			1.464.732,00	€			
PV investment			13.800,00				
Add-Ons investment			585.420,00	€			
Total Investment (Renovation + PV + Add-Ons)			**2.063.952,00**	€			
Savings (non weighted, thermal)			20.390,37	€ per year			
Profit from Add-ons' sale			**1.974.000,00**	€			
Savings (non weighted, electrical)			547,39	€ per year			
Fiscal incentive (30%)			443.559,60	€		Max 720.000,00	
Fiscal incentive rate (10 years plan)			44.355,96	€ per year			
Interest rate			0,0500				
Energy inflation rate			0,0300				
	Incoming				Outgoing		
Year	Savings	PV Production	Incentive 65%	Consumptions	Cash flow	NPV	Sum
0	0,00		0,00	0,00	-2.063.952,00	-2.063.952,00	-2.063.952,00
0	1.974.000,00		0,00	0,00	1.974.000,00	1.974.000,00	-89.952,00
1	20.390,37	547,39	44.355,96	2.627,63	65.293,72	62.184,49	-27.767,51
2	21.002,08	563,81	44.355,96	2.706,45	65.921,85	59.793,06	32.025,56
3	21.632,14	580,73	44.355,96	2.787,65	66.568,83	57.504,66	89.530,21
4	22.281,11	598,15	44.355,96	2.871,28	67.235,21	55.314,58	144.844,79
5	22.949,54	616,09	44.355,96	2.957,42	67.921,59	53.218,34	198.063,14
6	23.638,03	634,57	44.355,96	3.046,14	68.628,56	51.211,69	249.274,83
7	24.347,17	653,61	44.355,96	3.137,52	69.356,74	49.290,54	298.565,37
8	25.077,58	673,22	44.355,96	3.231,65	70.106,76	47.451,02	346.016,38
9	25.829,91	693,42	44.355,96	3.328,60	70.879,29	45.689,42	391.705,80
10	26.604,81	714,22	44.355,96	3.428,45	71.674,99	44.002,22	435.708,03
11	27.402,95	735,65		3.531,31	28.138,60	16.452,06	452.160,08
12	28.225,04	757,71		3.637,25	28.982,76	16.138,68	468.298,77
13	29.071,79	780,45		3.746,36	29.852,24	15.831,28	484.130,05
14	29.943,95	803,86		3.858,76	30.747,81	15.529,73	499.659,78
15	30.842,26	827,98		3.974,52	31.670,24	15.233,93	514.893,70
16	31.767,53	852,81		4.093,75	32.620,35	14.943,76	529.837,46
17	32.720,56	878,40		4.216,57	33.598,96	14.659,11	544.496,57
18	33.702,17	904,75		4.343,06	34.606,93	14.379,89	558.876,47
19	34.713,24	931,89		4.473,36	35.645,13	14.105,99	572.982,46
20	35.754,64	959,85		4.607,56	36.714,49	13.837,30	586.819,76
21	36.827,28	988,65		4.745,78	37.815,92	13.573,74	600.393,50
22	37.932,09	1.018,31		4.888,16	38.950,40	13.315,19	613.708,69
23	39.070,06	1.048,85		5.034,80	40.118,91	13.061,57	626.770,25
24	40.242,16	1.080,32		5.185,85	41.322,48	12.812,77	639.583,03
25	41.449,42	1.112,73		5.341,42	42.562,15	12.568,72	652.151,75
26	42.692,91	1.146,11		5.501,66	43.839,02	12.329,32	664.481,07
27	43.973,69	1.180,49		5.666,71	45.154,19	12.094,47	676.575,54
28	45.292,90	1.215,91		5.836,71	46.508,81	11.864,10	688.439,64
29	46.651,69	1.252,39		6.011,82	47.904,08	11.638,12	700.077,76
30	48.051,24	1.289,96		6.192,17	49.341,20	11.416,44	711.494,20
				NPV	30 years	2.775.446,20	
				IRR	30 years	0,14788	
				PAY BACK TIME	2 years		

Tab. 11 Cost-benefit analysis carried for deep renovation with Add-Ons of 470 m^2 considering an incentive of 30% according to the KfW . The payback time resulting from the NPV (2.432.941 euro) is 2 years and the IRR is 14,8 %

	Renovation investment		1.464.732,00	€		
	PV investment		13.800,00			
	Add-Ons investment + PV		585.420,00	€		
	Total investment (Renovation + PV + Add-Ons)		**2.063.952,00**	€		
	Savings (non weighted)		20.390,37	€ per year		
	Profit from Add-ons' sale		**1.974.000,00**	€		
	Savings (non weighted, electrical)		547,39	€ per year		
	Interest rate		0,0500			
	Energy inflation rate		0,0300			
	Incoming			Outgoing		
Year	Savings	PV Production	Consumptions	Cash flow	NPV	Sum
0	0,00		0,00	-2.063.952,00	-2.063.952,00	-2.063.952,00
0	1.974.000,00		0,00	1.974.000,00	1.974.000,00	-89.952,00
1	20.390,37	547,39	2.627,63	20.937,76	19.940,72	-70.011,28
2	21.002,08	563,81	2.706,45	21.565,89	19.560,90	-50.450,38
3	21.632,14	580,73	2.787,65	22.212,87	19.188,31	-31.262,07
4	22.281,11	598,15	2.871,28	22.879,25	18.822,82	-12.439,25
5	22.949,54	616,09	2.957,42	23.565,63	18.464,29	6.025,04
6	23.638,03	634,57	3.046,14	24.272,60	18.112,59	24.137,63
7	24.347,17	653,61	3.137,52	25.000,78	17.767,59	41.905,22
8	25.077,58	673,22	3.231,65	25.750,80	17.429,16	59.334,38
9	25.829,91	693,42	3.328,60	26.523,33	17.097,17	76.431,55
10	26.604,81	714,22	3.428,45	27.319,03	16.771,51	93.203,06
11	27.402,95	735,65	3.531,31	28.138,60	16.452,06	109.655,12
12	28.225,04	757,71	3.637,25	28.982,76	16.138,68	125.793,80
13	29.071,79	780,45	3.746,36	29.852,24	15.831,28	141.625,08
14	29.943,95	803,86	3.858,76	30.747,81	15.529,73	157.154,81
15	30.842,26	827,98	3.974,52	31.670,24	15.233,93	172.388,74
16	31.767,53	852,81	4.093,75	32.620,35	14.943,76	187.332,49
17	32.720,56	878,40	4.216,57	33.598,96	14.659,11	201.991,61
18	33.702,17	904,75	4.343,06	34.606,93	14.379,89	216.371,50
19	34.713,24	931,89	4.473,36	35.645,13	14.105,99	230.477,49
20	35.754,64	959,85	4.607,56	36.714,49	13.837,30	244.314,79
21	36.827,28	988,65	4.745,78	37.815,92	13.573,74	257.888,53
22	37.932,09	1.018,31	4.888,16	38.950,40	13.315,19	271.203,72
23	39.070,06	1.048,85	5.034,80	40.118,91	13.061,57	284.265,29
24	40.242,16	1.080,32	5.185,85	41.322,48	12.812,77	297.078,06
25	41.449,42	1.112,73	5.341,42	42.562,15	12.568,72	309.646,78
26	42.692,91	1.146,11	5.501,66	43.839,02	12.329,32	321.976,10
27	43.973,69	1.180,49	5.666,71	45.154,19	12.094,47	334.070,57
28	45.292,90	1.215,91	5.836,71	46.508,81	11.864,10	345.934,68
29	46.651,69	1.252,39	6.011,82	47.904,08	11.638,12	357.572,80
30	48.051,24	1.289,96	6.192,17	49.341,20	11.416,44	368.989,24
			NPV	30 years	2.432.941,24	
			IRR	30 years	0,09188	
			PAY-BACK TIME	5 years		

Tab. 12 Cost-benefit analysis carried for deep renovation with Add-Ons of 470 m^2 . The payback time resulting from the NPV (2.432.941 euro) is 10 years and the IRR is 9,1 %

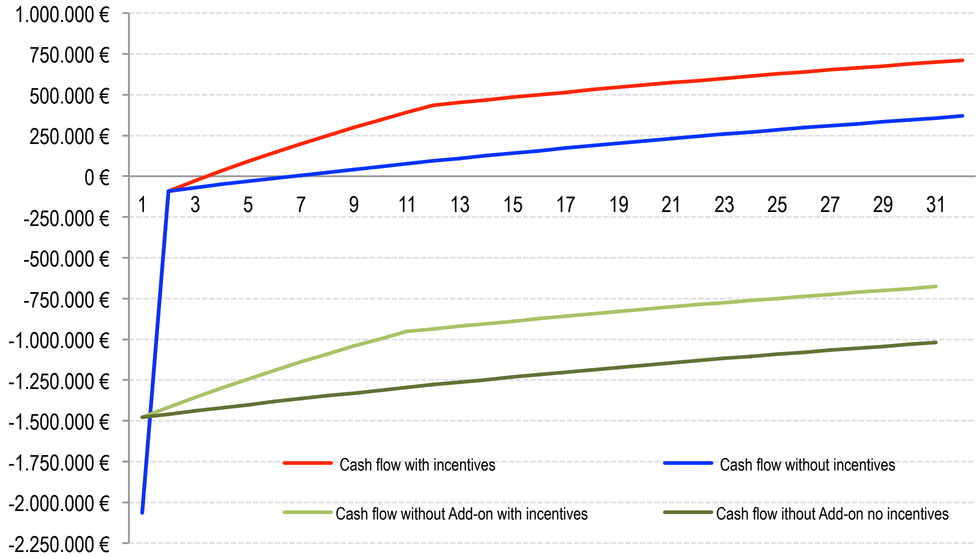
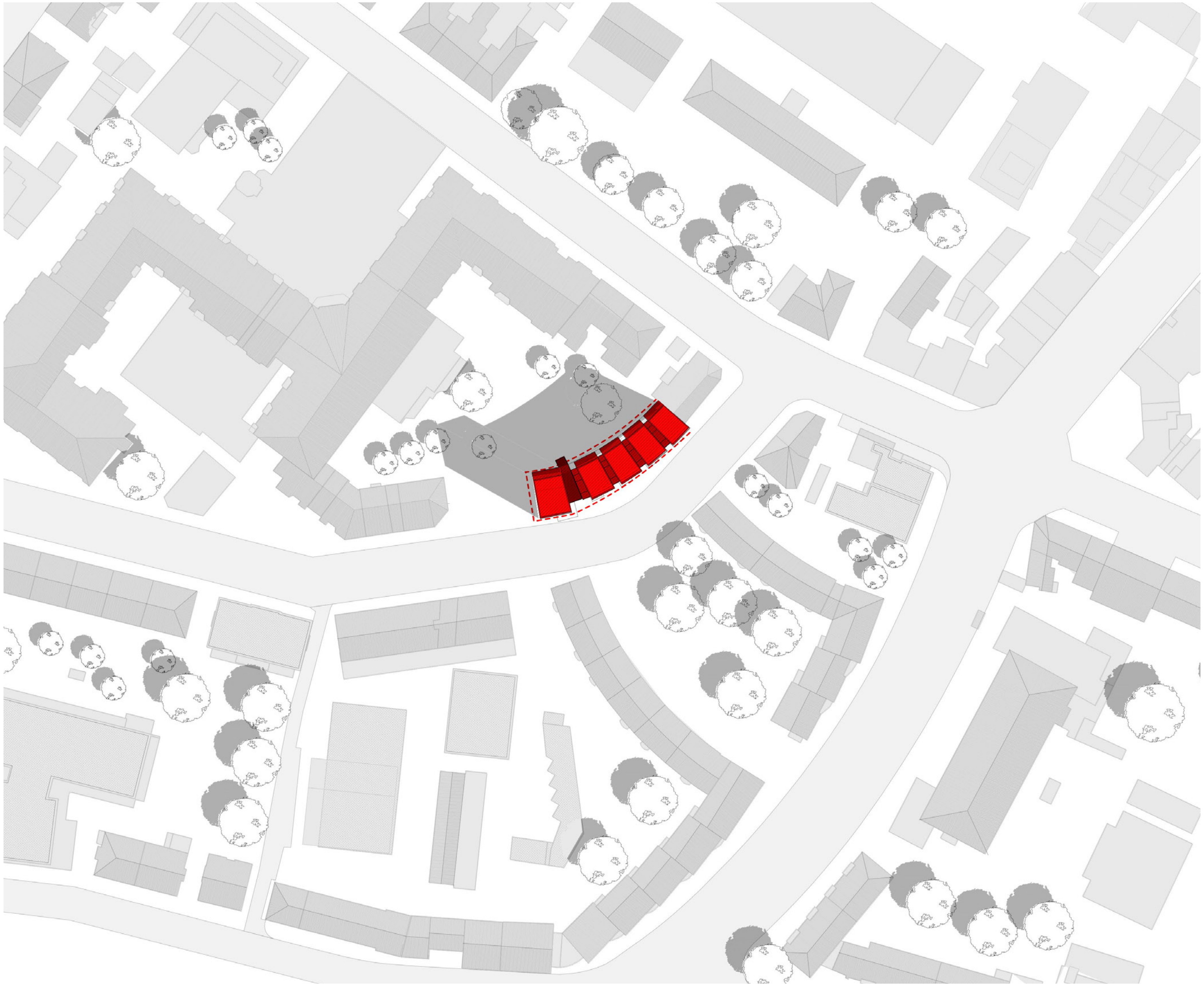


Fig. 39 The graphic shows the comparison between the two cost-benefit analysis carried for deep renovation with Add-On as the design experiment for the case study 02. Deep renovation with Add-Ons' investments without incentives (blue in the graphic), can reach a pay-back time of 5 years whereas the pay-back time of Deep renovation with Add-ons, with incentive - for the German legislative framework accounting for 30% of the initial investment - (red in the graphic) is about 2 years. The graphic shows the comparison between the Deep Renovation with Add-on as above illustrated and the case of no Add-on (in green in the graphic) both with and without incentives.

The graphic in Fig. 39 illustrated the cashflow and cost-benefit analysis as carried for the case study 02. It is clear that the current real estate and construction market condition in Germany has different trends compared to the Italian case study and the construction costs are relativly comparable with the one in case study 01 but at the same time the profit from the sale of the Add-ons unit is significant and the NPV as well as the IRR of the investment clearly show the advantages of this type of intervention in such a context. It is significant to underline however that the incentive scheme currently ongoing in Italy is one of the most supportive in economical terms and manages to counterbalance the current disadvantaged market in the construction and renovation field. The same can not be said for the Greek condition where the lowest incentives are provided by the governament and also the market is suffering the consequences of the recent economical crisis. In the third case study a different approach will have to be undertaken to apply the Add-on method to the Deep renovation to produce the desired results.

5.2.5 TABLE AND DRAWINGS, CASE STUDY 02



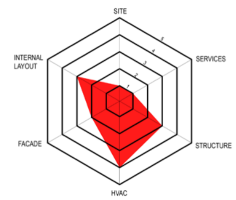
CASE STUDY

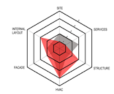
Mousson Str. 53,
Frankfurt am Main(DE)

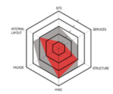
RELEVANT DATA

Total net Surface	1.617	mq
Total gross Surface	2.470	mq
Total gross Volume	7.180	mc
S/V (1)	0,34	
Average gross Unit Surface	99	mq
Number of units	25	
Dwellings involved	10	
Number of car parks	12	
Area Lotto	1.014	mq
FAR Density (2)	0,41	-

ADDITIONAL INFORMATION







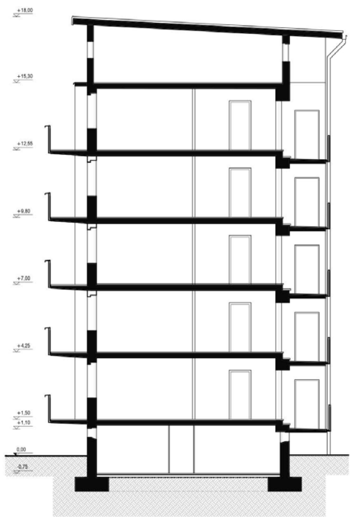
MOUSONSTRASSE 35,FFM
GERMANY

MEDIUM

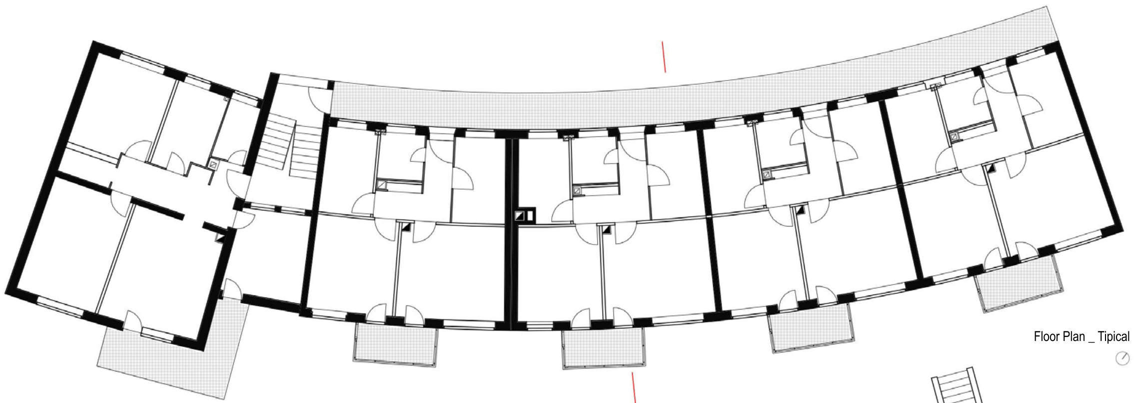
Current state, urban scale
1.1000

P.de.01

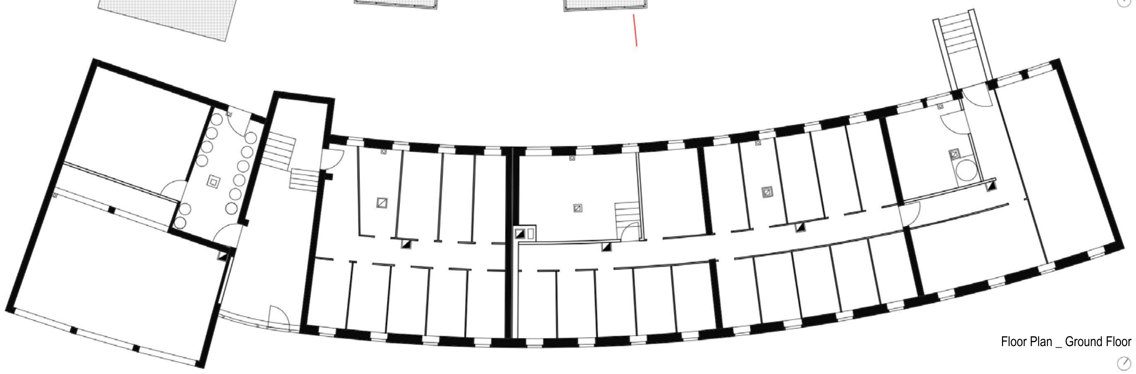
South-East Elevation



Section



Floor Plan _ Tipical



Floor Plan _ Ground Floor

CASE STUDY

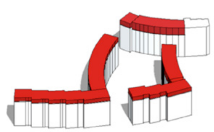
Mousson Str. 53,
Frankfurt am Main(DE)

RELEVANT DATA

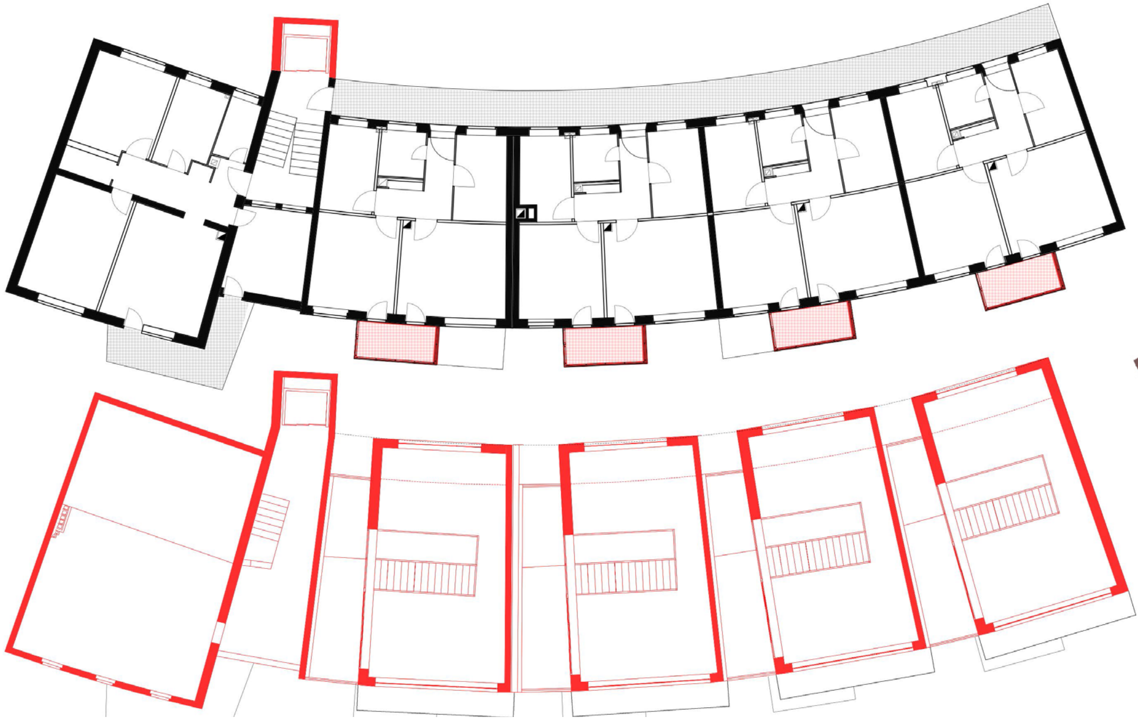
Year of construction	1958
Restoration intervention	2004
Structure	loadbearing walls
Roof construction type	Flat roof with attic
Facade	Reused bricks
Shading system	Tends
Add-on typology (3)	Topping – Parasitic

ADDITIONAL INFORMATION

Energy consumptions, heating and cooling	219	kWh/mq
Envelope transmittance	0,854	W/mq°K
Total primary energy consumptions	354.123	kWh/y
Energy savings by retrofitting (3)	401.198	kWh/y
Unit Energy reduction by retrofitting	106	euro/mq
Co2 reduction	34	t/CO2
Available PV surface	115	mq
Renewable energy production	2.715	kWh/y



Current State, building scale 1.200 **P.de.02**

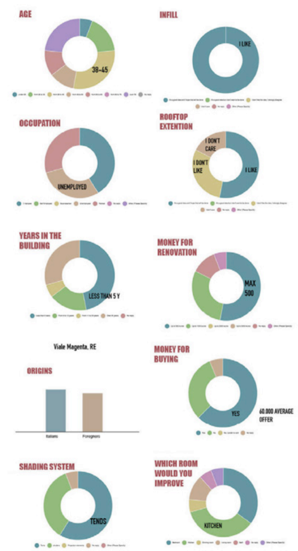


CASE STUDY

Mousson Str. 53,
Frankfurt am Main(DE)

RELEVANT DATA

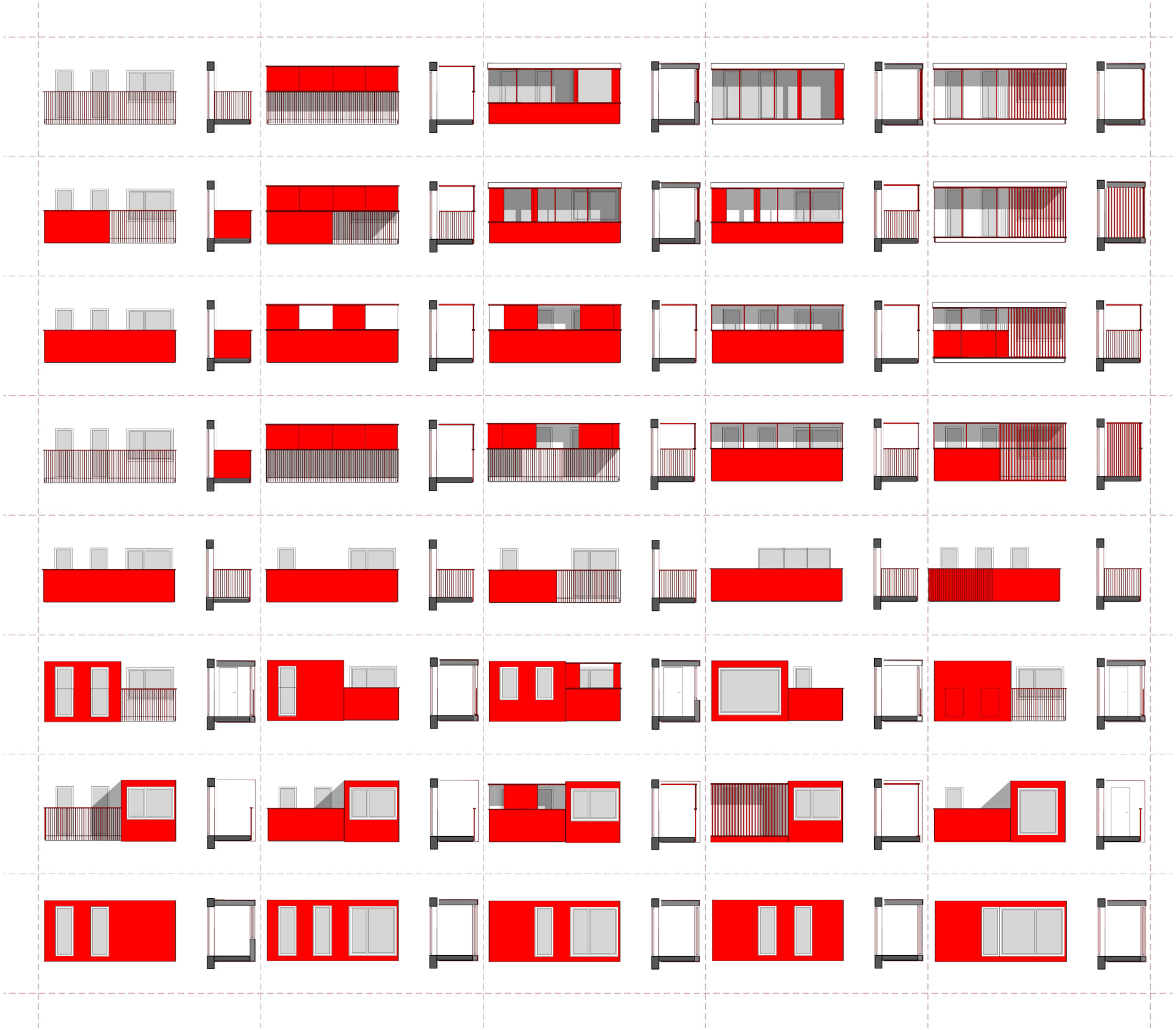
Window replacement (triple glazing)	944.000,00 €
Rooftop insulation	24.120,00 €
Facade insulation	153.400,00 €
Ground Floor slab insulation (against earth)	32.160,00 €
Insulation of floor slabs adjacent to cold spaces (parkings, pilotis etc.)	27.300,00 €
Insulation of balconies, bow-windows, frames	22.500,00 €
New balconies and finishing	7.500,00 €
New heating system with heat pump	80.000,00 €
Thermostat for consumptions check	10.000,00 €
Total renovation cost	1.464.732,00 €
New windows in the addition	46.200,00 €
Addition construction cost	585.420,00€
PV plant	13.800,00 €
Total Investment	2.050.152,00 €



Possible outcome,
multi-variable design

1.200

P.de.03



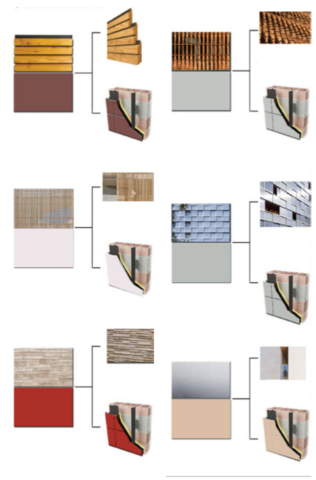
CASE STUDY

Mousson Str. 53,
Frankfurt am Main(DE)

RELEVANT DATA

YOUNG USERS
EMPLOYED
OLD INHABITANTS
MANY FOREGNERS
SATISFIED WITH THE AREA
SATISFIED WITH THE BUILDING
DWELLINGS ARE GOOD SIZE
ELEVATOR
NO EXTRA ROOM
BALCONIES ARE USED
SHAIDNG WITH TENDS
NO AIRCONDITIONING
CENTRALISED HEATING
KEY ROOM: BATHROOM
INFILL NOT POSSIBLE
ROOFTOP SUPPORTED
EXTRA BUILDING NOT POSSIBLE

POSSIBLE MATERIALS



Typological Façade Abacus

1.200

P.de.04

5.3 The high density scenario: Athens case study

The reference existing building complex selected for the pilot study is the urban compound called “Workers’ House” between Ravine St, Orfeos St, Sardeon St, Idras St, in the Municipality of Peristeri. Strategically located in the centre of Peristeri, highly visible from the main road of the town, it is at the exit of the metro station and in front the new Town Hall building. This urban compound is an historic building complex, built to shelter the first refugees from Istanbul and Smyrna. Nowadays it is inhabited by poorly paid workers and other vulnerable social groups and has not been retrofitted or maintained for more than 20 years. Home-ownership is the formal dominant public housing regime, in this context and in the general context of Greece. High prices for centrally distributed energy have prompted many residents switch to alternative and less efficient heating means such as kerosene, electricity, coal or wood, increasing deprivation and environmental pollution. The large number of standard multi-apartment residential building blocks means that similar solutions for improved energy efficiency may be used, thus ensuring an economy of scale. From the constructive point of view, all the building types consist of a series of block buildings with a structure made of reinforced concrete and infill walls. The strong tradition of centralized district heating in larger cities represents an excellent institutional and technical foundation for efficient heating and cooling in the future. The Municipality of Peristeri is willing to undertake a proper retrofitting strategy in this urban compound and some investigations and studies (questionnaires, inhabitants’ involvement, preliminary feasibility studies, etc.) have already been developed. Renovations with a high-energy efficiency measures and deep renovation strategies can improve the financial situation of the inhabitants. The blocks of buildings that in Peristeri, are typical social housing from the 60’s constructed by pillars and beams, and as a basic structure material concrete. The urban compound in Peristeri is characterized by the presence of massive volumes with different building types and building geometry. In particular, the Peristeri urban settings consists of 12 stand alone buildings segmented in four main building types: 3 tower buildings, 3 double block buildings south-north oriented (typology chosen for the analysis here conducted) and the four east-west oriented blocks.

Pilot case	**WORKERS' HOUSES IN PERISTERI (ATHENS, GREECE)**
Year of construction:	1972
Number of units:	144
Main building typology:	Block building
Construction system	Skeleton in reinforced concrete
Dimension of units:	About 100 m^2
Technical Data	Residential surface: about 43.900m2 Structure: concrete skeleton, concrete slabs and brick external walls Window: aluminium or wood with single/double glass Plants: centralized plant for each block building
Last refurbished	1992
Energy performance:	About 180 Kwh/m^2 per year
Energy management:	Home owners
Property regime:	Entirely privately owned
Adaptability degree (1-5)	3,7
Social Mixture	All Greeks
Average rental cost	Mainly homeowner (average rent market 300 euros/month)
Critical points:	Property regime: condominium approval s necessary. Earthquake and seismic conditions Proximity with the street, high traffic zone
Possible additions	Front addition, side addition, ground floor addition, rooftop addition

Tab. 13 Greek case study description sheet

5.3.1 Adaptability assessment, densification potential

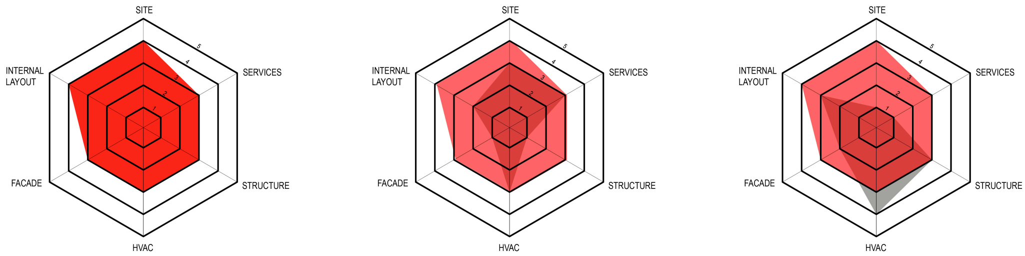


Fig. 40 Adaptability study for the case study of Peristeri (left) and comparison between the adaptability status of Peristeri (GR) and viale Magenta (IT) (in the centre) and between Peristeri (GR) and Mousonstrasse (DE) (right)

The adaptability assessment on the Greek case study shows a significant difference with the other case study. The high degree of adaptability, especially on the site (consistent free green surface and car park availability), facade and internal layout of the building, allows a deeper transformation when compared with the other case study. It has been evaluated possible to intervene through rooftop extensions but also through a-side significant extensions that can include independent new building with autonomous circulation systems. The existing ground floor level is mainly used as car parking although there are sufficient parking areas in the compound and could be enclosed to create a new entrance space to dedicate to common activity or social functions as for example a nursery school for the children of the neighbourhood. The HVAC system is very poor in quality. The majority of the apartments have a cooling system with autonomous heat pumps and the external part of the cooling devices is installed outside the windows creating an uncontrolled façade disorder. The heating is supplied by also autonomously through the heat pumps (electricity) or rather through the use of petrol boilers. The plant system should also be object of renovation possibly including plug and play systems directly in the technological façade components as introduced in Chapter 3.

As for the architectural outline of the facade, it is characterised by a sever and regular rigidity which allows to intervene through variations and transformation by maintaining the overall structural grid as support and altering the order within the single cells.

5.3.2 Data results of the questionnaires

Considering the Peristeri neighbourhood, more than one hundred questionnaires have been collected. The following graphics show the most significant statistic results related to the questions that have been considered central in the survey. Other considerations, inferred from informal behaviours or by the course of the research and the non-structured interviews have been summarized in the text.

We can state that the great majority of inhabitants are middle aged, between 45 and 65 years old and mostly retired. They have been living in the neighbourhood for longer than 20 years so their attachment and level of belonging to the area is relatively strict. They are almost entirely Greeks, we assume therefore that there is no strong conflict between the dwelling typology and layout and the traditions, backgrounds, culture and religion of the inhabitants that occupy the buildings.

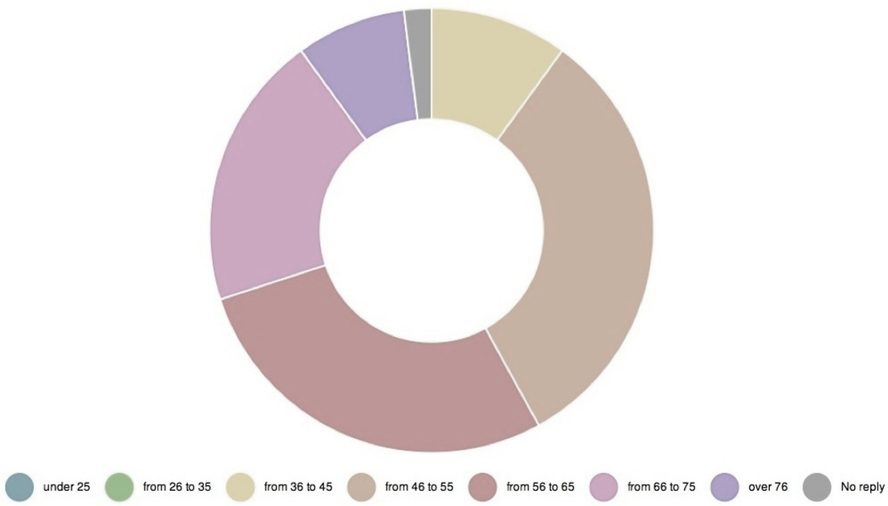


Fig. 41 Age groups that took part in the survey

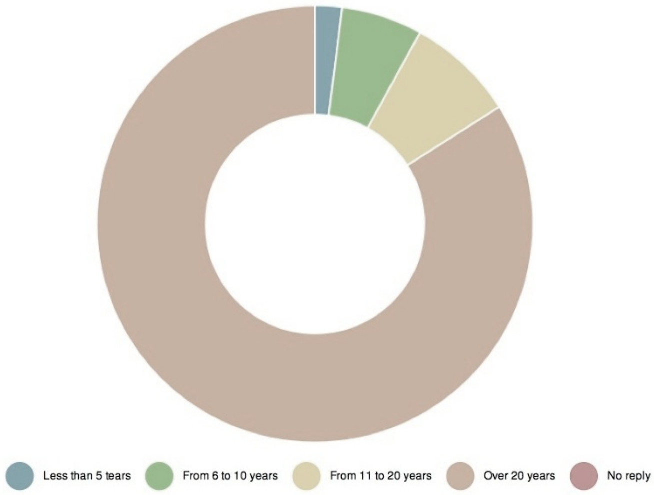


Fig. 42 Answers regarding the time of permanence in the neighbourhood

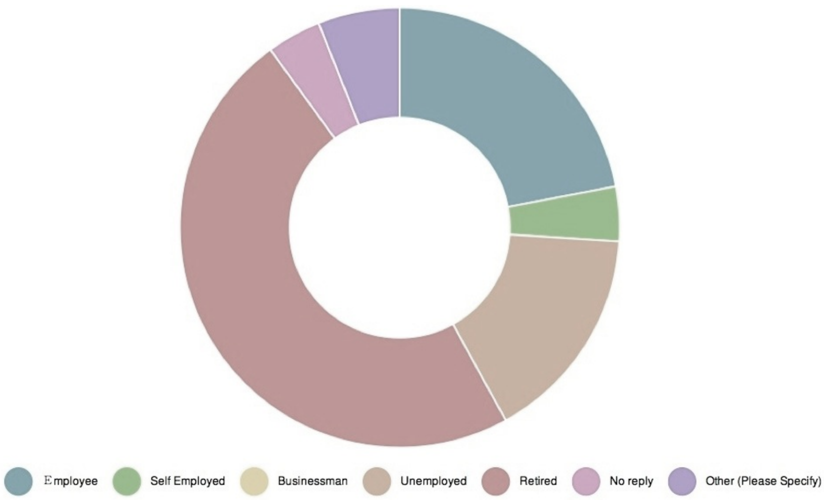
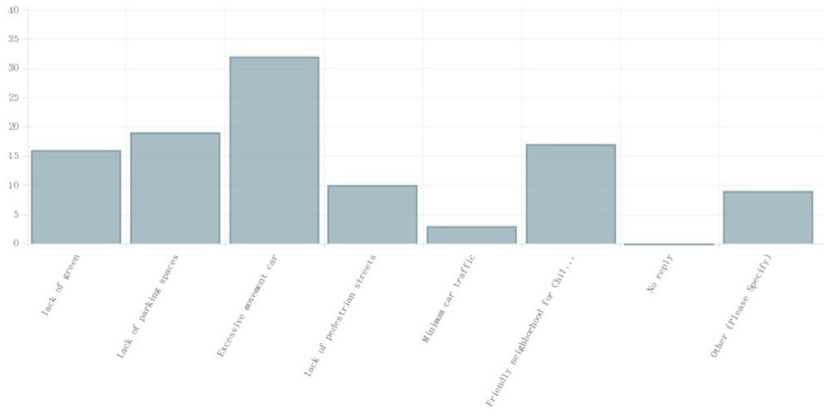


Fig. 43 Employment type

From an urban point of view, as it can be seen from the following graphic, the interviewed are generally satisfied with the urban setting and the condition at the ground level. However the most critical points are related to traffic and car occupancy, noise and lack of green areas. Therefore, most of the interviewees have answered positively to the possibility of reorganizing the ground floor area and the surroundings of the neighbourhood in order to implement a more efficient parking plan and integrate more green areas, trees and shaded zones. This would increase the level of comfort (from a climatic point of view, see chapter…) but also improve the safety of the neighbourhood and give to the children a larger playground.



Text Responses

Needs surroundings renovation, care for the playground
Disable access
Noisy area
At the center of town, yet a qquiet area
Problems with strange people at the playground
Too noisy
Not friendly neighborhood for children and seniors
Not friendly neighborhood for children and seniors
Lack of recreation areas for children and seniors

Fig. 44 Answers to the request of expressing an opinion regarding the current condition in the Peristeri neighbourhood

As for the buildings them selves, from the survey it has been registered a general dissatisfaction, connected with the lack of maintenance and the poor quality of the buildings. The old window frames, plaster and in general the buildings in their complexity result no longer capable of meeting the minimal hygienic and safety standards. Although the majority of the interviewees would like to improve their apartments and the buildings they inhabit, when asked an opinion upon the possibility of adding extra volume on the rooftop as strategy to pay-off the interventions, a large and surprisingly high number of them has shown reluctance and disappointment. The main concern is related to the safety of the building in case of earthquake and the inhabitants, who already nowadays don’t feel safe in the buildings, are sceptical about the static performances of the entire system in case of rooftop extension. An intense communication campaign would be necessary in case the planners are still intending of undertake this strategy, otherwise the community will surely oppose the intervention.

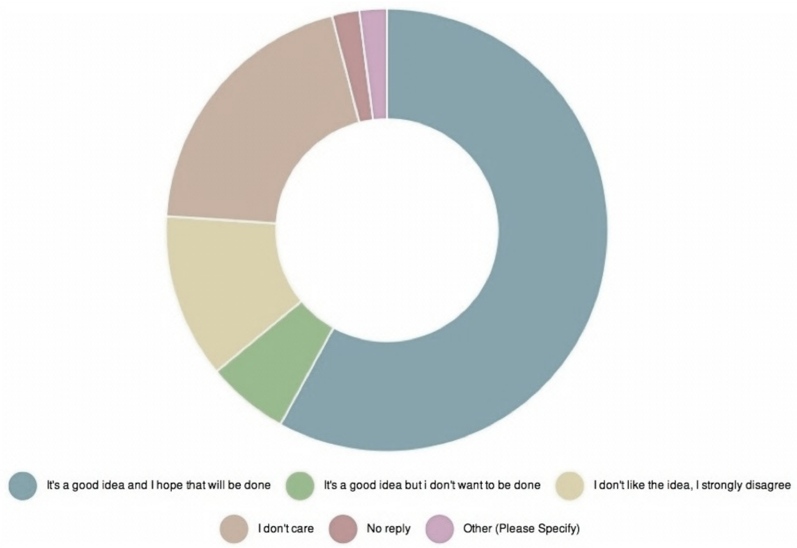


Fig. 45 Answers regarding the possibility of re-planning the parking area and the ground floor, possibility of adding additional units

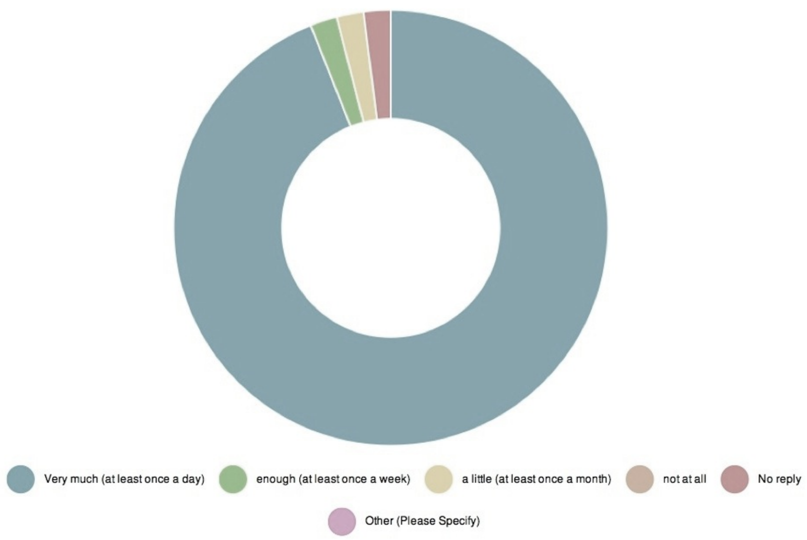


Fig. 46 Answers regarding the current use of the balconies

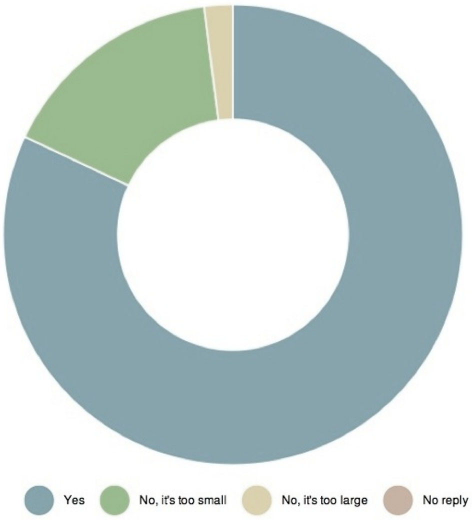


Fig. 47 Answers regarding the satisfaction with the size of the apartment units

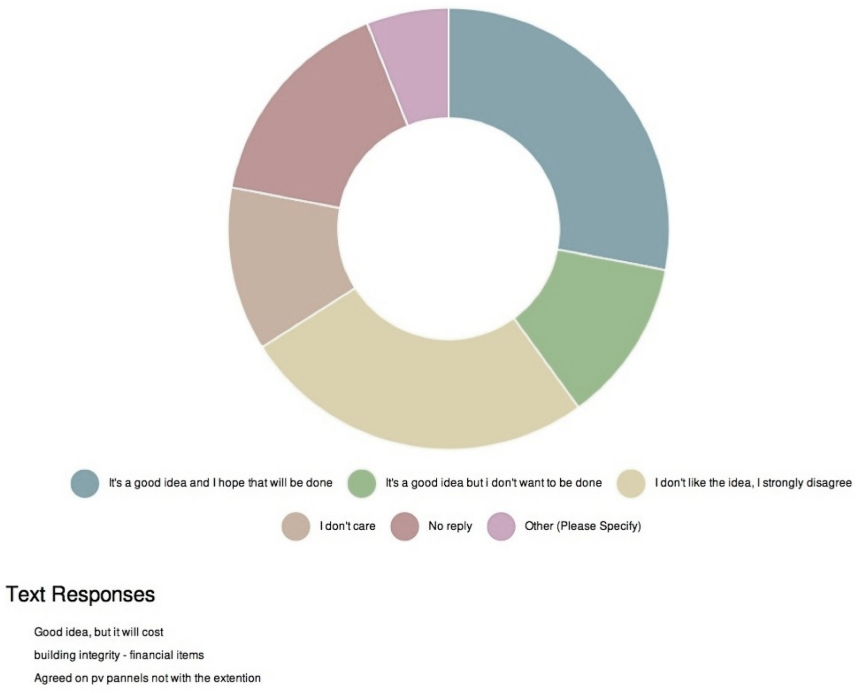
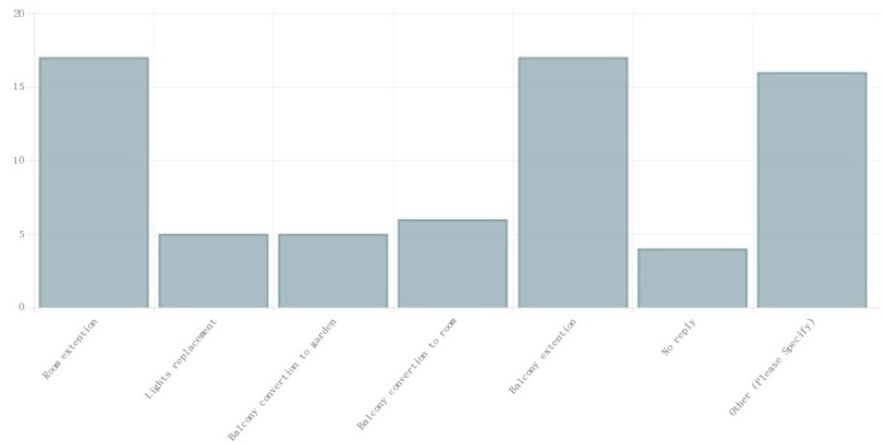


Fig. 48 Answers regarding the possibility of building extra volume on the roofs

In the Mediterranean and seismic areas of the EU, became imperative to couple energy retrofit with development of tools increasing confidence on safeness, to make visible that higher initial investments of retrofit are more interesting in the long term than lower investments with higher paybacks. The survey experience has shown how inhabitants perceive their houses in an holistic way, without sectorial and separate considerations on weather a solution is just energy saving or has other benefits. Showing a sensible interest for saving money or improving their life conditions, in front of possible alternative solutions for energy retrofit of their houses, they asked: are these building safe? The concern in terms of structural safety following the last earth quake episodes and emergencies have created an attention from the inhabitants who generally do not feel 'safe' inside the buildings.



Text Responses

thermal insulation
Windows replacement
other
Windows replacement
no changes
Window opeming
Not interested
Windows replacement
Windows replacement
Change of stair windows
Stair windows replacement
Change of stair windows
Windows replacement
Change of stair windows
Windows replacement
Change of stair windows

Fig. 49 Answers regarding the possibility of changing the layout or size of some rooms or portions of the apartments

Considering the possible transformation on the single units, the inhabitants have expressed their preferences that have been grouped and illustrated in the above histogram. Mostly the 'room or balcony extension' is the preferred option, although more then 80% of the interviewee has previously answered positively to the question regarding the satisfaction upon the apartments' size. However, the current size of the balcony is smaller then what would be suitable for a four-person family. The survey has shown that the interviewees use often (average of once a day has been the answer) the balcony for several type of activity such as drying the cloths, storage and eating outside. Gardening and socialising with the neighbours are activities that have not often been mentioned. Indications on the usage of the balcony can help in the design phase to improve the quality of the balconies and loggias. The areas of the house that are mostly used, for this case study, are both equally the living room and the kitchens; the project will therefore include interventions in these areas that would act as trigger points points to gain consensus in the renovation from the inhabitants during the negotiation process.

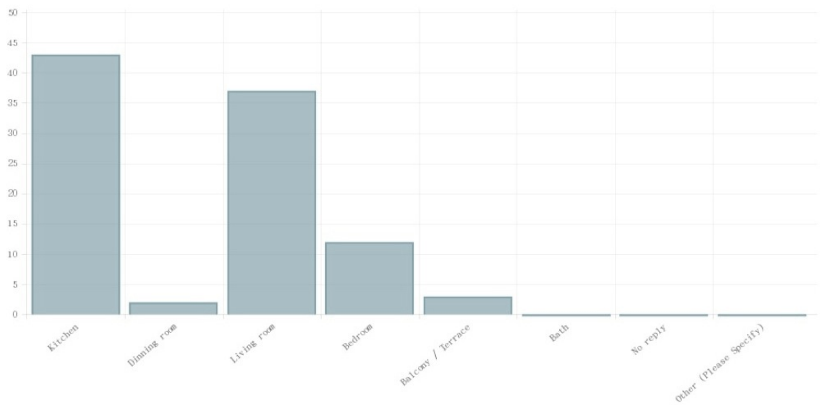


Fig. 50 Answers to the question: what areas of your apartment are mostly used

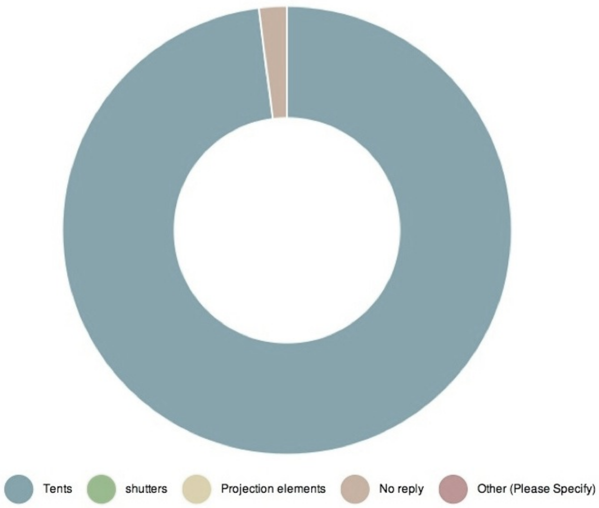


Fig. 51 Answers to the question related to the shading system currently used

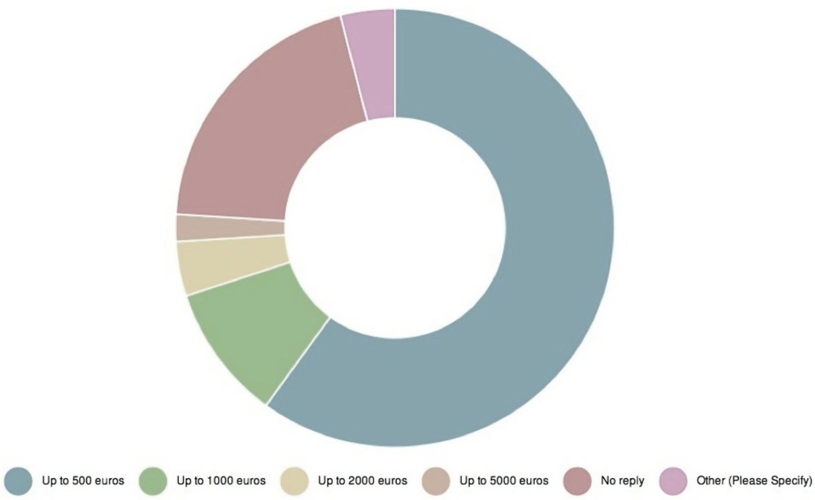


Fig. 52 Answers regarding the amount of money that the inhabitants would be willing to co-invest to finance the renovation intervention

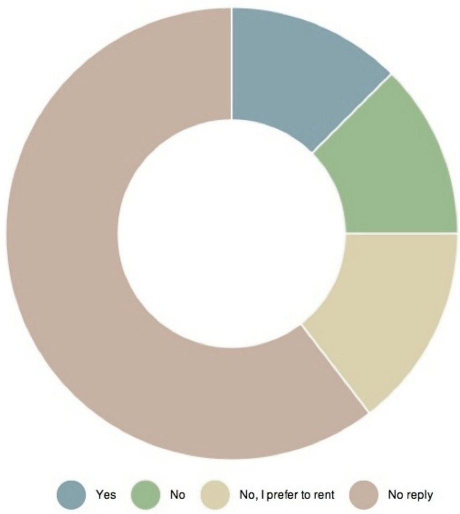


Fig. 53 Answers regarding the possibility of buying the apartment after renovation, how much would you be willing to pay for it?

Many among the persons interviewed expressed the desire of renewing the window of their dwelling and renovate the windows of the staircases, in general intervention on the façade have been proposed as a possible solution to improve the current condition. It is moreover important to consider an appropriate shading system for the southern facing facades: almost the entire interviewees sample uses only tends (external ones) to protect the direct sun irradiation and use air conditioning throughout the summer months.

Analysing the investment possibilities and scheme, the questionnaire included several questions regarding possibility of exchange floor surface for money, investment for the renovation and intention from the tenants to buy the apartments. When asked if they would be willing to support the renovation costs with a contribution in euros, the inhabitants have mostly agreed a sum of less than 500 euros. Only two interviewees could foreseen and investment of around 2,000 euros.

To the question 'If you would be asked to place a financial contribution for the energy renovation intervention in exchange of a convenient loan rate to buy the apartment you are currently renting, would you be interested?' Only 5 % showed interest and suggested a total sum of about 40,000 euros to buy the entire apartments, which would mean about 500 euro/m^2. The market price for selling apartments in the same state in areas like Peristeri is currently 1700 Euros/m^2. The research group has considered important to proceed the investigation and analysis upon the collected data through cross analysis. The three questions that have been further investigated are:

4. Which is your opinion about apartment construction on the roof of the building? Please keep in mind that this would allow the installation of solar panel, improve the energy performance and consequently reduce both the energy and the renovation costs

5. If you would be given the opportunity to renovate your apartment, would you be in favour of a volumetric extension? What type of intervention would you like to suggest?

6. Have you ever heard of energy efficiency?

In relation to questions number 1 and 2, the research aimed at understanding the level of education and the social position of the interviewees that have answered positively, e.g. in favour to the volumetric addition strategy. In relation to the awareness on the subject of energy efficiency, question 3., the cross analysis has been carried together with the investment-related questions.

In other words, the research team tried to evaluate if it exists a direct relations between the level of knowledge on the subject and the willingness of the inhabitants to contribute, also financially, to the energy renovation intervention. In the following diagrams, the column in blue represents the interviewees that are in favour of rooftop and volumetric extensions, the green one represents the ones that are in favour of the idea but would not support its application in Peristeri whereas the yellow one represents the interviewee that are against the idea and its application.

The cross-analysis has shown that the majority of the interviewees that have express their disapproval to the volumetric addition strategy are retired person, mostly with only a primary education.

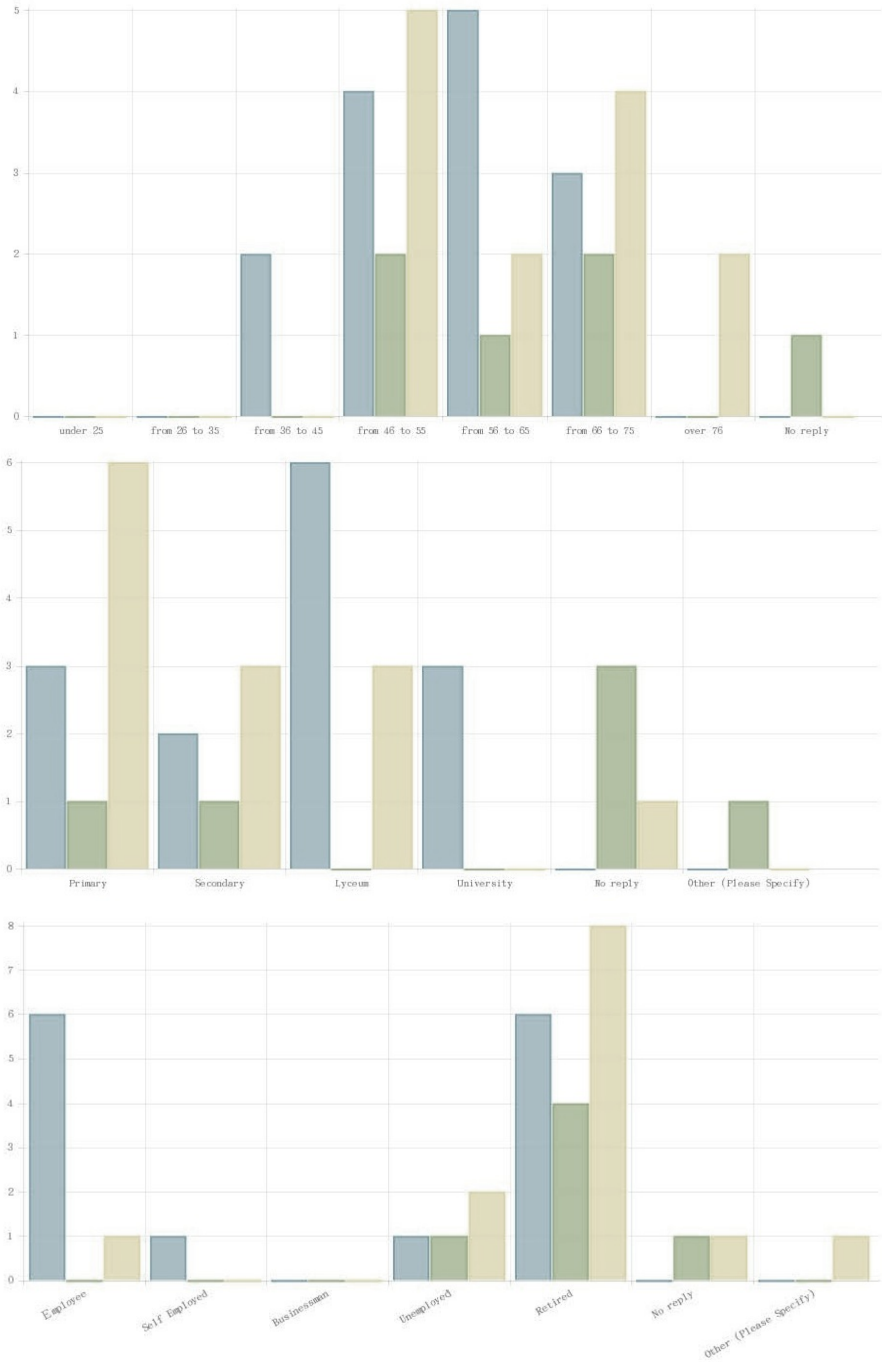


Fig. 54 Comparison among the opinion on the volumetric addition strategy and (from above): a. the age of the interviewees, b. the level of education of the interviewees, c. the type of occupation (social level) of the interviewees

On the other hand, the subjects that have supported the proposal both as an idea and for its application in Peristeri have a Lyceum diploma or a university degree and are employed or retired. The following graph shows the relationship between the knowledge on energy efficiency and the support to the proposal. The majority of the ones that are in favour (blue column) are also the majority of the subjects that are interested in energy efficiency and are informed on the subject. A significant part of the yellow ones, subjects against the volumetric addition, are also in the groups that are never been interested in the topic or have never heard of the term energy efficiency.

The majority of the interviewees that are interested in energy efficiency are also the same ones that are in favour of the volumetric addition and would support it also economically. In fact, as shown in the graph that follows, the blue column – that here represents the subjects that would be interested in buying the apartment after renovation- is concentrated in the group that are interested and know energy efficiency. The green column represents the interviewees that would support the renovation with a contribution of 500 euros.

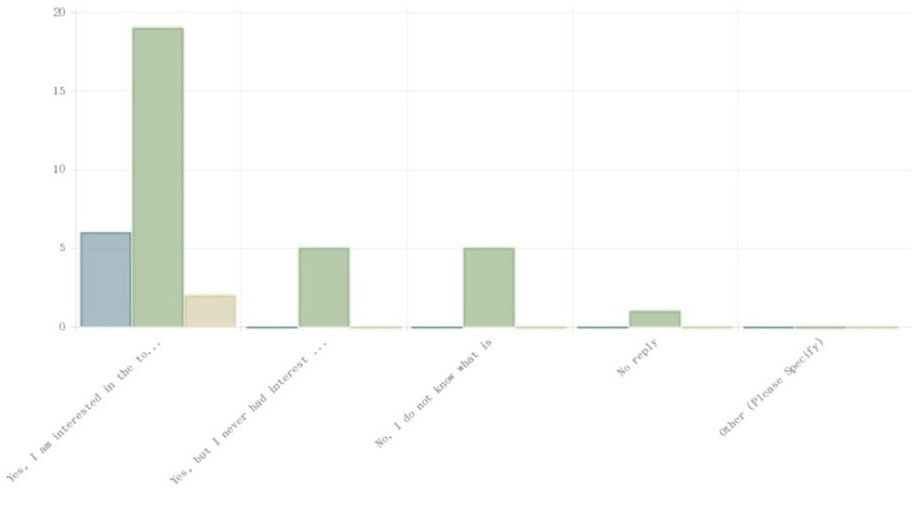


Fig. 55 Cross-survey between energy efficiency awareness and interest in supporting the renovation also financially

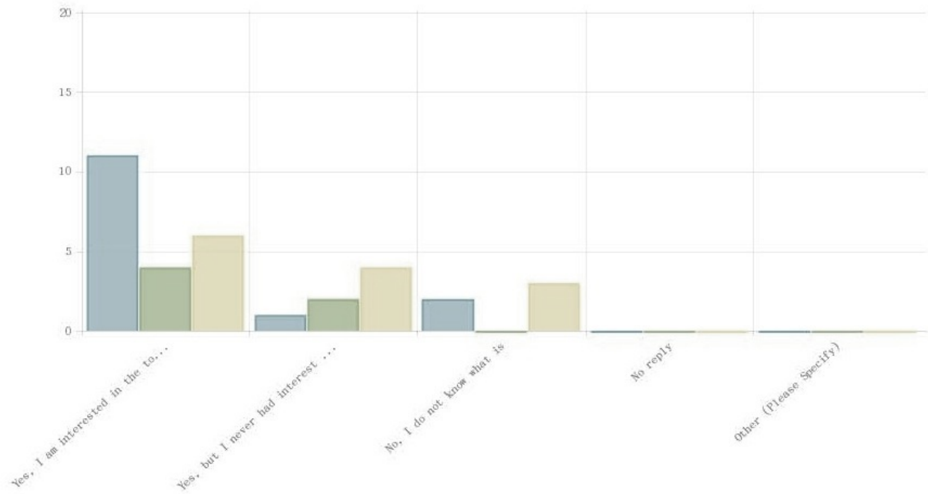


Fig. 56 Cross-survey between energy efficiency awareness and support to the volumetric addition strategy

Also the small group, represented by the yellow column, of the persons that would support the intervention with a contribution up to 2,000 euros are among those that already know the energy efficiency matter. From the considerations above and the results of the survey, it is clear that, in order to increase the support and commitment of the inhabitants in this type of intervention, it would be necessary to develop a communication policy and create a sufficient common knowledge on the energy efficiency subject, on the pay-back potentials and on the techniques that could be applied on the buildings. This would definitely contribute to shift some of the sceptical inhabitants towards supporting the renovation action.

In conclusion, the evaluation and dialogue with the inhabitants of the Peristeri neighbourhood has lead to important conclusions that will be implemented in the design proposal. The volumetric addition, as will be tested in this case study will be addressed towards the creation of a consistent volumetric addition that can improve the current disadvantage renovation market in Greece. The idea is to extra space as extensions side-extension of the building towards the park and internal side of the neighbourhood; this scenario could contribute in to balancing the investment and increase the satisfaction of the existing inhabitants by improving the quality of their dwelling.

Micro-scale intervention, at the unit level, will be proposed as negotiation points to gain the consensus in the renovation by the inhabitants. Shading systems will be provided and integrated in the façade and envelope systems. Storage space should be created in the balcony or in the apartments, since it is needed by the users. An improvement in the layout could be offered for the living room and kitchens, which are the preferred areas of the apartments. Rooftop additions are not supported by the majority of the inhabitants, there is a need to increase the safety and static conditions of the buildings' structure. This aspect could be integrated in the renovation proposal acting therefore again as a trigger node to overcome the disadvantages and problems that inhabitants will face in case of renovation (noise, dirt, disturbance). As for the ground floor, it is important to propose a new organization of the parking lots, reduce the numbers of cars that traffic closely to the buildings, and re-arrange the entrance to the buildings in the *pilotis* area. The following image shows in red the extra-volumes that could be created as part of the renovation. The next step consists in revising the scenario that has come out of the sociological feasibility study according to the economic and technical feasibility study. This study will bring to a better definition of the project according to its payback and real technical potential. In summery, from the results of the questionnaires the strategy will keep account of:

- MIDDLE AGE
- UNEMPLOYED
- NEW INHABITANTS
- MANY FOREGNERS
- NOT SATISFIED WITH AREA
- NOT SATISFIED WITH BUILDING
- DWELLINGS ARE SMALL
- ELEVATOR
- EXTRA ROOMS
- BALCONIES NOT USED
- SHADING WITH TENDS
- NO AIRCONDITIONING
- AUTONOMUS HEATING
- KEY ROOM: KITCHEN
- INFILL SUPPORTED
- ROOFTOP REJECTED
- ENLARGEMENT SUPPORTED

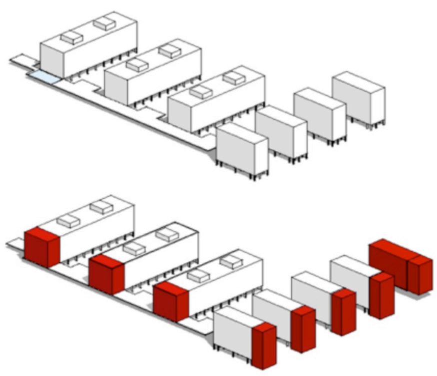


Fig. 57 Urban and architectural strategy layout, red volumes represent the potential volumetric addition that would foster the renovation intervention by decreasing the pay-back time

5.3.3 Project summary

The building chosen as Greek case study among the others in the Peristeri neighbourhood is a concrete skeleton building, six storeys high. There are in total six building with the same construction typology as the one chosen as case study, with the same orientation north-south. The ground floor is structured with pilotis open area, currently mostly used as car parking. The current condition of the buildings presents several critical aspects in terms of architectural, energetic and urban quality. In particular it is evident also from a first analysis of the outside envelope, a generalised disorder resulting from the needs and devices installed by the inhabitants to answer to the climatic conditions of the surroundings. Emergency shading devices as well as air conditioning external units are characterising the entire façade (see Fig. 58). The building typology is building block and the distribution system is based upon three staircase with autonomous entrances at the pilotis level, already equipped with elevators.

The structure of the building is massive therefore there would be residual load potential to consider a roof-top addition. According to the social survey however, the inhabitants would not agree and have expressed their doubts in terms of seismic safety. Although the Peristeri neighbourhood is already fairly densely populated, vast green and parking areas are dividing the different building groups and southern from the building chosen as case study there is a vast open surface. The street net is evenly distributed through out the compound allowing several access to each building and providing a consistent flexibility to reorganise the urban services and the accesses to the buildings.

Fig. 58 Current condition of the building facades in Peristeri. The majority of the inhabitants have installed various shading systems. In addition a large number of dwellings have autonomous cooling pumps whose external machines have been installed directly on the facade

Each staircase serves two apartment units. The entrance space is dedicated to the daily functions whereas the two bedrooms are facing west and east. The dwellings are distributed to have mostly cross ventilation and good exposures, they are provided with loggias on both sides. As emerged by the dialogue with the inhabitants there is a strong need of improving the current envelope performance, especially considering the summer regime and providing proper shading systems. The plants are obsolete and require a consistent renovation of the distribution devices therefore the plan includes new installations through plug and play solutions. The channels and distribution system has thus been integrated directly in the new facade panels and will be connected through the new floor slabs directly to the apartments providing mechanical ventilation and new heating and cooling plants.

The aim of design proposals is to achieve current standards of energy efficiency in terms of thermal performance and optimization of consumption, not to mention the architectural context in which they occur. Several proposals of intervention were evaluated, and then combined together to provide valid retraining scenarios. The proposals are summarized as follows:

- Insulation cladding (walls and floor on stilts);
- Replacement of windows;
- Insulation of the roof with green roof

As for the facade, a secondary support structure has been proposed adjacent to the existing one. The idea is to create a synergy that could improve also the structural behaviour of the existing building in case of earthquake. The additional structure provides the support for the extension of the apartments according to the wishes of the users through a balcony, a new loggia or the increase in size of the existing rooms. Proper shading panels have been included in the proposal.

According to the preliminary calculation, a consistent Add-on would have been necessary to counterbalance the cost of this intervention especially considering the current market rates and costs in Greece. The feasibility study has led to the definition of a side extension that has been combined with the front horizontal addition of the balconies.

Aside the existing building a new portion has been built, reproducing in size and distribution system the existing building therefore assuming the role of a coherent extension towards south. The facade has been planned as a continuous succession of modules identical in size but diverse in function and form that have been collected in the abacus of facade components among which the inhabitants' can chose and express their wishes. The new envelope is thus characterised by high performance levels and a great flexibility in its different parts that can be combined: inhabitants can choose among, serras large balconies, loggias or extra rooms.

The urban layout allows this increase in surface and the access to the building by cars and pedestrians remains from the northern side (Orpheos Street). As the economical evaluations will show the Add-on has been more consistent than required therefore a consistent benefit in terms of real estate increase value has been created, repaying almost entirely the intervention on the existing building. The 'after' configuration is therefore increase in size and volume of one third if compared to the 'before' situation of the building (Fig. 59). Differently from the conceptual approach used in the previews two case study, the Add-on has not been designed as 'external' and 'para-site' element but is rather hidden behind an overall uniformity of the elevation. The high costs resulting from the introduction of an entirely new prefabricated support structure and the renewal of the plant system could be balanced by the consistent addition suggested for this case study.

5.3.4 Cost-benefit analysis

Table 15 illustrates the unit cost for each of the renovation intervention foreseen for the case study 3. The object is to define a specific cost per square meter of the renovation intervention in the specific Greek market, which in this case resulted 450 euro/m^2. The intervention included façade and floor slab insulation (ground floor and rooftop), window replacement including shading systems, basic substitution of plant instalments and integration of plug and play systems, thermostat devices in all the apartments, finishing and balconies as presented in the panels (P.gr3-5). In parallel, the construction cost of the Add-on has been estimated.

The case study has tested the feasibility of a consistent Add-on to counterbalance the disadvantaged market condition of 2.900 m^2 also considering the cost evaluations carried with the inhabitants and the fact that further Add-on extensions on the rooftop would have not been supported by the population. Considering the schematic design presented in the project experiment carried , the overall cost per square meter to construct the Add-on would be 715 euro/m^2.

A Photovoltaic plant has been planned on the portion of the roof facing west to integrate RES in the renovation, for an overall of 750 m^2 for a power plant of 112 kWp (solar panel yield 15%). Tab. 16 collects the energy savings and consumptions data. Energy related aspects are the results of the calculations and simulations carried instead on a series of dwelling, located at different levels and with different exposure, of the buildings with energy simulations programs (Design Builder).

The overall energy consumptions have been compared with the bills and the real data provided by the inhabitants that took part in the survey; there is no social housing scheme in Greece and all the inhabitants are homeowners or tenants. This status makes it harder to develop concerted actions and collect the overall consensus since the only party that could support meetings and gathering as well as participation events is the Municipality of Peristeri, who contributed in the research but does not have a control right upon the building. As for the cost evaluation, the current situation of the Greek market has been analysed searching for the unit cost of the Add-on and the real estate value of the Add-on according to the area the case study is located (Greek ministry of Economic)[13].

The energy prices have been collected from the Greek local energy provider (DEI) considering that most of the energy consumptions refer to electrical consumptions or rather petrol for the summer season. The suggested PV plant evaluated and included in the project simulation has been counted and inserted in the evaluation accounting its potential energy production.

The actual market situation in Greece is used as case study also to show the full potential of the Add-on strategy also in those disadvantaged economical situations. The incentives schemes in Greece are extremely low when compared to the other two contexts analysed in this research. However, the construction costs remains also fairly low. A consistent Add-on - as proposed in this case study would then increase the upfront costs but still create profit, although lower than what could be expected in healthier markets such as the German one for example. The renovation interventions in Peristeri could never be considered bankable for a series of various reasons, first of which is the need of financial support which banks would not provide and credit institutes.

Moreover considering the private regime that is spread in Greece the suggestion is to create cooperative groups of investment among inhabitants, which could partially contribute in the renovation when convinced of the return of their investment. In this scenario the interest rate could also be reduced from 5 to 3 %. The following analysis shows the overall cost-benefit trend of the proposal.

[13] Data have been collected at www.kathumerini.gr and at www.realestatecorner.gr

Renovation Interventions	UoM mq	Quantity (Case study 01)	Unitarian cost (Italian market)	Total cost 450,90 €
Window replacement (triple glazing)	mq	480,00	700,00 €	336.000,00 €
Rooftop insulation	mq	420,00	45,00 €	18.900,00 €
Facade insulation	mq	1.720,00	120,00 €	206.400,00 €
Ground Floor slab insulation (against earth)	mq		70,00 €	- €
Insulation of floor slabs adjacent to cold spaces (parkings, pilotis etc.)	mq	420,00	65,00 €	27.300,00 €
Insulation of balconies, bow-windows, frames	mq	516,00	150,00 €	77.400,00 €
New balconies and finishing	mq	360,00	40,00 €	14.400,00 €
New heating system with heat pump	cad	-	50.000,00 €	50.000,00 €
Thermostat for consumptions check	cad	24,00	310,00 €	7.440,00 €
				737.840,00 €
			with extra costs	**811.624,00 €**
Addition construction	mq			**715,20 €**
New windows in the addition	mq	240,00	600,00 €	144.000,00 €
New steel structure cost for the Addition	kg	178.752,00	0,84 €	150.151,68 €
Addition construction cost (1) without structure	mq	2.910,00	550,00 €	1.600.500,00 €
				1.894.651,68 €
PV plant	**kWp**	112,50	500,00 €	**56.250,00 €**
Total Investment				**2.895.740,85 €**

Tab. 14 Cost overview for the renovation intervention, the Add-on construction and for the installation of a PV plant on the roof of the building. The data here presented are collected also in Tab.15 and will be the base for the cost-benefit analysis carried in Tab. 16-17.

Energy consumptions (1)			
178,00	kWh/mq per year	Before	DB simulations
25,00	kWh/mq per year	After	SET point
295.836,00	kWh per year	Before	
41.550,00	kWh per year	After	
Energy prices (2)			
1,38	€/l	Petrol price	(World Petrol price , 2015)
0,12	€/kWh	Electricity price	(DEI, 2015)
Energy savings (thermal)			
27.051,70	mc per year	Gas savings after intervention	
4.420,21	mc per year	Gas consumptions after intervention	
37.331,35	**€ per year**	**Energy Savings after intervention**	
6.099,89	**€ per year**	**Energy Costs after intervention**	
Energy production (electrical)			
29.513,31	kWh per year	Electrical energy production from PV	
112,50	kWh peak	Total power of the plant	
3.541,60	**€ per year**	**Energy Savings after intervention**	

Tab. 15 Energy consumptions and production as for the Greek market and the considered case study. (1) The energy consumptions have been derived by the simulations carried with Design Builder on the case study. Thermal and electrical benefit in economical terms has then been calculated. The energy prices (2) have been collected from the Greek local energy provider (Dei) and the current Greek petrol price since most of the apartment have fuel heating boilers. The data here presented are collected also in Tab.117 and will be the base for the cost-benefit analysis carried in Tab. 18-19.

GEOMETRY		
Total net Surface	**1.662**	**mq**
Total gross Surface	2.520	mq
Total gross Volume	7.056	mc
S/V (1)	0,36	
Average gross Unit Surface	105	mq
Number of units	24	dwellings
Dwellings involved in the sociological survey	18	%
Number of car parks	26	parking
Area Lotto	3.064	mq
FAR Density (2)	0,14	-
ARCHITECTURE TECHNOLOGY		
Year of construction	1972	-
Restoration intervention	none	-
Structure	concrete skeleton	-
Roof construction type	Flat roof	-
Facade	bricks	-
Shading system	sliding shadings	-
Add-on typology (3)	**Aside and Front Addition-Semi-parastic**	-
ENERGY RELATED ASPECTS		
Energy consumptions heating and cooling (4)	178	kWh/mq
Envelope transmittance (average)	1,389	W/mq°K
Yearly energy consumptions	**295.836**	**kWh/y**
Energy savings by retrofitting (5)	254.286	kWh/y
Unit Energy reduction by retrofitting	139	euro/mq
Co2 reduction	22	t/CO2
Available PV surface	750	mq
Renewable energy production (6)	**29.513**	**kWh/y**
COST EVALUATIONS		
Real estate value (7)	1.400	Euro/mq
Renovation cost (8)	451	Euro/mq
Total renovation cost	**1.192.524**	**Euro**
Energy savings after renovation	37.331	Euro
Add-On construction cost (9)	716	Euro/mq
Incentives (10)	15	%
Petrol cost (11)	1,38	Euro/liter
Electricity cost (11)	0,12	Euro/kWh
PV plant cost	**56.250**	**Euro**
Energy savings through solar energy	3.542	Euro
ADD-ON NECESSARY TO SET THE PAYBACK BELOW 5 YEARS (12)	**1.445**	**mq**
ADD-ON FEASIBLE AS DEMONSTRATION PROJECT	**2.910**	**mq**

Tab. 16 (1) The surface area to volume (S/V) ratio defines the heat loss and gain.The greater the surface area the more the heat gain/loss through it. (2) FAR denisty is calculated as the ration between the total liveable surface and the plot area. (3) The Add-on typology is defined according to the categorisation made in Chapter 2 (Tab.2.2). In this case it is a *Aside- semiparastic Add-on* (4) Energy consumptions and EP average values have been calulated through simulation run by Design Builder considering both the summer and the winter regime (5) The value of energy savings has been calculated considering to reduce the current consumptions down to 25 kWh/m^2 per year which has been set as target (see Tab. 4) (6) The renewable energy production given by the proposed PV plant has been supposed to be installed on an overall surface of 750 mq with a power of 112,5 kWp. (7) The real estate value is intended as the potential selling value of new real estate units as derived by the market situation in Pristeri as well as the unitarian construction cost (Source: http://www.enet.gr/?i=news.el.article&id=13074) (8,9) The renoavion and Add-on construction cst per square meter have been calculated on the specific case study as showed in Tab. 3 (10) The incentives provided by the Italian government is calculated upon the 15% of the total investment for those interventions that reach the standards required by the Greek Energy Law by the Exikonomia (11) The data are derived by Dei as main energy provider and by th epublic greek price of pertrol for 2015 (12) The volumetric addition calulcated accoding to the formula presented in Chapter 3 to reduce the payback time below the 5 years threshold

	Renovation investment	811.624,00	€
	PV investment	56.250,00	
	Add-Ons investment	2.084.116,85	€
	Total Investment (Renovation + PV + Add-Ons)	2.895.740,85	€
	Savings (non weighted, thermal)	37.331,35	€ per year
	Profit from Add-ons' sale	2.856.000,00	€
	Savings (non weighted, electrical)	3.541,60	€ per year
	Fiscal incentive (15%)	121.743,60	€
	Fiscal incentive rate (10 years plan)	12.174,36	€ per year
	Interest rate	0,0500	
	Energy inflation rate	0,0300	

	Incoming			Outgoing			
Year	Savings	PV Production	Incentive	Consumptions	Cash flow	NPV	Sum
0	0,00		0,00	0,00	-2.895.740,85	-2.895.740,85	-2.895.740
0	2.856.000,00		0,00	0,00	2.856.000,00	2.856.000,00	-39.740
1	37.331,35	3.541,60	12.174,36	6.099,89	53.047,31	50.521,24	10.780,40
2	38.451,29	3.647,85	12.174,36	6.282,89	54.273,49	49.227,66	60.008,06
3	39.604,83	3.757,28	12.174,36	6.471,38	55.536,47	47.974,49	107.982,54
4	40.792,97	3.870,00	12.174,36	6.665,52	56.837,33	46.760,21	154.742,76
5	42.016,76	3.986,10	12.174,36	6.865,48	58.177,22	45.583,37	200.326,13
6	43.277,26	4.105,68	12.174,36	7.071,45	59.557,31	44.442,58	244.768,71
7	44.575,58	4.228,85	12.174,36	7.283,59	60.978,80	43.336,49	288.105,20
8	45.912,85	4.355,72	12.174,36	7.502,10	62.442,93	42.263,83	330.369,04
9	47.290,24	4.486,39	12.174,36	7.727,16	63.950,99	41.223,38	371.592,41
10	48.708,94	4.620,98	12.174,36	7.958,98	65.504,28	40.213,95	411.806,36
11	50.170,21	4.759,61		8.197,75	54.929,82	32.116,33	443.922,69
12	51.675,32	4.902,40		8.443,68	56.577,72	31.504,59	475.427,28
13	53.225,58	5.049,47		8.696,99	58.275,05	30.904,50	506.331,78
14	54.822,34	5.200,95		8.957,90	60.023,30	30.315,84	536.647,62
15	56.467,01	5.356,98		9.226,64	61.824,00	29.738,40	566.386,03
16	58.161,03	5.517,69		9.503,44	63.678,72	29.171,95	595.557,98
17	59.905,86	5.683,22		9.788,54	65.589,08	28.616,30	624.174,28
18	61.703,03	5.853,72		10.082,19	67.556,75	28.071,23	652.245,50
19	63.554,12	6.029,33		10.384,66	69.583,45	27.536,54	679.782,04
20	65.460,75	6.210,21		10.696,20	71.670,96	27.012,03	706.794,07
21	67.424,57	6.396,52		11.017,09	73.821,09	26.497,52	733.291,59
22	69.447,31	6.588,41		11.347,60	76.035,72	25.992,80	759.284,39
23	71.530,72	6.786,07		11.688,03	78.316,79	25.497,70	784.782,09
24	73.676,65	6.989,65		12.038,67	80.666,30	25.012,03	809.794,12
25	75.886,95	7.199,34		12.399,83	83.086,28	24.535,61	834.329,73
26	78.163,55	7.415,32		12.771,82	85.578,87	24.068,26	858.397,99
27	80.508,46	7.637,78		13.154,98	88.146,24	23.609,82	882.007,81
28	82.923,71	7.866,91		13.549,63	90.790,63	23.160,11	905.167,92
29	85.411,43	8.102,92		13.956,12	93.514,34	22.718,97	927.886,89
30	87.973,77	8.346,01		14.374,80	96.319,77	22.286,22	950.173,11
				NPV	30 years	3.845.913,96	
				IRR	30 years	0,13536	
				PAY-BACK TIME	1 year		

Tab. 17 Cost-benefit analysis carried for deep renovation with Add-Ons of 2910 m^2 considering the current incentive scheme which in Greece covers up to 15% of the initial investment as fiscal reduction. The payback time resulting from the NPV (3.845.914 euro) is 1 years and the IRR is 13,5 %

	Renovation investment		811.624,00	€			
	PV investment		56.250,00				
	Add-Ons investment + PV		2.084.116,85	€			
	Total investment (Renovation + PV + Add-Ons)		2.951.990,85	€			
	Savings (non weighted)		37.331,35	€ per year			
	Profit from Add-ons' sale		2.856.000,00	€			
	Savings (non weighted, electrical)		3.541,60	€ per year			
	Interest rate		0,0500				
	Energy inflation rate		0,0300				

	Incoming		Outgoing			
Year	Savings	PV Production	Consumptions	Cash flow	NPV	Sum
0	0,00		0,00	-2.951.990,85	-2.951.990,85	-2.951.990,85
0	2.856.000,00		0,00	2.856.000,00	2.856.000,00	-95.990,85
1	37.331,35	3.541,60	6.099,89	40.872,95	38.926,62	-57.064,23
2	38.451,29	3.647,85	6.282,89	42.099,13	38.185,16	-18.879,08
3	39.604,83	3.757,28	6.471,38	43.362,11	37.457,82	18.578,74
4	40.792,97	3.870,00	6.665,52	44.662,97	36.744,34	55.323,08
5	42.016,76	3.986,10	6.865,48	46.002,86	36.044,45	91.367,53
6	43.277,26	4.105,68	7.071,45	47.382,95	35.357,88	126.725,41
7	44.575,58	4.228,85	7.283,59	48.804,44	34.684,40	161.409,81
8	45.912,85	4.355,72	7.502,10	50.268,57	34.023,75	195.433,56
9	47.290,24	4.486,39	7.727,16	51.776,63	33.375,67	228.809,23
10	48.708,94	4.620,98	7.958,98	53.329,92	32.739,95	261.549,18
11	50.170,21	4.759,61	8.197,75	54.929,82	32.116,33	293.665,51
12	51.675,32	4.902,40	8.443,68	56.577,72	31.504,59	325.170,10
13	53.225,58	5.049,47	8.696,99	58.275,05	30.904,50	356.074,60
14	54.822,34	5.200,95	8.957,90	60.023,30	30.315,84	386.390,44
15	56.467,01	5.356,98	9.226,64	61.824,00	29.738,40	416.128,84
16	58.161,03	5.517,69	9.503,44	63.678,72	29.171,95	445.300,80
17	59.905,86	5.683,22	9.788,54	65.589,08	28.616,30	473.917,10
18	61.703,03	5.853,72	10.082,19	67.556,75	28.071,23	501.988,32
19	63.554,12	6.029,33	10.384,66	69.583,45	27.536,54	529.524,86
20	65.460,75	6.210,21	10.696,20	71.670,96	27.012,03	556.536,89
21	67.424,57	6.396,52	11.017,09	73.821,09	26.497,52	583.034,40
22	69.447,31	6.588,41	11.347,60	76.035,72	25.992,80	609.027,21
23	71.530,72	6.786,07	11.688,03	78.316,79	25.497,70	634.524,91
24	73.676,65	6.989,65	12.038,67	80.666,30	25.012,03	659.536,94
25	75.886,95	7.199,34	12.399,83	83.086,28	24.535,61	684.072,55
26	78.163,55	7.415,32	12.771,82	85.578,87	24.068,26	708.140,81
27	80.508,46	7.637,78	13.154,98	88.146,24	23.609,82	731.750,63
28	82.923,71	7.866,91	13.549,63	90.790,63	23.160,11	754.910,74
29	85.411,43	8.102,92	13.956,12	93.514,34	22.718,97	777.629,71
30	87.973,77	8.346,01	14.374,80	96.319,77	22.286,22	799.915,93
			NPV	30 years	3.751.906,78	
			IRR	30 years	0,11512	
			PAY-BACK TIME	3 years		

Tab. 18 Cost-benefit analysis carried for deep renovation with Add-Ons of 2910 m^2. The payback time resulting from the NPV (3.751.907 euro) is 3 years and the IRR is 11,5 %

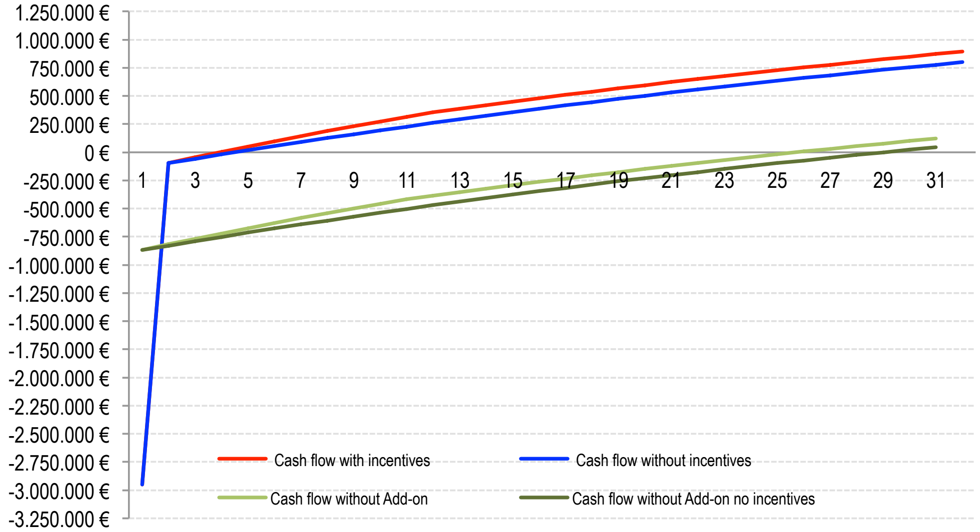


Fig. 59 The graphic shows the comparison between the two cost-benefit analysis carried for deep renovation with Add-On as the design experiment for the case study 03. Deep renovation with Add-Ons' investments without incentives (blue in the graphic), can reach a pay-back time of 3 years whereas the pay-back time of Deep renovation with Add-ons, with incentive - for the Greek legislative framework accounting for 15% of the initial investment - (red in the graphic) is about 1 years. The graphic shows the comparison between the Deep Renovation with Add-on as above illustrated and the case of no Add-on (in green in the graphic) both with and without incentives.

The analysis shows the low contribution given by the incentives scheme in Greece, especially if comparing this with the other case studies previously presented. Fig. 59 shows also the scenario of Deep renovation without Add-on (in green) demonstrating that the low prices for the renovation and the high prices for energy (petrol and electrical) generate lower pay back times than in the Italian context for example, but yet far beyond the 15 years. The consistent profit gained by the Add-on is here justified by the fact that the design experiment has willingly included a consistent surface of Add-on including both: i. a front extension of the balconies as benefit to the current inhabitants that could partially take part in the investment and ii. A side extension as additional building with autonomous circulation and entrances which could be sold as 'new' building and could generate an economical and energetic synergy with the old portion of the building.

5.3.1 TABLE AND DRAWINGS, CASE STUDY 03

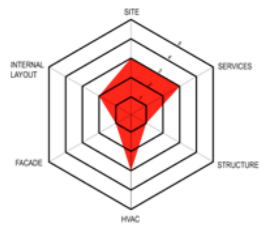
CASE STUDY

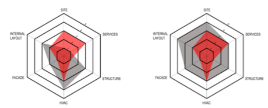
Peristeri, Athens (GR)

RELEVANT DATA

Total net conditioned Surface	1.662	mq
Total gross Surface	2.520	mq
Total gross Volume	7.056	mc
S/V	0,36	
Average gross Unit Surface	105	mq
Number of units	24	
Dwellings involved in the survey	18	
Number of car parks	26	
Area Lotto	3.064	mq
FAR Density (1)	0,14	-

ADDITIONAL INFORMATION



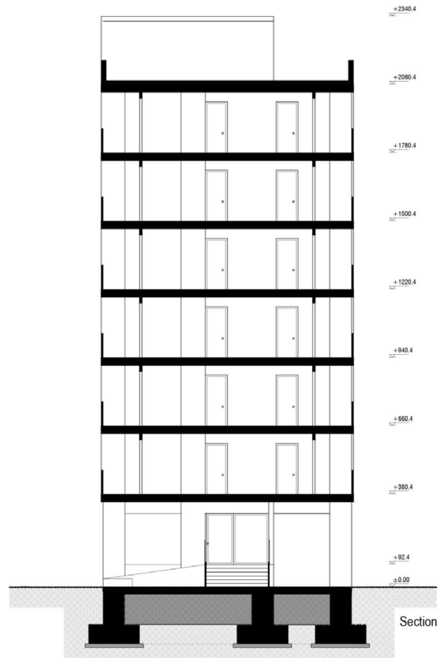


PERISTERI, AT GREECE

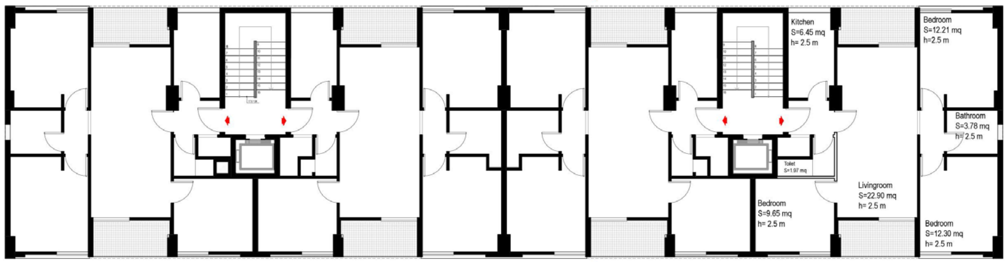
LARGE

Current state, urban scale 1.1000 **P. gr.01**

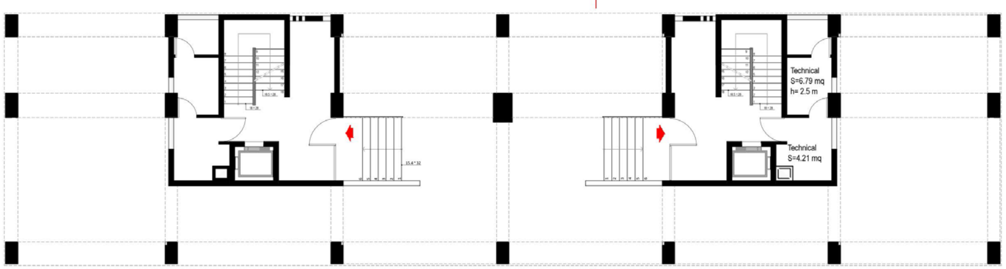
West Elevation



Section



Floor Plan _ Tipical



Floor Plan _ Ground Floor

CASE STUDY

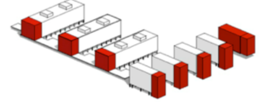
Peristeri, Athens (GR)

RELEVANT DATA

Year of construction	1972
Restoration intervention	none
Structure	concrete skeleton
Roof construction type	Flat roof
Facade	bricks
Shading system	sliding shadings
Add-on type	Aside-Semi-Parastic

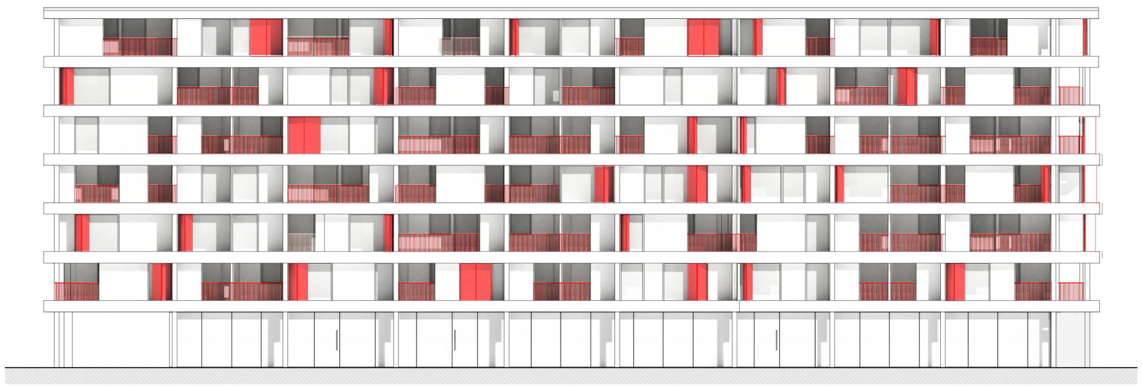
ADDITIONAL INFORMATION

Energy consumptions,		
heating and cooling	178	kWh/mq
Envelope transmittance	1,389	W/mq°K
Total primary energy consumptions	295.836	kWh/y
Energy savings by retrofitting (3)	254.286	kWh/y
Unit Energy reduction by retrofitting	139	euro/mq
Co2 reduction	22	t/CO2
Available PV surface	750	mq
Renewable energy production	29.513	kWh/y

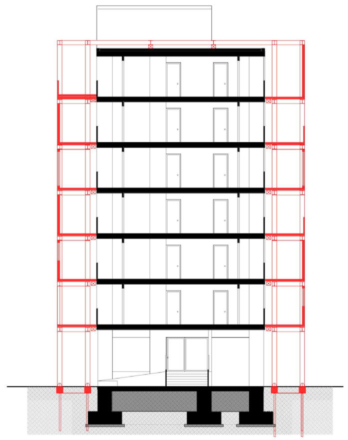


Current State, building scale
1.200

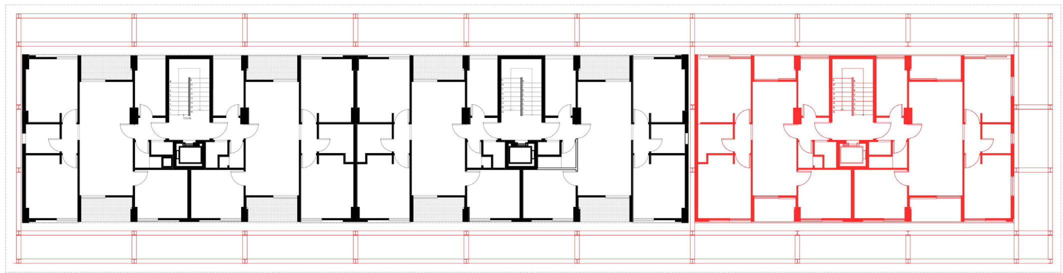
P. gr.02



West Elevation



Section



Floor Plan _ Tipical

CASE STUDY

Peristeri, Athens (GR)

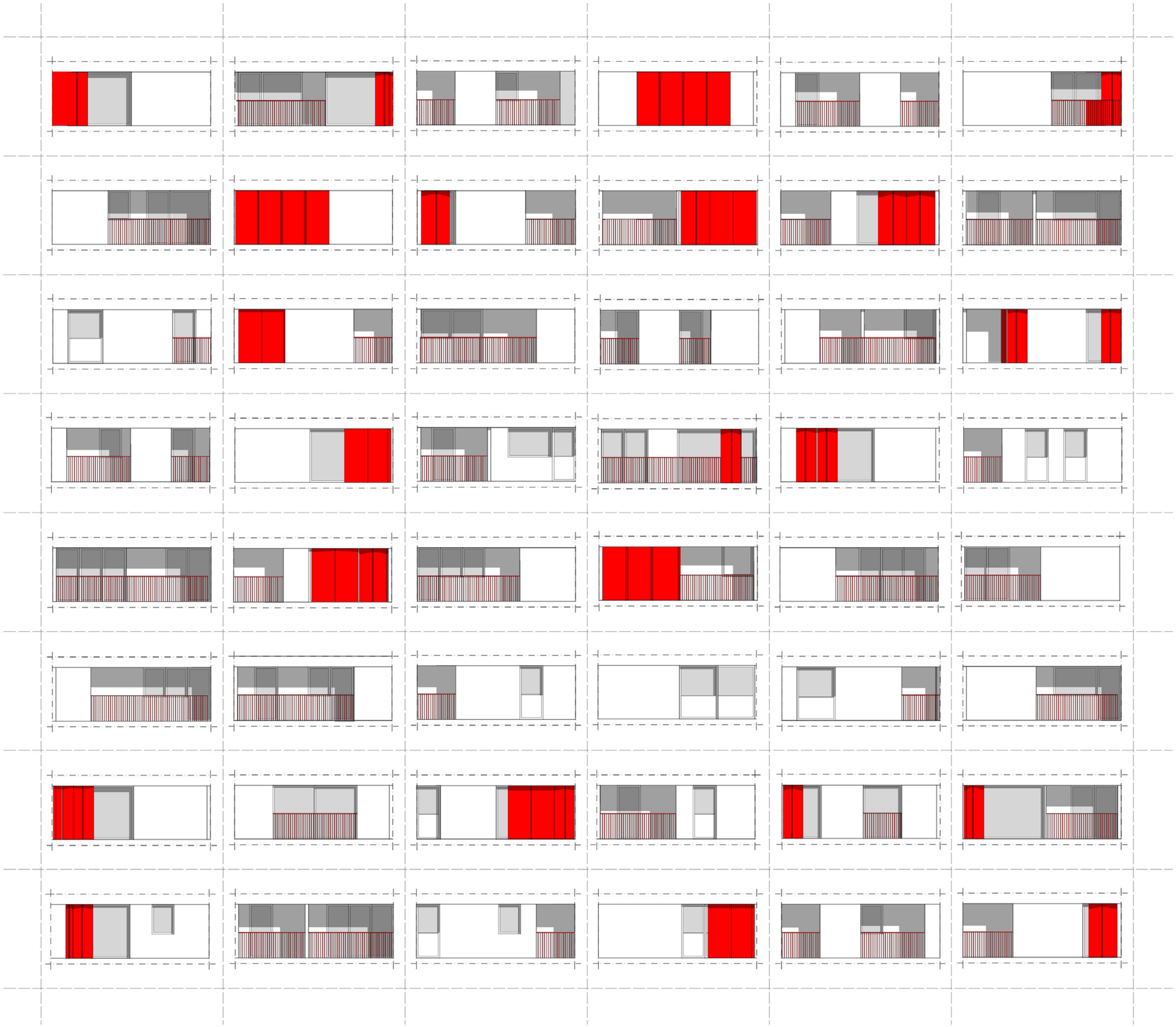
RELEVANT DATA

Window replacement (triple glazing)	336.000,00 €
Rooftop insulation	18.900,00 €
Facade insulation	206.400,00 €
Ground Floor slab insulation (against earth)	- €
Insulation of floor slabs adjacent to cold spaces (parkings, pilotis etc.)	27.300,00 €
Insulation of balconies, bow-windows, frames	77.400,00 €
New balconies and finishing	14.400,00 €
New heating system with heat pump	50.000,00 €
Thermostat for consumptions check	7.440,00 €
Total renovation cost	811.624,00 €
New windows in the addition	144.000,00 €
New steel structure	150.151,68 €
Addition construction cost	1.894.651,68 €
PV plant	56.250,00 €
Total Investment	2.895.740,85 €

Possible outcome,
multi-variable design

1.200

P. gr.03



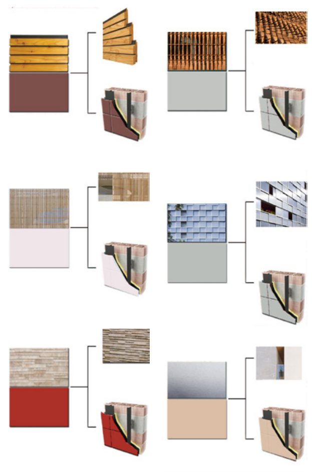
CASE STUDY

Peristeri, Athens (GR)

RELEVANT DATA

MIDDLE AGE
UNEMPLOYED
NEW INHABITANTS
MANY FOREGNERS
NOT SATISFIED WITH AREA
NOT SATISFIED WITH BUILDING
DWELLINGS ARE SMALL
ELEVATOR
EXTRA ROOMS
BALCONIES NOT USED
SHADING WITH TENDS
NO AIRCONDITIONING
AUTONOMUS HEATING
KEY ROOM: KITCHEN
INFILL SUPPORTED
ROOFTOP REJECTED
ENLARGEMENT SUPPORTED

POSSIBLE MATERIALS



Typological Façade Abacus

1.200

P.gr.04

CHAPTER 6_ CONCLUSIONS

6.1 Results and conclusions

Almost two third of the buildings that make up the European real estate assets have been designed in total absence of specific regulations and with very few considerations on energy efficiency. This results in buildings which are responsible for over the 40 % of the total European energy consumption, of which residential use represents two third of the total building sector's consumption, namely 27%[1] of the overall European energy consumption. Up until 2015, only about 1,2% of Europe's existing buildings is renovated every year[2]. Given the size and the number of buildings that can be grouped in this analysis, it is clear **that a punctual and local strategy for renovation can no longer be effective**. As shown in the first part of this work, several consistent barriers are slowing down the process of Deep Renovation through the existing building stock. It is imperative to increase the bankability and attractiveness of the Deep Renovation from an economical perspective, creating extra value: this means combining the standard retrofitting interventions (insulation, window replacement, etc.) with the construction of new living space, extra units and/or buildings that could act as financial guarantee, counter-balance the initial investment and reduce significantly the pay-back times. Moreover social aspects need to be included in the renovation plan in order to reduce the risk of bureaucratic and authorisation impediments and promote an active participation of the inhabitants and owners in the from the design phase. Policies, strategy and technologies are moving fast towards the definition of the 'right path' towards deep renovation whereas tools and methodologies to overcome the social barrier are left behind and it is ultimately the lack of inhabitants and owners consensus that often opposes to successful renovations.

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1 Calculation made upon the total floor area of the European building stock and residential portion

2 The demolition rates is about 0.1% per year and highly energy efficient new-build reach 1% additions/yr. JWG: Towards assisting EU Member States on developing long term strategies for mobilising investment in building energy renovation (EU EED Article 4), Joint Working Group of CA EED, CA EPBD and CA RES, November 2013 (http://www.ca-eed.eu/reports/art-4-guidance-document/eed-article-4-assistance-document).

The need of generating new real estate value to balance the significant up-front investments that characterise the renovation market, suggests to combine the renovation of existing buildings with the construction of extra units or new 'satellite' buildings: this would counterbalance the initial costs and act as guarantee for banks, financial institutions and investors by increasing the attractiveness of renovation and decreasing its risks. In many cases the building structure can not be modified in an economically sustainable manner but it is possible to integrate secondary systems, extend the existing and redefine the layouts and functions: renovation becomes a smart alternative to total demolition in favour of a metamorphosis that responds to current and future needs of the users. As demonstrated through the validation of the methodology by the design experiments carried in three different European contexts, the proposed renovation process through Add-on offers a combined socio-economical added value that sign a turn-around in Deep-renovation practice. The central aim of this research thus consists in **defining a new approach based upon Add-ons** for the renovation of the social housing building, as programmatic and integrated methodology that could lead towards a resolved renovation upgrade of the entire European building stock.

In fact, through the comparative analysis of the case study conducted, it has been possible to prove the feasibility of the proposal at the three main levels: technical, social and economical. For all the three case studies, regardless the differences in construction typology, structure, envelope and energy consumptions, it has been demonstrated the highly innovative character of the Add-on renovation. The **new façade components** have been designed to be added to the existent building envelope as an additional layer that improves the overall performances or, in case of need, substitute entirely/partly the existing façade. An additional structure supporting the new façade modules could be placed adjacent to the existing building, as shown in the Greek case study. This structure is similar to a portal structure and can be connected by junction crossing elements on the roof. This *support* structure could be seen as new collaborative structure to support the construction of entire extra units, volumetric additions (Add-ons) to the existing volume. The type of expansion could involve not only the increasing of one room size but the entire roof top level, as showed in the German case study or the side as showed in the Greek case study or once again the in-between space of building blocks as tested in the Italian case study. The **energy tests and simulation** carried have demonstrated the effectiveness of the technological solutions applied by reducing the energy consumptions to the target of 25 kWh/m^2 per year. By transferring the customization and prefabrication logics into the field of Energy Renovation, it is possible to re-interpret the residential artefact, no longer in its dimension of building object with a close and rigid configuration, but in the adaptive nature typical of the housing function, subjected to time transformations and users changes. The re-reading and re-writing process applied on the renovation practice represents therefore an important opportunity to develop a new technological, constructive and functional model that infers and subtend also a political revision of the current legislation, shifting towards an increase application of prefabricated and highly adaptable products that can allow an open re-definition of the building as a whole.

The possible application of these instruments to the energy renovation of residential building blocks, as multi-property realities where the possibility of investing for renovation is considerably low otherwise, offers a significant occasion to **reinterpret the legislative instrument** to use them as leverage in fostering the energy renovation. The existing European Energy Union together with the Energy Efficiency Financial Institutions Group should include in their agenda and in the EPBD framework a legislative structure for Add-ons as tool to foster energy renovation on a broader scale. The possibility of defining a surface and volumetric index that sets the maximum possible additional surface that in case of renovation it can be added to the existing surface to cover the upfront cost shall be set. As shown in the case study, the extra Add-on surface could be preliminary estimated as function of the selling potential of the Addition according to the market. In a broader vision, it is necessary to develop urban maps of the cities where the residual urban load of the cities is quantified through an urban index. The development of these maps could help planners and stakeholders in defining those areas where renovation through Add-ons could be feasible. It is suggested to consider the transferability of the current construction rights from agricultural land or periphery areas, partly into the existing consolidated areas where yet services could allow a controlled densification through additional volume on existing buildings. The volumetric Add-ons on the roof of the buildings, as infill or façade extension represent therefore a powerful design strategy not only to foster the refurbishment process, gaining the economic surplus necessary to overcome the existing economical and financial barriers but also an important occasion to sign a **turning point in land and urban development**, towards a new sustainable idea of planning and building smart cities.

Inhabitants tend to intervene on their dwellings given the inadequacy of the building in responding to environmental conditions. There is also an evident tendency in craving for ways to express their creativity and personal taste. In this attempt it is possible to recognize the different cultural background and the very poor level of adaptability and flexibility allowed by the original layout of the buildings. The proposal is based upon the idea of developing a collection of possible technological and formal solutions for the new envelope, the abacus as showed in a schematic representation for each case study, that should give the inhabitants the possibility to express their needs within a common order, respecting the guidelines of the project. From a **social perspective**, the typological and technological abacus have provided for each case study a sample of variation that could lead to a multi-variant definition of the new façade. The architects and planners define the different shapes of the panels that could fit within a large number of scenarios and at the same time could be produced in opened forms and configurations so to answer to a vast number of possibilities, as required by the vast housing stock and various user needs. In this terms, the abacus becomes one of the main design tools for planners and professionals involved in the process: it the catalogue of options among which the inhabitant can choose and will enrich the possibilities of synergies between the technical and sociological proposed strategies. The design approach, named **multi-variant design** and tested on the case study leads to multiple design outcomes and not one pre-fixed and over imposed result. The variation in function, materials and form of the new façade elements results in a balanced and coherent combination of the inhabitants' needs and the planners' intentions. The Add-on strategy is thus based on the assumption that it is possible to develop multi-variant design and multiple criteria analysis of a building refurbishment in order to enabled one to form up to 100,000 alternative versions.

Another significant impact that increases the effectiveness of the volumetric addition strategy as user-oriented methodology lies in the proposition that the end-user will deal with only one party, responsible for the total renovation, starting from an inventory of the existing situation, inventory of specific end-user demands, translation into modular renovation kits, mounting and installing, financing and aftercare. The individual interest of ordinary residents/end-users is mostly not focused on energy saving, but there are plenty desires for improving the houses, such as improving the indoor air quality, thermal comfort, to improve the acoustic quality, protection for burglary, etc. Many of these improvements are efficiently to combine and to integrate with energy saving measures. The standardised but flexible and multi-layered list of options for transformations included in the abacus (as shown in the project case study simulations) can be integrated with the production of the elements without compromising the main function.

Leaving the freedom to the users to express their preferences delivers also a procedural upgrade in the standard renovation plans and consistently reduces the risks of failures or bureaucratic slow downs. The proposed revision of the process proposed showed through the social survey conducted and the design outcome the potential of a direct involvement of the inhabitants in the design phase, bringing to light those **attractive nodes** that could be used as leverages in the realization phase to foster the inhabitants' consensus. In the Italian case study the core leverage has been represented by the enlargement and reorganisation of the kitchens, in the German case study the reduced energy consumptions resulting from the combination of the new Symbiont and the old building while in the Greek one the core social benefit consists in the integration of a flexible shading system included in the overall reorganisation of the balconies. The heterogeneity of those attractive nodes demonstrates that *a-priori* design solutions can not fit the purpose: it is crucial to place the users at the centre of the process to investigate and define the real needs of the buildings and foster the renovation especially in the realisation/negotiation phase. As the design schemes proposed for the case study show, the freedom of the design is left to the inhabitants and only control and supervise within certain formal boundaries that will be set by the architect, the style will be based upon randomness but not left to disorder: a controlled balance of the diversity and variation of the addition will be guarantee by the planning team and the computer-aided tools will be used as interface to control the variation.

The specific cost-benefit analysis carried out for the three case studies underlined the differences related to the construction markets and the different real estate trends. In fact, the payback time, in most of the case studies has been reduced below 3 years considering sustainable intervention scenarios with Add-ons above the limits dictated by the current regulation in Italy. It can be stated that the here presented methodology achieves a unit cost reduction up to 32%-38% compared to typical renovation. It is clear that the upfront costs of standard interventions are lower but it has also been proven that the profit given by the sale of the Add-ons significantly reduce the payback time beyond the 15-20 years as for standard renovation in case of incentives (light green) and beyond the 30 years as it would be in case of no Add-on and no incentives. The case study have shown that the beneficial effect of the Add-on depends on the existing market variance between the cost of construction and the real estate value as well as the energy prices and reduction potential. However, considering three different scenarios with opposite construction market trends (as for Greece and Germany) the strategy has proven to be effective and capable of **reducing the payback time to 1-3 years** and resulting in highly competitive investments. The NRV and IRR of the renovations as proposed at a schematic and conceptual stage, have indeed showed a real picture of the different markets the case studies are representative of. Among all the above highlighted results, it is of high significance, in the search for innovative financial and economical schemes to foster deep renovation, to have identified a methodology – the Add-on strategy - that could reduce to such an extent the return of investments for this type of intervention.

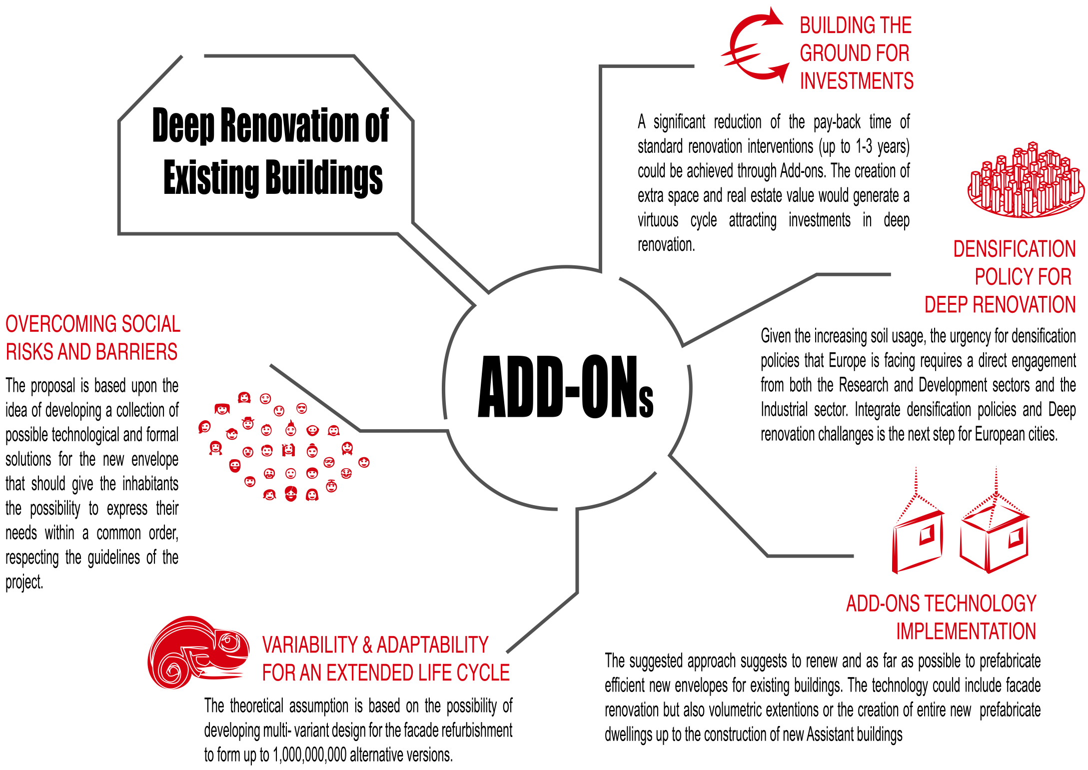

Fig. 1 Integrated Deep renovaton strategy based on Add-ons. The image shows the overall results of the research summing up the benefits presented in this thesis

6.2 Potential impact at EU level

The integrated and multi-purpose nature of the Volumetric Addition strategy determines the high level of effectiveness of the proposal. Moreover the consolidated knowledge used in the technical solution proposed and the combination of different products already available on the market in the definition of a new system.

By assessing and answering -in one prefabricated solution- to the energy, structural and fire safety needs, together with the possibility of integrating personalisation of the different components within the same mass produced product, this research opens to a methodological revolution in the renovation practice.

The research has a high **potential impact** on different target groups belonging to the main categories of private owners, market actors and policy-makers: owners/administrations of private and public buildings, building construction SMEs, RES market, ESCOs. This research has in fact identified new processes to accelerate the competitiveness and attractiveness of energy efficient measures in existing and deteriorated urban compounds.

In particular, the project implemented intersections and interactions between different -and often segmented- building market sectors to properly match the complexity of deep renovation in the existing buildings, find cross-fertilizing actions and win-win solutions for different requirements involved. As showed, this methodology has already been tested at European level in the design workshops carried in first in Kanaleneiland, Utrecht (NL, 2011) and in Corticella, Bologna (IT, 2014) and later in the comparative scenario here thoroughly described in Via Magenta, Reggio Emilia, (IT, 2015) and Mousonstrasse, Frankfurt am Main (DE, 2015), Peristeri Athens (GR, 2015). Those experiences allowed to calculate and estimate the potential impact resulting by the implementation of the Add-on strategy for Deep Renovation at national and international scale.

The comparison between the results of the design researches shows a very high degree of possible combinations: the design solutions have not been constrained to a simple prefabricated structure, indeed the need of developing modular and variable solutions has lead to a wide set of possible architectural, technical and structural configurations. The different façade abacuses that have been produced for these case studies represent the base for the development of a new construction system for the façade production. The design becomes a game with no specific rules[4] between technicians and inhabitants.

Ethnographic and cultural differences can be considered in the development of customized solutions to revision the envelope towards a more **culturally responsive skin**, keeping into account not only the performances aspects but also the cultural background of the inhabitants. The flexibility and interactive character of the proposed system shows the high potential impact on the social housing renovation market: through the application of one process, the revision of millions of building would be possible, not through standardized intervention but with user-driven and tailored solution, different for each building and each user. There are two main innovation contribution in this research. On one hand the attempt of combining computer-aided design and participatory approaches to enhance the technological and productive aspect seeking for a mass customization of the process that could foster the renovation of the entire building stock. On the other hand, the aspects connected to the densification strategy proposed based on prefabricated extensions within the same construction system that enables the facade renewal. By systematically consider the volumetric addition option in the renovation project it is in fact possible to open up a new architectural paradigm and to foster the investment process by reducing the pay back time, stretching the life cycle and increasing the real estate value of the buildings.

The Add-on strategy for Deep renovation has an impact on each one of the following fields :

[4] Friedman Y., Pro Domo, Actar Junta de Andalucia, Consejeria de Cultura, 2010

Time reduction	Add-on strategy **cuts down the construction times to one third if compared to present standard renovation** thanks to mass production and prefabricated systems. Standard energy renovation have construction times estimated around 6 months (including scaffoldings, insulation, window replacement and new plant installations), whereas through the presented technology it is possible to reduce the construction time down to 2 months and consistently cut the risks of delays and errors on site. Keeping into account the possible partial overlapping of all the different construction phases, the total estimated construction time in standard renovation is about 9-12 months. The proposed system allows a reduction of the construction time down to 3-4 months in total.
Energy reduction	The energy performances that can be obtained through the Add-on strategy go beyond the standard renovation targets. The horizon for the proposed deep renovation looks at the possibility of setting to **Nearly Zero Energy consumptions** the buildings; through integration of envelope renovation the current energy consumptions are reduced down to 25 kWh/m^2. The application of RES systems, directly integrated in the prefabricated elements for the renovation or on the rooftop as shown in the Case studies, allows to bring down to the zero target the energy consumptions of the buildings. In a long term perspective, considering the LCA calculated on a lifespan of the building of 25 years, maintenance and replacement cost for a traditional renovation and integrated addition renovation are accounted for 150 euro/m^2 in both case[6].
Social engagement	Through the potential social benefit that the project has show it is possible to count on an increased participation from the inhabitants and on a substantial growth in the consensus. The multi-variant design as proposed in the case study could represent a trigger to engage an inter-active dialogue with the inhabitants. The effectiveness in the proposal lays in the possibility of implement the number of renovation that actually reach the construction phase, overcoming the procedural and social barrier that has been identified as one of the major existing barriers.
Cost reduction	It can be stated that the here presented methodology achieves a unit cost reduction up to 32%-38% compared to typical renovation. The construction costs are reduced as well as the relocation of inhabitants, which is no longer necessary in case of Add-on renovation through prefabricated elements. The actual cost reduction, comparing standard renovations and Add-ons renovation, per square meters, is about 16.5%. Moreover, it is significant to also consider the added value - in economic terms - consisting in the extra surface generated by the proposed system. The real estate increased unit value has been evaluated around 130-250 euro/m^2 depending on the different regional markets. It is clear that the upfront costs of standard interventions are lower but it has also been proven that the profit given by the sale of the Add-ons significantly reduce the payback time beyond the 15-20 years as for standard renovation in case of incentives (light green) and beyond the 30 years as it would be in case of no Add-on and no incentives.

Tab. 1 The table reports the potential impact of the strategy proposed in terms of time, cost and energy reduction

[6] New steel structure require high maintenance cost that balance the costs of maintenance of the standard renovation

6.3 Limits and barriers of the Add-ons strategy

The volumetric addition strategy here proposed aims, inter alia, at overcoming the technical, legislative and financial barriers to the adoption of deep renovation and nZEB retrofitting of existing buildings through the strategy of the assistant buildings' additions. The limits and critical aspects have been evaluated from a series of different perspective, considering the multi-sectorial approach proposed in this research – especially sociological, organizational, economics and business. The barriers to the diffusion of innovation are multifaceted phenomena; there are **general barriers connected to the European energy framework**, **industry-based barriers** and also **project-based barriers**.

In general terms, the diffusion of the new methodology and strategy as proposed by the means of including volumetric addition for energy renovation projects could encounter problems related to: human resources, organizational structure, construction culture and decision process, local and governmental restrictions, market context, industry characteristics, communication channels and social networks, technical attributes of innovation, economic attributes of the innovation and supplier characteristics. As already mentioned, above all the major barrier is determined by the existing lack of a proper European regulation on the subject and the different country regulation allow certain type of intervention without specifically refer to the proposed strategy.

There is a clear lack of ambition on energy efficiency in the 2030 Climate and Energy Package where the target is an indicative, EU level 27% (at least). This is far below the cost effective level shown by a detailed Fraunhofer Study published in 2014 on the topic, which demonstrated that a 40% target is the cost-effective level for 2030. One of the concerns is the modelling used by the Commission in its Impact Assessments where the discount rate has been unrealistically high. A different scenario has to be underlined in order to have a significant impact on the upcoming legislative directives or rather European Member states will not be provided with the necessary instruments to engage a real turn around in Energy Efficiency policies.

A second concern is how the targets are set in the 2030 framework and how will the objectives of the Energy Union Framework be monitored and checked. The key question is what happens if the Member States do not propose measures that are adequate enough to add up to the agreed target? Beyond these aspects, the concern regards the slow progress that is being made at Member State level in implementing the key energy efficiency directives. There is a widespread lack of awareness among national stakeholders of the potential of these directives and a low level of ambition in the Member State administrations in the manner in which they implement the EU requirements. And it goes further to a palpable lack of understanding of the multiple benefits of energy efficiency programs and hence a lack of buy-in at the highest political levels.[18]

Industry-based barrier are connected to the innovation adopter's cost-benefit perspective[19] since generally the high costs of adopting the new technology slow down the diffusion process. This not only includes the price of the acquisition, but more importantly the cost of the complementary investment and learning required to make use of the technology. In case of the proposed strategy the two aspects underlined during the research have to be considered: 1. The behavioural economic, considering therefore those benefits that go beyond the merely economic and financial return of the investment; 2. The consistent reduction of the short-term investment ensured by the real estate value of the additional units created and evaluated as new surface. Chakravorti[20] argues that the successful innovation diffusion requires development and market equilibrium, condition that can hardly be compared to the current market condition in Europe. This equilibrium in the energy renovation sector might occur when each stakeholder makes a choice that they consider to be the best one, based on the

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[18] Ibid.
[19] Rogers, E. M. 2003. Diffusion of innovations (5th ed.). New York, NY: Free Press.
[20] Chakravorti, B. 2003. The Slow Pace of Fast Change, Harvard Business School Press, Cambridge, MA.

alternatives available and the different interests. Therefore, to guarantee the success of the proposal, enough stakeholders must choose the Add-on strategy, increasing coordinated use.

Moreover, technology advocates are important in the diffusion of the suggested residential building technologies[21]. However, the acceptance of new technologies and materials ultimately depends on meeting consumer and builder needs better than with existing technologies and materials. The possibility left to the final users to discern and enact which solution best fits their need during the renovation project, involves the inhabitants from the very beginning of the planning process. This methodology and its innovation are therefore tightly bonded with users satisfaction and its main goal consists in better responding to the final user than other existing approaches whose failure lies in fact in the missing consensus. Recent studies conducted by Rennings et al.[22] have examined construction innovation diffusion barriers. The authors state that technological uncertainty is a key barrier for the implementation of new technologies and systems. The new technologies shall indeed compete and integrate the "old" technologies in order to overcome the barrier. Often a less convenient technological system has been successful in technological evolution in construction due to its advantages in standardization, the possible economy scale and reproducibility of the technology. As demonstrated the proposed method is exclusively based on existing technologies and materials in order to ensure the integration of the new system with the traditional practice. The innovation stands in a new procedural methodology and in the creation of a programmatic application of the Add-on strategy to the Deep renovation market as tool to overcome the existing barriers.

Furthermore, the proposal seeks for a unified process highly standardized where the risk for mistakes and delay are minimal. The differentiation of works and expertise has been reduced in order to appoint one single contractor (possibly also responsible of the financial and economical contracts such as ESCOs) that is able to control the construction phase and ensure rapid

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[21] Koebel, C.,T., Papadakis, M., Hudson, E., Cavell, M. 2004. The Diffusion of Innovation in the Residential Building Industry, U.S. Department of Housing and Urban Development Office of Policy Development and Research
[22] Rennings K., Markewitz P., Vögele S. 2010. "Why Radical Innovations Fail: The Case of Technological Change in German Coal-Fired Power Plants", African Journal of Science, Technology, Innovation and Development (AJSTID), Vol. 2, No. 1, pp. 10-36.

construction and management. This approach significantly reduces the disturbances for the inhabitants. The highly replicable and standardized nature of the technical solutions at the base of the Add-ons ensures the success of the methodology.

However it is true that the construction culture industry lacks of innovation when compared to our industrial fields and has shown its inadequacy in keeping pace with the societal innovation rhythm. This barrier becomes even more sever when considering that local building officials and public administrations could discourage the use of Add-ons since not explicitly permitted by building renovation. The most concrete barriers are thus represented by the legislative framework and, as above already mentioned, its rigidity together with the lack of clear, crosscutting and innovative European directive on the subject. Once again it becomes clear that the shift in building codes and the call from the European authorities to develop specific and appropriate legal instruments to regulate Add-on interventions as well as other innovative and strategic renovation schemes is vital to ensure the applicability, replicability and development of a concrete upgrade of the existing building stock.

6.4 Further steps of the research and future scenarios

The future efforts to further develop and implement the Add-on strategy in the deep renovation market could be grouped in three main directions:

1. Building Information Modelling (BIM) implementation for deep energy renovation through Add-ons
2. Investigate and quantify the structural potential of the Add-on strategy as to improve the existing structural behaviour of the existing buildings, with special regards to seismic performances
3. Develop an open source platform to collect the inhabitants data and to translate the multi-variant design into an inter-active digital tool

The production process of components in off-site factories, their supply to the construction site, and the onsite assembly procedures could be optimized following a BIM-based process in order to maximise the workflow and project efficiency. Many firms are already using BIM design to collaborate with general contractors and construction managers to automate production and prefabricate building components such as mechanical equipment and curtain-wall systems[27]. As possible future scenario of the research, BIM could be exploited as a pipelined process among researchers, designers, managers, engineers, architects and contractors, sharing a common

[27] Computers have gradually integrated the process of the traditional methodologies where buildings were represented by surveys, mainly carried out by direct measurements, annotations and eidotypes due with data mining on databases made of different media; this potential has been expanded, since information is now hierarchically embedded into three-dimensional models, which can be digitally explored by means of queries or visual navigation. The information required in the design, construction and operation of facilities from their inception onward, is nowadays based on computer-generated models containing accurate geometry and relevant data needed to support the whole lifecycle of buildings. This concept refers to as Building Information Modelling, as pointed out by Charles Eastman (Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2008). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. Hoboken, NJ: John Wiley and Sons).

language made of digital representations[28] that will be paramount to coordinate on site construction works as well[29]. Dealing in particular with the existing building, key point for the selected case study, accurate surveys performed using Terrestrial Laser Scanning (TLS) and state-of-the-art digital photogrammetric algorithms (Structure from Motion, SfM) will support the investigation, providing knowledge materials useful to the modelling stage[30]. This is an innovative application of a consolidated process generally dedicated to new facilities, even if very little scientific literature has already been written about BIM on the existing domain. Also advanced practitioners still struggle to implement BIM beyond the generation of standard survey drafts, albeit it could guarantee high productivity gains and long term benefits[31]. The **application of the Add-on strategy to the BIM methodology** will lead to the ability to model any geometry connected with a complete management of relations among building's components, in order to guarantee the model consistency during the whole design process of the facility's extension; the opportunity to test different decisions from concept onwards (also in a late stage of the design development or during the construction phase) according to the inhabitants wishes; iii)the optimal retrofit for renovation, restoration or maintenance activities ; iv) the definition of a versatile "as-built" information system, generated before the delivery through the editing of BIM models to update them with building annotations and construction modifications. To date, in fact, there is no standardized method for updating a design model to reflect changes made during construction.

Available **advanced technologies** in the field of deep and facade renovation have already been applied to a large number of buildings in the centre and northern Europe thanks to also a

[28] These aspects were considered in many scientific works, even if main references can be found in Young, N. W. Jr., Jones, S. A., & Bernstein, H. M. (2008). *Building Information Modeling (BIM): Transforming Design and Construction to Achieve Greater Industry Productivity*. New York, NY: McGraw-Hill.

[29] In fact, by virtue of its nature, BIM strategies and federated digital models will be authored to favour a coordinated, consistent and always up to date process among actors, strongly supported by software tools continuously improved in order to reach quality, reliability, optimized scheduling, costs reduction together with avoidance of any possible project misinterpretation.

[30] Garagnani, S. (2015). "*Digital semantic modeling for the Cultural Heritage: integrated representation of real architecture*". In S. Brusaporci, "Handbook of Research on Emerging Digital Tools for Architectural Surveying, Modeling, and Representation", Vol. II, IGI Global Publishing (pp. 292-310).

[31] Bogus, S.M., Molenaar, K. R., & Diekmann, J. E. (2005). Concurrent Engineering Approach to Reducing Design Delivery Time. In *Journal of Construction engineering and management*, press release, November 2005.

large number of financed European project referenced in this work. Unfortunately, the same cannot be said for Southern and Eastern Europe, especially considering those countries where building regulation on structural safety are tightly bonded to the **seismic safety**. This represents another crucial aspect that needs to be tackled in the future steps of the research. Acting through façade (total or partial) substitutions as well as introducing roof top addition in order to contain the costs of the renovation are examples of strategies that still cannot be fully exploited in their wide range of typological forms as exposed in this work in those European regions with high seismic risk rate. The Italian and the Greek case study have confirmed the impossibility of proceeding through rooftop Add-ons for structural safety reasons. One of the main future steps of the research is to open up the potential of those strategies also in those contexts, integrating the energetic aspects with the seismic safety and social emergencies that building blocks are facing in countries like Italy, Greece, Romania etc.

The **structural system** proposed for the Add-ons introduces a metal structure with efficient stiffness, however, applied externally to the existing structure, with benefits in regarding the construction site, since it does not require the performance of special operations inside the buildings. The installation is less complicated than that of the walls in reinforced concrete and the need of foundation is significantly lower, with a significant reduction in terms of cost of the base/profound structure. For the advantages of increased rigidity and the consequent reduction of displacement, the system increases the number of vertical elements on which are distributed the horizontal forces due to seismic action, with consequent reduction of the shear stresses on the individual pillars of the existing structure of reinforced concrete. The element of great importance for the system is the bond that can link the existing structure in reinforced concrete and the new metal structure. Preliminary structural and seismic simulations FEM software (EN 1998) carried on the Greek case study have shown an overall potential reduction of horizontal displacements and stresses of the retrofitted structures with a percentage up to the 50%. Further research to analyse the potential of the strategy as technical solution that improves the structural safety of the buildings subject to renovation could therefore increase the number of buildings that could benefit of the technology all around Europe and at the same time extend the advantages of the Add-ons also to structural aspects.

Finally, it is important to underline that the highly potential approach for Deep Renovation requires a powerful and international dissemination strategy to break through a real revolution and overcome the existing frictions existing in the process. In particular the social survey and the data collections carried during this work, have been extremely time consuming and not as effective as the process would require. The search for a method to communicate the possible design options to the inhabitant suggests that a further step to implement the Add-on strategy could be the development of an application for smart phone and tablets that could be downloaded directly by the users and 'speak' an easy and understandable language, translating the design process into a common practice.

Dwellers and human being are different and more and more our multi-cultural society cannot fit with homogenous and standardized forms and schemes. More and more inhabitants tend to intervene on their dwellings given the inadequacy of the buildings in responding to environmental conditions. There is also an evident tendency in craving for ways to express their creativity and personal taste in turning a mere housing unit into a home. In this attempt it is possible to recognize the different cultural background and the very poor level of adaptability and flexibility allowed by the original layout of the buildings. Top-down actions usually ignore the dynamics of users needs variability, and often result in standardized spaces. As shown through the case studies, the existing barriers that are slowing down the process of renovation of our suburbs could be overcome by a proper transition from a merely technical approach towards an integrated socio-oriented perspective. The idea is to communicate the 1,000,000 possible façade transformations directly to the inhabitants and let them play with them, controlling the results but not imposing a choice, leaving the users free to decide what to do, to improve their apartments within the proposed options. Through an Internet portal that could become an application for smartphone, the DesignITapp, users will be asked to insert data regarding their habits and wishes to find out the existing conflicts between the buildings and their needs. A first set of façade transformation options will be displayed and the inhabitant will 'play' the role of the architect, experimenting the different solutions and changing them on the screen of their smart phones. The theories and visions of many thinkers of the past regarding the possible interaction between machine and users in designing housing could today find their proper means of expression in the most recent technological and network innovations.

The **DesignITapp** has been structured and preliminary constructed in order to set the basis for the next possible implementation of the Add-on strategy at the digital level. DesignITapp could indeed provide a constant review of the choices that the inhabitants might take, the basic and overall order set by the planners will be guiding the entire self-planning system. In some ways it could become a modern version of the Flatwriter that Friedman has envisaged. The different façade components as presented in the abacus of the multi-variant design could be presented to the users with their specific energy performance indicators, economic payback previsions, material-colour variations and possible suppliers. The façade choice made by the user will then be evaluated through a grading system made of the mathematical average scores among three levels: grate of performance (EnScore), grade of price (EnEuro), grade of correspondence with the user need (EnYou). The scheme at the base of the parametric code ensures a cross checking with the choices of the other users in the building, at the three scales defined by the cells, as explained above. One specific solution is never fitting with all the others: there are only a certain number of possible combination paths for each solution upon the rules and boundaries set by the planner, thereforethe warning error will be displayed in the decision making phase when inappropriate combinations occur. The proposal is based upon the search for a system and algorithm that allows a series of design with a core invariant system and multiple outputs.

The current society, social media and digital oriented, requires a revision of the methods so far used in standard participatory designs (such as questionnaires) in favour of more contemporary and direct tools. Through an online open source platform the Add-on strategy could reach a larger number of users and benefits from the internet and global market involving a larger number of case studies and also rapidly fostering the necessary legislative revolution.

The goal is to re-interpret the evolutionist theories presented in this work to improve socio-technical environments in the specific contexts of energy retrofitting, collaborative learning, and architecture technology.

The presented methodology provide thus planners with new multi-variant design tools, inhabitants can test the different options through an easy and direct application on their smart phones, evaluate them and chose the best option. Project managers are entitle of checking and guiding the entire process and guarantee an overall order that stands at the base of the process. The proposal consists in a **digital revolution** for the renovation practice to overcome the existing barriers and foster the entire renovation of social housing practice in Europe.

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ANNEX 01

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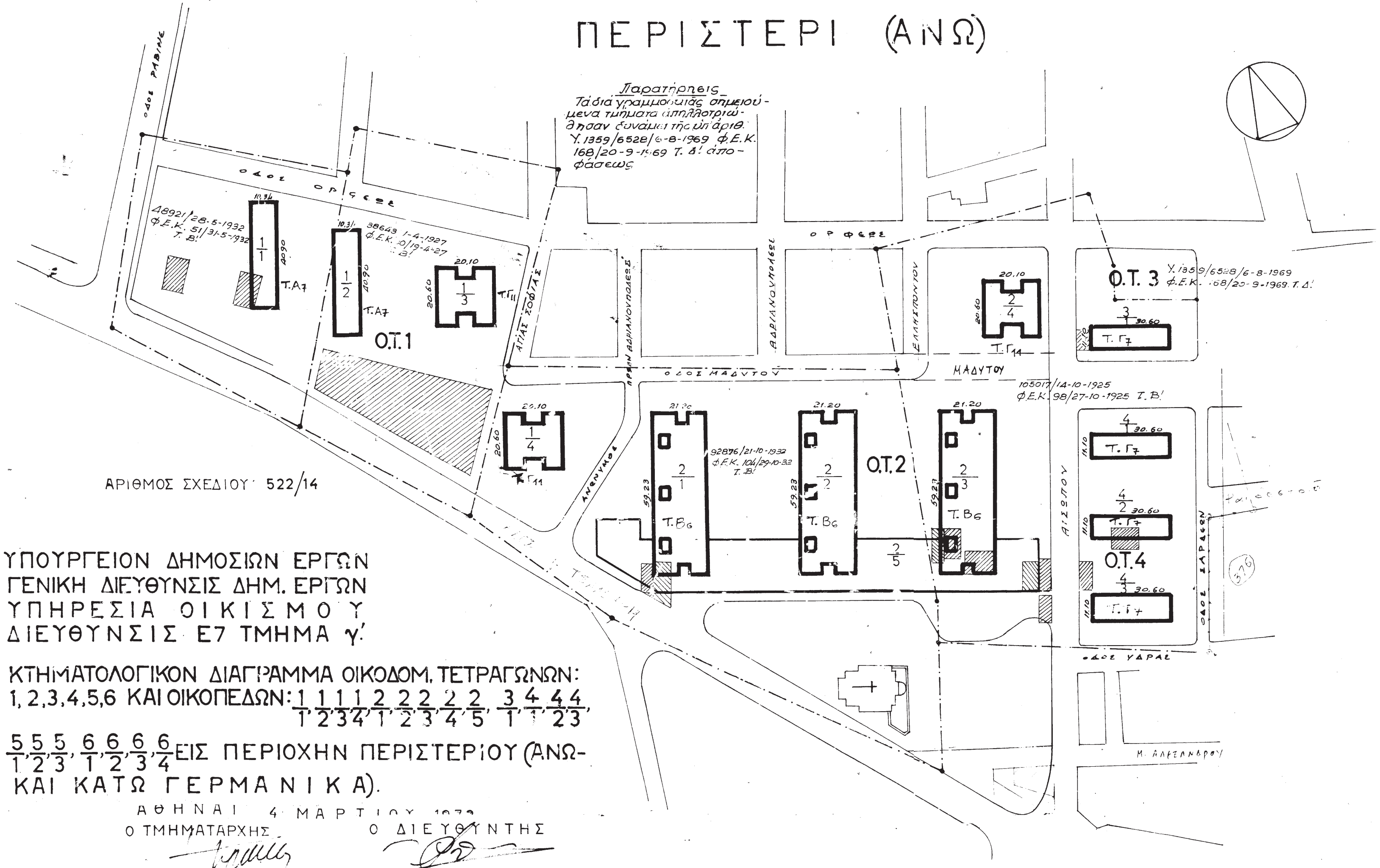
Ὑπουργεῖον Κοιν. Ὑπηρεσιῶν
Δ/νσις Τεχν. Ὑπηρεσιῶν
Τμῆμα Τοπογραφήσεω



ΑΡΙΘΜΟΣ ΣΧΕΔΙΟΥ 522/14

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ΓΕΝΙΚΗ ΔΙΕΥΘΥΝΣΙΣ ΔΗΜ. ΕΡΓΩΝ
ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ
ΔΙΕΥΘΥΝΣΙΣ Ε7 ΤΜΗΜΑ γ'

ΚΤΗΜΑΤΟΛΟΓΙΚΟΝ ΔΙΑΓΡΑΜΜΑ ΟΙΚΟΔΟΜ. ΤΕΤΡΑΓΩΝΩΝ: 1, 2, 3, 4, 5, 6 ΚΑΙ ΟΙΚΟΠΕΔΩΝ: $\frac{1}{1}, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{2}{1}, \frac{2}{2}, \frac{2}{3}, \frac{2}{4}, \frac{2}{5}, \frac{3}{1}, \frac{4}{1}, \frac{4}{2}, \frac{4}{3}, \frac{5}{1}, \frac{5}{2}, \frac{5}{3}, \frac{6}{1}, \frac{6}{2}, \frac{6}{3}, \frac{6}{4}$ ΕΙΣ ΠΕΡΙΟΧΗΝ ΠΕΡΙΣΤΕΡΙΟΥ (ΑΝΩ- ΚΑΙ ΚΑΤΩ ΓΕΡΜΑΝΙΚΑ).

ΑΘΗΝΑΙ 4 ΜΑΡΤΙΟΥ 1972

Ο ΤΜΗΜΑΤΑΡΧΗΣ
Ε. ΤΡΕΠΕΚΛΗΣ

Ο ΔΙΕΥΘΥΝΤΗΣ
ΑΝ. ΡΟΓΚΑΝ

ΕΘΕΩΡΗΘΗ
Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΗΣ ΥΠΗΡΕΣΙΑΣ

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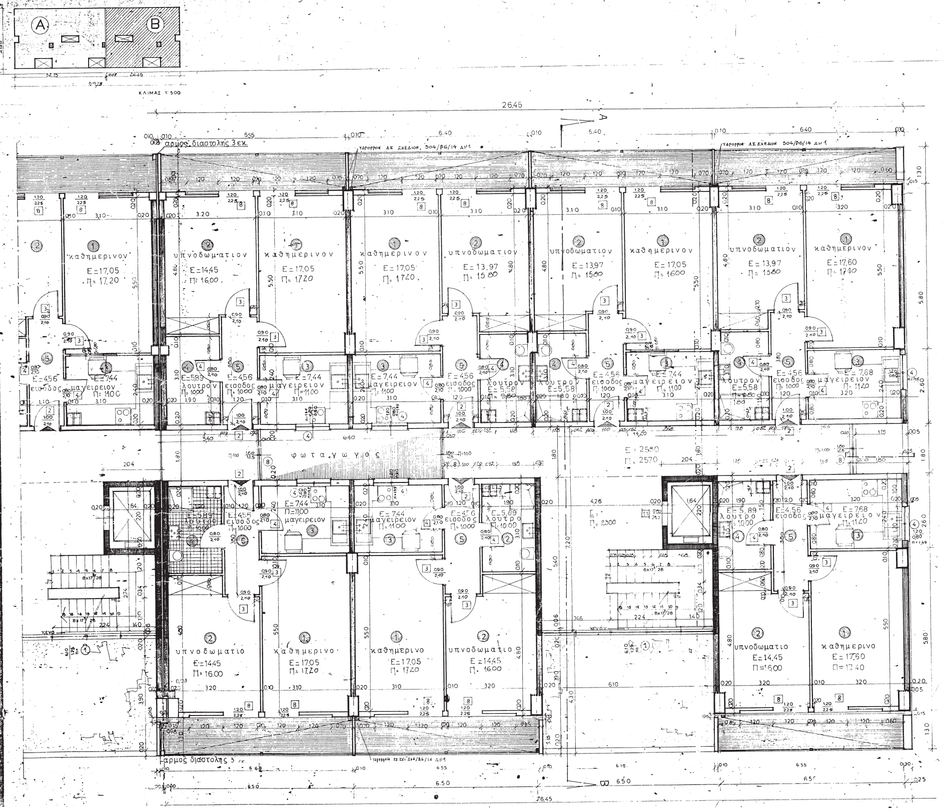
ΤΥΠΟΣ Β6



1 καθημερινον
2 υπνοδωματιον
3 μαγειρειον
4 λουτρον
5 εισοδος

Β6

ΑΝΑΘΕΩΡΗΣΙΣ ΑΠΡΙΛΙΟΣ 1970

Τροποποίησις ἀφορῶσα εἰς
1) Τὴν θέσιν τῶν ὑδρορροῶν ἐπὶ τῶν ἐξωστῶν
2) Τὴν τοποθέτησιν κιγκλιδώματος εἰς τὸ πλατύσκαλον τῆς κλίμακος

Ο ΑΡΧΙΤΕΚΤΩΝ	Ο ΕΛΕΓΞΑΣ	ΕΘΕΩΡΗΘΗ
Τ. ΣΑΠΟΥΝΑΚΗΣ	Ε. ΤΡΕΠΕΚΛΗΣ	ΑΧ. ΣΠΑΝΟΣ

ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ ΔΙΕΥΘΥΝΣΙΣ Ε7			
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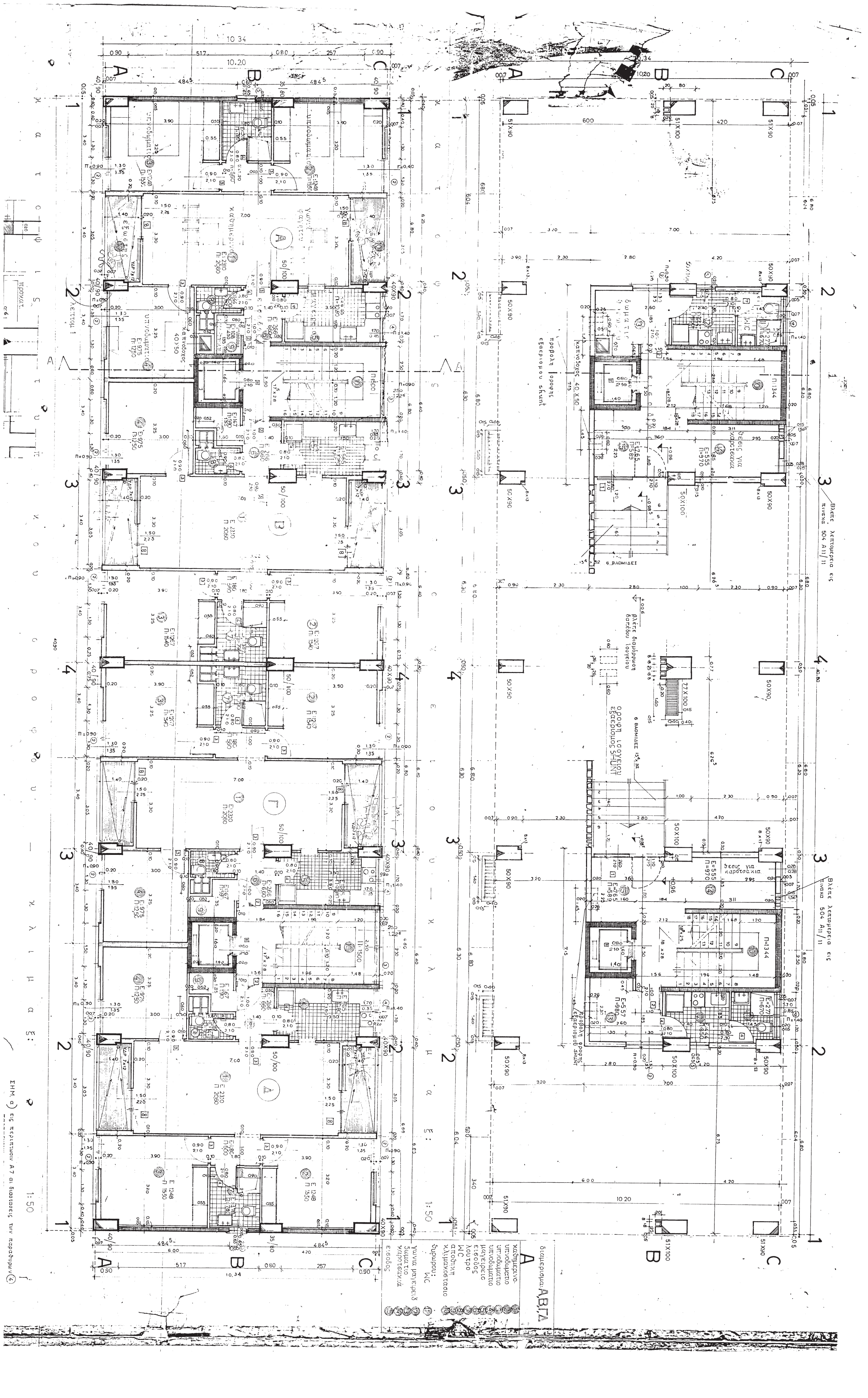
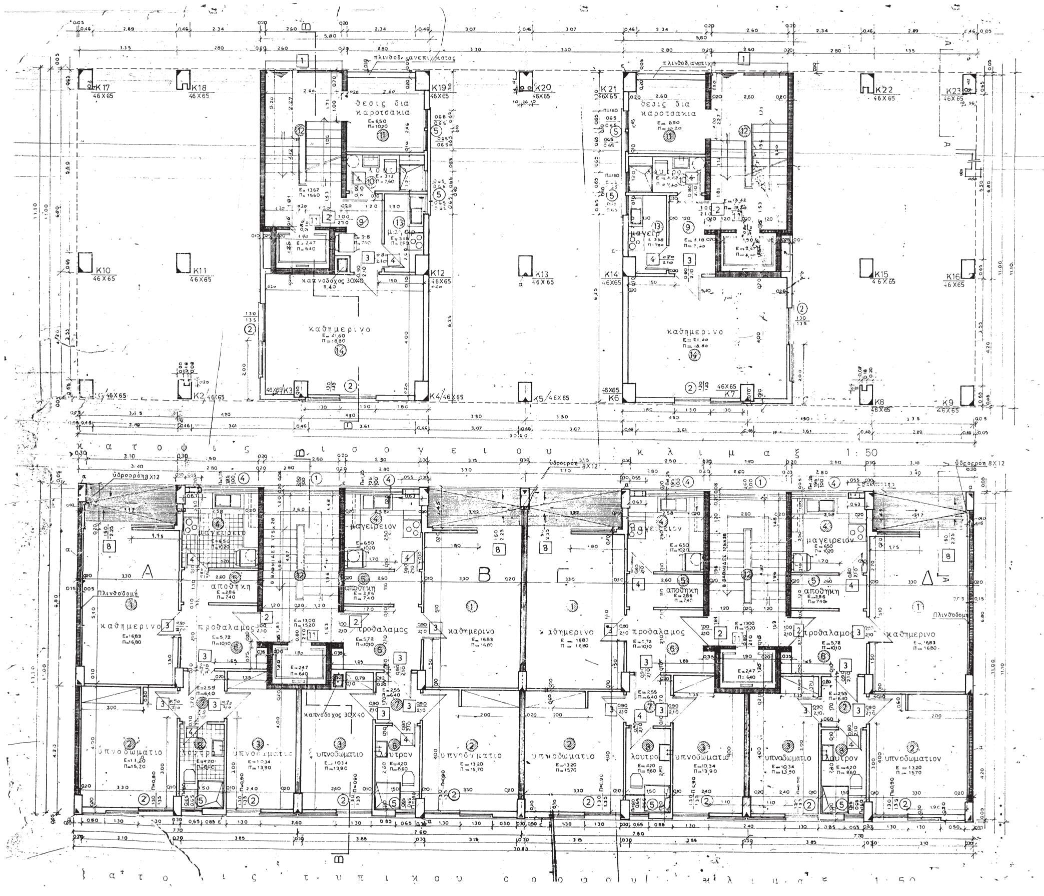
24.5.69.
ειδοποιήθη



Γ7



διαμερισματα Α,Β,Γ,Δ

καθημερινο 1
υπνοδωματιο 2
υπνοδωματιο 3
μαγειρειο 4
αποθηκη 5
προθαλαμος 6
διαδρομος 7
λουτρο 8

θυρωρειο

διαδρομος 9
λουτρο 10
χωρος δια καροτσακια 11
κλιμακοστασιο 12
μαγειρειο 13
καθημερινο 14

Αριθμός δωματίου 1

Αριθμός παραθύρου 1

πιναξ διαστασεων υποστυλωματων

οροφος	K1 K9	K2 K8	K3 K7	K4 K6	K5	K10 K16	K11 K15	K12 K14	K13	K17 K23	K18 K22	K19 K21	K20
1ος	30x55	30x50	30x50	30x50	30x50	30x55	45x65	45x65	45x65	30x55	30x50	30x50	30x60
2ος	30x50	30x45	30x50	30x45	30x45	30x50	40x65	40x65	40x65	40x65	30x45	30x45	30x55
3ος	30x45	30x40	30x40	30x40	30x40	30x45	40x55	40x55	40x55	30x45	30x40	30x40	30x45
4ος	30x40	30x35	30x35	30x35	30x35	30x40	35x50	35x50	35x50	30x40	30x35	30x35	30x40
5ος	30x30	30x30	25x30	30x30	30x30	30x30	30x40	30x40	30x40	30x30	30x30	30x30	30x30
6ος	30x30	30x30	25x25	30x30	30x30	30x30	25x35	25x35	25x35	30x30	30x30	30x30	30x30

ΑΝΑΘΕΩΡΗΣΙΣ ΑΠΡΙΛΙΟΣ 1970

Τροποποιησιν αφορωσα εις

1. Τοποθετησιν πτεριγιου θεμελιωσεως ισογειου στοας
2. Ενσωματωσιν γαλβανισμενων υδρορροων εξ εντα υποστυλωματα ισογειου

O ΑΡΧΙΤΕΚΤΩΝ O ΕΛΕΓΞΑΣ ΕΘΕΩΡΗΘΗ

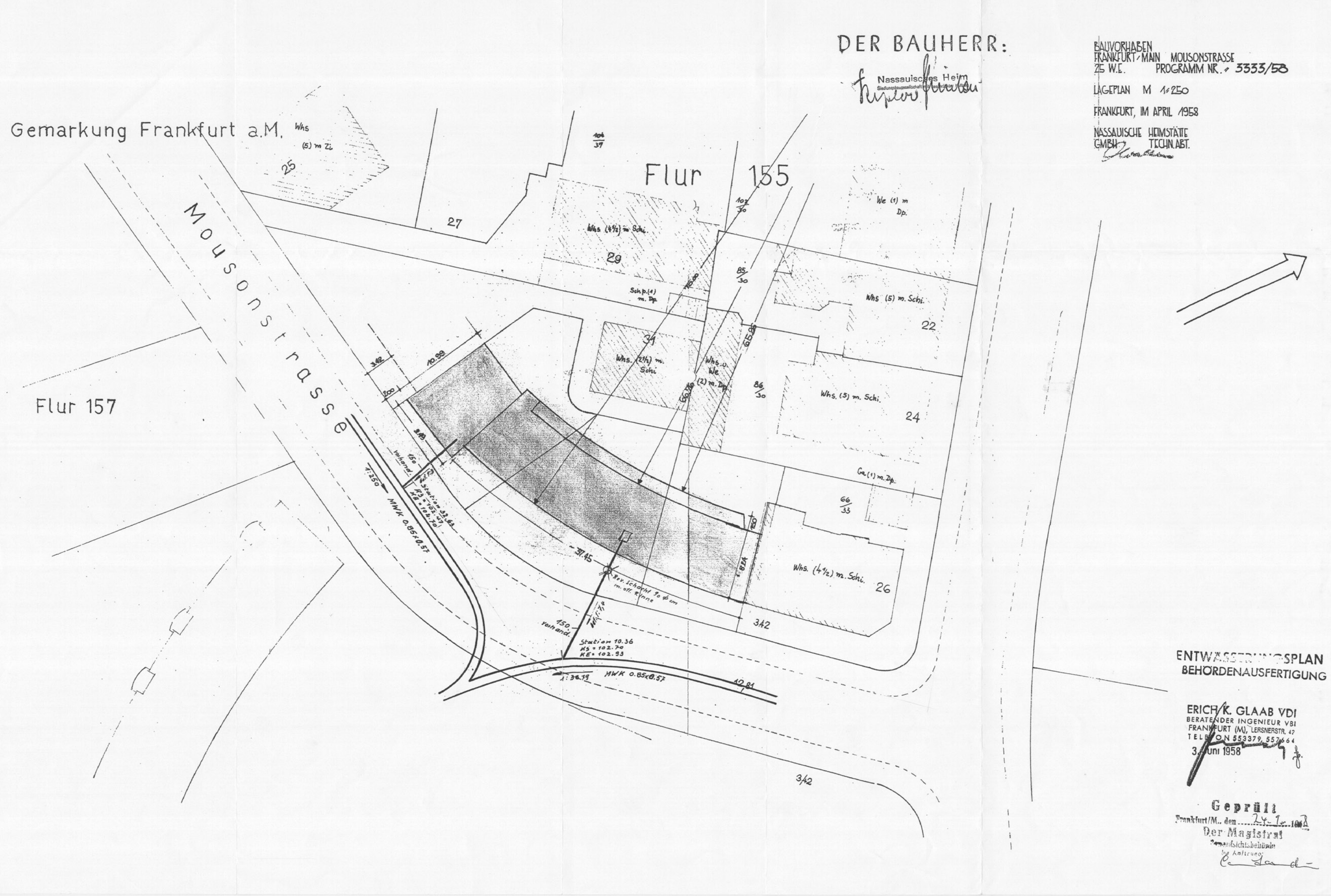
Τ. ΣΑΠΟΥΝΑΚΗΣ Ε. ΤΡΕΠΕΚΛΗΣ ΑΧ. ΣΠΑΝΟΣ

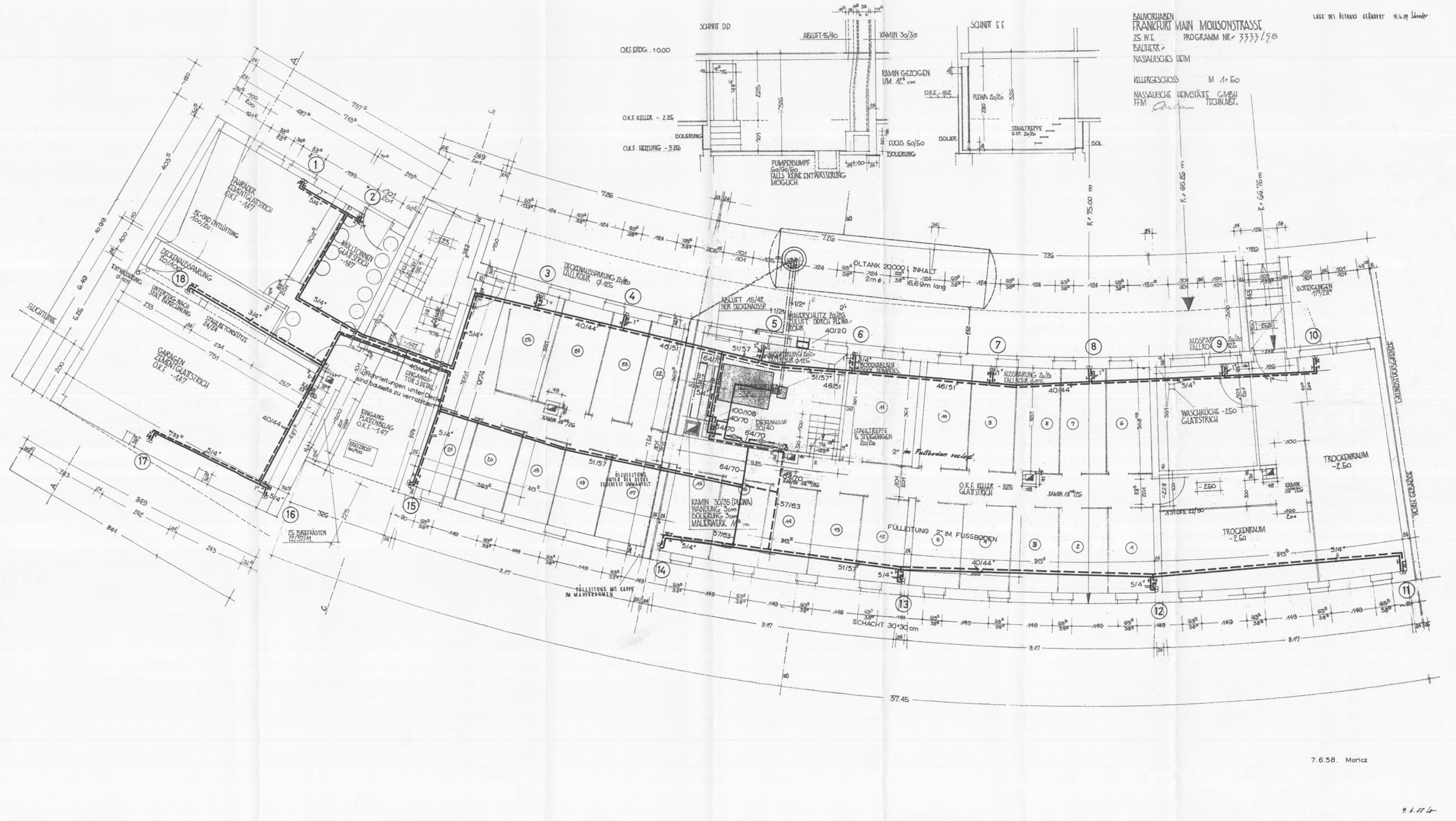
ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ ΔΙΕΥΘΥΝΣΙΣ Ε7			
ΜΕΛΕΤΗ	ΠΟΛΥΚΑΤΟΙΚΙΑ ΤΥΠΟΥ - Γ7		
ΤΕΥΧΟΣ	ΣΧΕΔΙΑ ΚΑΤΑΣΚΕΥΗΣ		ΑΡ. ΣΧ. 504/Γ7/1/Α
ΘΕΜΑ ΠΙΝΑΚΟΣ	ΚΑΤΟΨΙΣ ΙΣΟΓ. & ΤΥΠ. ΟΡΟΦ.		ΚΛΙΜΑΞ 1:50
Ημερομηνια	Ο ΑΡΧΙΤΕΚΤΩΝ Ο. ΣΥΓΚΟΥΡΙΑΔΟΥ	Ο ΣΧΕΔΙΑΣΑΣ Ε. ΛΑΜΠΙΡΗ	Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΟΥ ΤΜΗΜΑΤΟΣ Ε7γ Ε. ΤΡΕΠΕΚΛΗΣ
ΑΠΟΦΑΣΙΣ ΥΠΟΥΡΓΟΥ Ε.200 40/1781/ 6/6/69	ΘΕΩΡΗΣΙΣ		
	Ο ΔΙΕΥΘΥΝΤΗΣ ΑΧ. ΣΠΑΝΟΣ		Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΗΣ ΥΠΗΡΕΣΙΑΣ Ι. ΒΑΣΙΛΕΙΟΥ
ΕΦΑΡΜΟΓΗ 1) 2) 3) 4)	ΕΓΚΡΙΣΙΣ Ο ΓΕΝΙΚΟΣ Δ/ΝΤΗΣ ΔΗΜ. ΕΡΓΩΝ Α. ΚΟΡΚΟΛΟΠΟΥΛΟΣ		

29-5-69
αυθημερον

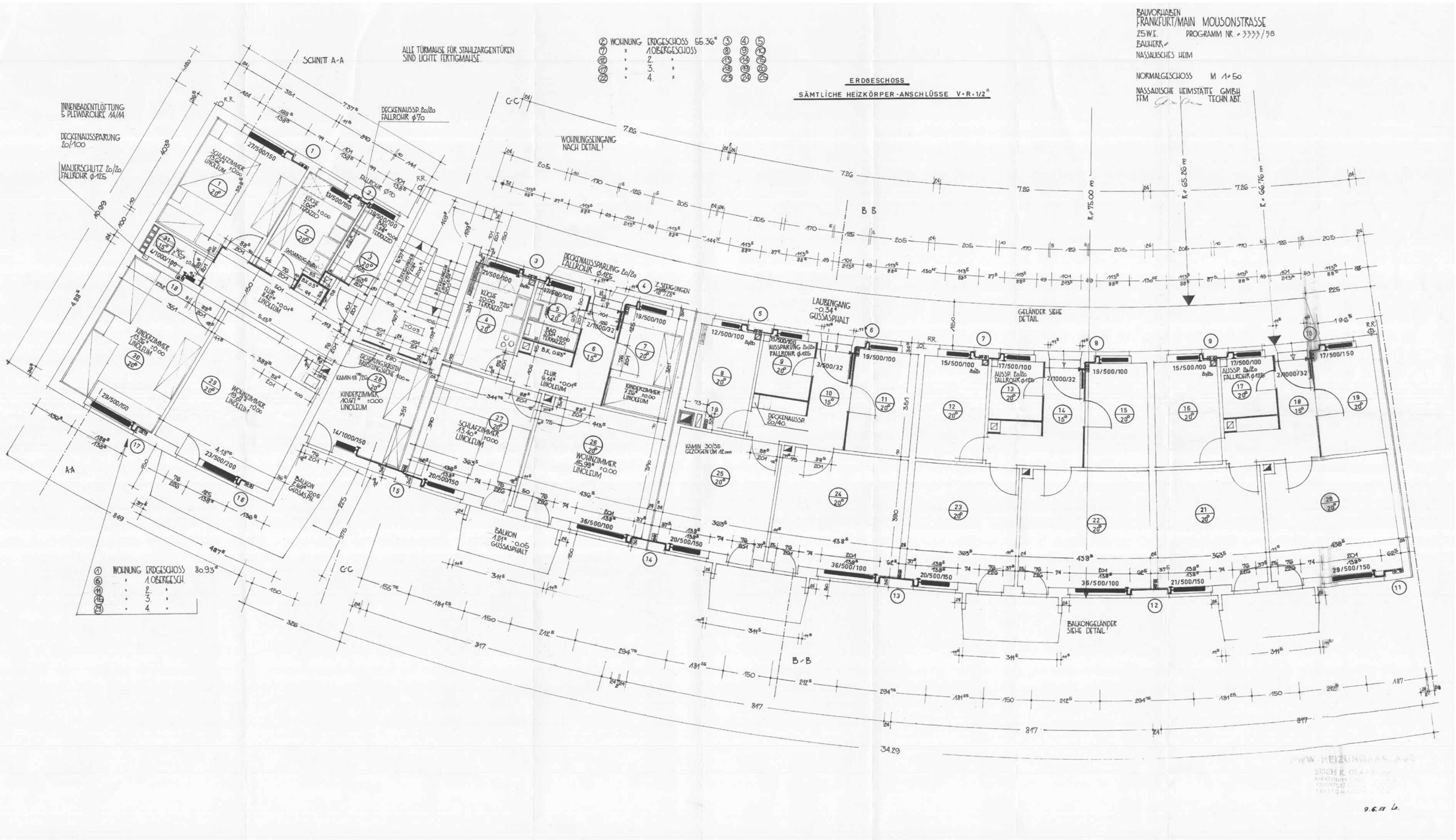
Γ7

396


DER BAUHERR:
Nassauisches Heim
BAUVORHABEN
FRANKFURT/MAIN MOUSONSTRASSE
25 W.E. PROGRAMM NR. 3333/58
LAGEPLAN M 1:250
FRANKFURT, IM APRIL 1958
NASSAUISCHE HEIMSTÄTTE
GMBH TECHN.ABT.
Gemarkung Frankfurt a.M.
Flur 155
Flur 157
Mousonstrasse
Whs (5) m Zi
25
27
29
31
22
24
26
Whs. (4½) m. Schi.
Whs. (2½) m. Schi.
Whs. (5) m. Schi.
We (1) m Dp.
Ga.(1) m. Dp.
MWK 0.85/0.57
Station 10.36
3/42
ENTWÄSSERUNGSPLAN
BEHÖRDENAUSFERTIGUNG
ERICH K. GLAAB VDI
BERATENDER INGENIEUR VBI
FRANKFURT (M), LERSNERSTR. 47
3. Juni 1958
Geprüft
Frankfurt/M., den
Der Magistrat



BAUVORHABEN
FRANKFURT MAIN MOUSONSTRASSE
25 W.E. PROGRAMM NR. 3333/58
BAUHERR:
NASSAUISCHES HEIM
KELLERGESCHOSS M 1:50
NASSAUISCHE HEIMSTÄTTE GMBH
FFM TECHN.ABT.
LAGE DES ÖLTANKS GEÄNDERT 15.4.59 Schrader
SCHNITT DD
SCHNITT EE
O.K.F. ERDG. ±0.00
O.K.F. KELLER -2.25
O.K.F. HEIZUNG -3.35
KAMIN 30/35
KAMIN GEZOGEN
PUMPENSUMPF
FALLS KEINE ENTWÄSSERUNG MÖGLICH
ÖLTANK 20000 l INHALT
GARAGEN
ZEMENTGLATTSTRICH
MÜLLTONNEN
GLATTSTRICH
EINGANG
PLATTENBELAG
TROCKENRAUM
WASCHKÜCHE
FÜLLEITUNG 2" IM FUSSBODEN
O.K.F. KELLER -2.25
GLATTSTRICH
STAHLTREPPE
SCHACHT 30/30 cm
GRUNDSTÜCKSGRENZE
VORH. GEBÄUDE
FLUCHTLINIE
37.45
R = 75.00 m
R = 65.86 m
R = 64.76 m
7.6.58. Moricz

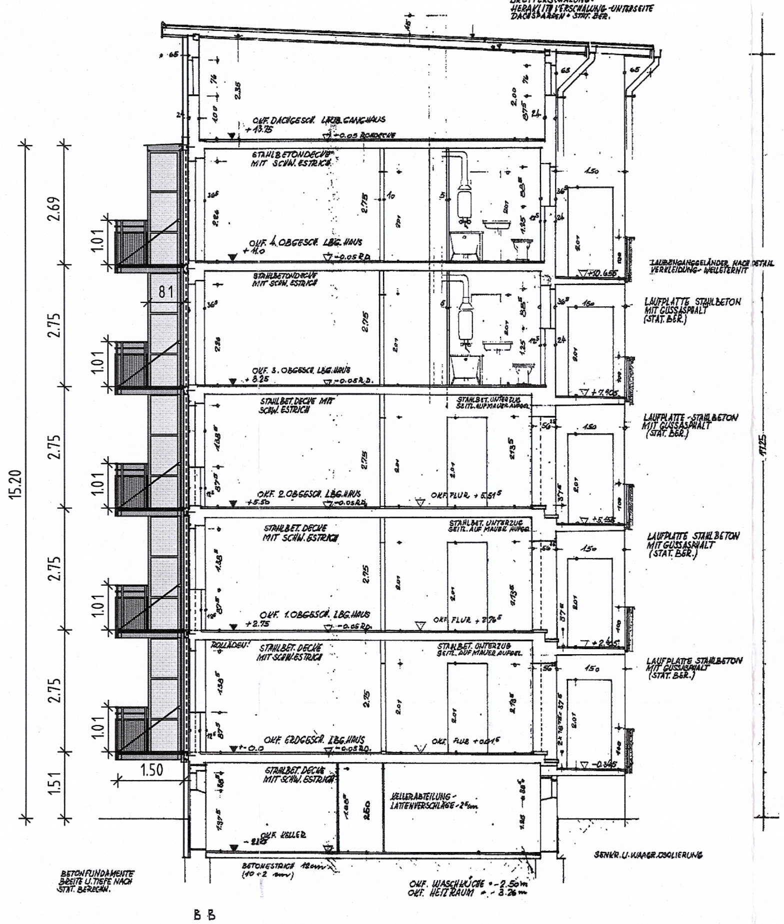


BAUVORHABEN
FRANKFURT/MAIN MOUSONSTRASSE
25 W.E. PROGRAMM NR. 3333/58
BAUHERR
NASSAUISCHES HEIM
NORMALGESCHOSS M 1:50
NASSAUISCHE HEIMSTÄTTE GMBH
FFM TECHN. ABT.
ERDGESCHOSS
SÄMTLICHE HEIZKÖRPER-ANSCHLÜSSE V.R. 1/2"
ALLE TÜRMAßE FÜR STAHLZARGENTÜREN SIND LICHTE FERTIGMAßE.
SCHNITT A-A
INNENBADENTLÜFTUNG 5 PLEWAROHRE 14/14
DECKENAUSSPARUNG 20/100
MAUERSCHLITZ 20/20 FALLROHR Ø125
DECKENAUSSP. 20/20 FALLROHR Ø70
WOHNUNGSEINGANG NACH DETAIL!
LAUBENGANG -0.34 GUSSASPHALT
GELÄNDER SIEHE DETAIL
BALKONGELÄNDER SIEHE DETAIL
WOHNUNG ERDGESCHOSS 55.36
WOHNUNG ERDGESCHOSS 80.93
1. OBERGESCHOSS
R = 75.00 m
R = 65.26 m
R = 66.76 m
34.29
9.6.58

Neuplanung

BAUVORHABEN
FRANKFURT MAIN MOUSONSTRASSE
25 W.E. PROGRAMM NR. ~~3333/50~~ 3312/88
BAUHERR
NASSAUISCHES HEIM

NORMALSCHNITT M 1/50
NASSAUISCHE HEIMSTÄTTE GMBH
FFM TECHN.ABT.



Der Bauherr
NASSAUISCHE HEIMSTÄTTE
Wohnungs- und Entwicklungsgesellschaft mbH
Organ der staatlichen Wohnungspolitik
Schaumainkai 47 · 60596 Frankfurt am Main

Der Architekt
NASSAUISCHE HEIMSTÄTTE
Wohnungs- und Entwicklungsgesellschaft mbH
Organ der staatlichen Wohnungspolitik
Schaumainkai 47 · 60596 Frankfurt am Main

Dipl.-Ing. Architekt H. Caesar

Teilbilder: 41/43/46/47/48/52

DATUM	GEZ.	INDEX	GEÄNDERT

ÄNDERUNGEN

FREIGEGEBEN AM:

NASSAUISCHE HEIMSTÄTTE
Organ der Staatlichen Wohnungspolitik

BAUHERR: NASSAUISCHE HEIMSTÄTTE GMBH
SCHAUMAINKAI 47
60596 FRANKFURT AM MAIN

BAUVORHABEN: NEUPLANUNG VON 25 BALKONEN
MOUSONSTR. 35
60316 FRANKFURT

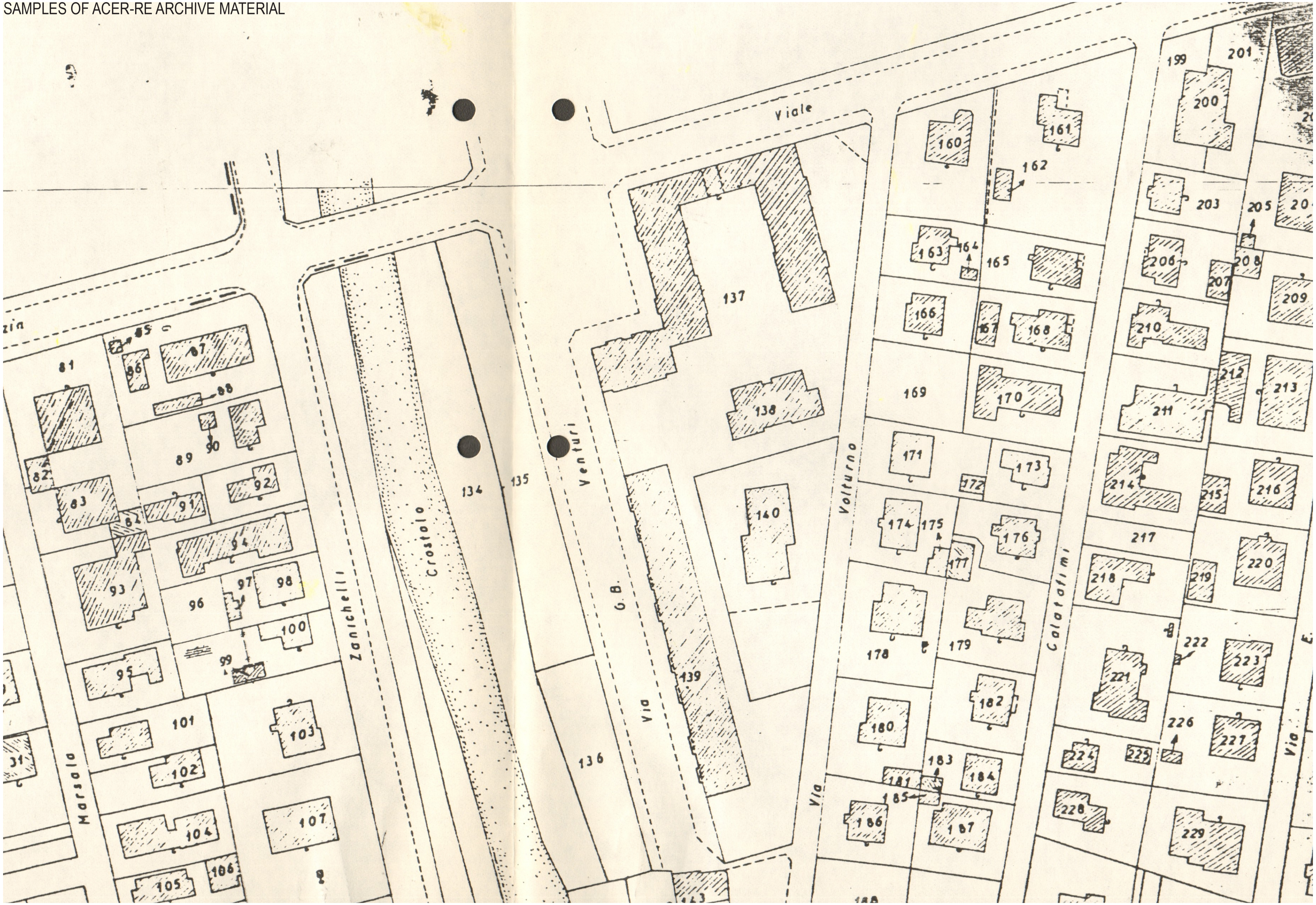
PROGRAMM-NR.
VE 1545

PLANINHALT:
SCHNITT

DATUM	GEZ.	GEPRÜFT	MASSTAB	BLATT-NR.	INDEX
25.11.04	HOF		1:100	4.0	A

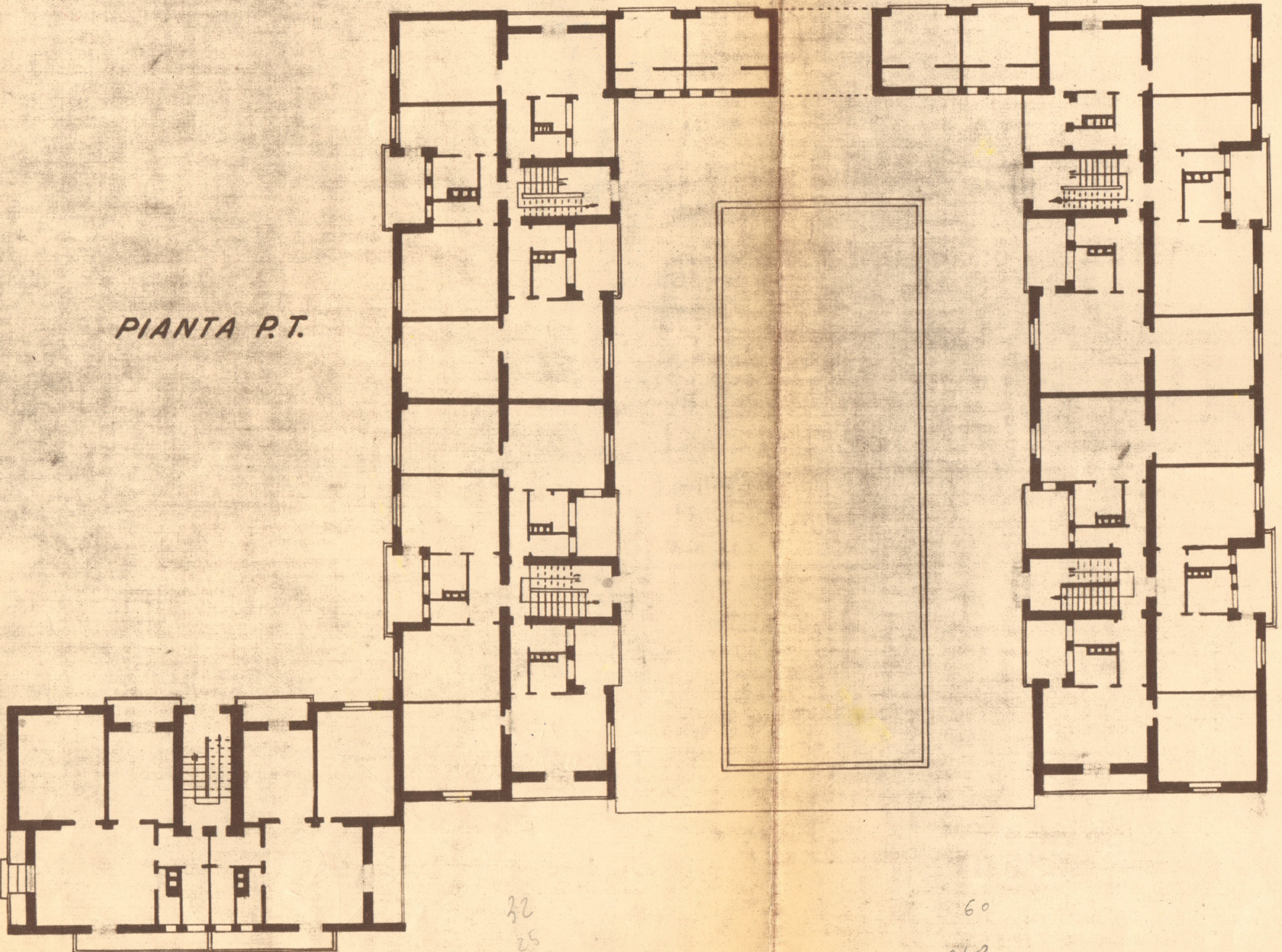
H/B = 297.0 / 420.0 (0.12m²)

Allplan


Viale
Marsala
Zanichelli
Crostolo
Via G.B. Venturi
Via Volturno
Calatafimi
Via

QUARTIERE DI VIA MAGENTA (TAGLIATE) CASA PER OP

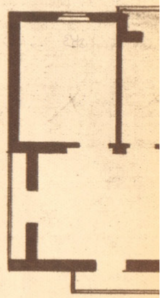
PIANTA P.T.



22
25

60
240

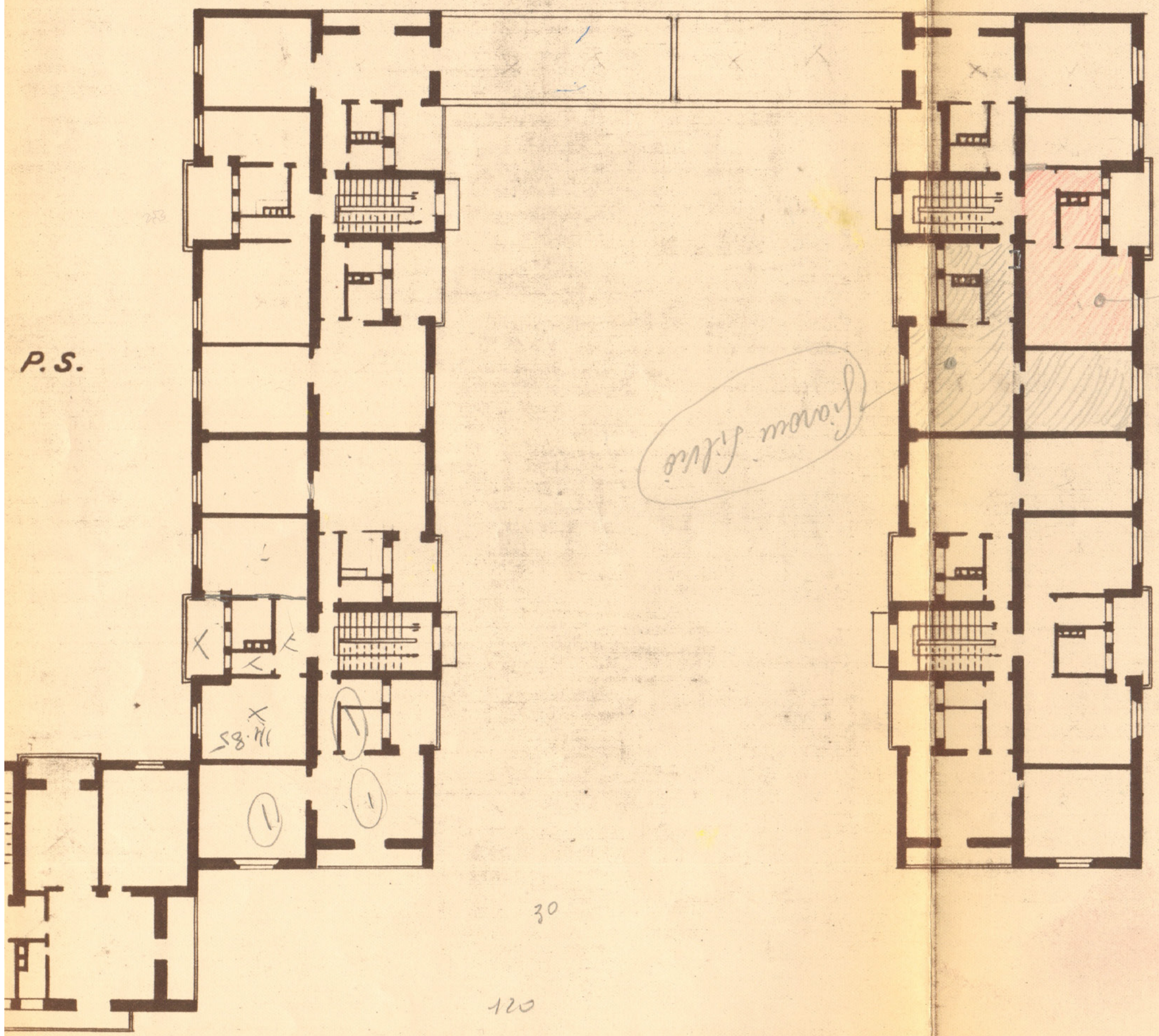
PI



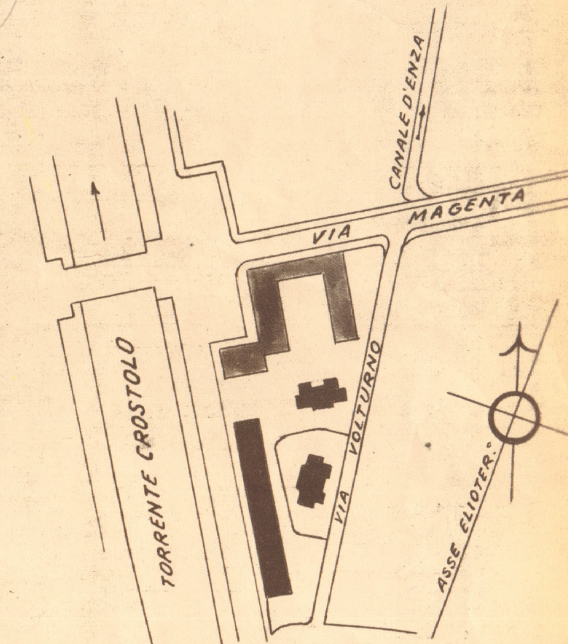
Scala: 1:200

\- TIPO A

P.S.



PLANIMETRIA



Scala : 1:2000

ANNEX 02

Senato della Repubblica XVII LEGISLATURA

N. 1413

DISEGNO DI LEGGE

presentato dal Presidente del Consiglio dei ministri (RENZI)

e dal Ministro delle infrastrutture e dei trasporti (LUPI)

di concerto con il Ministro dell'economia e delle finanze (PADOAN)

e con il Ministro per gli affari regionali (LANZETTA)

COMUNICATO ALLA PRESIDENZA IL 28 MARZO 2014

Conversione in legge del decreto-legge 28 marzo 2014, n. 47, recante misure urgenti per l'emergenza abitativa, per il mercato delle costruzioni e per Expo 2015

TIPOGRAFIA DEL SENATO

Gli effetti totali risultano i seguenti:

in milioni di euro

	2014	2015	2016	2017	2018	2019
Cedolare secca	-24,37	-25,62	-25,62	-25,62	0,29	1,62
IRPEF	-7,16	-9,58	-9,58	-9,58	-4,88	-3,28
Addizionale regionale	0	-0,46	-0,46	-0,46	-0,46	-0,16
Addizionale comunale	0	-0,16	-0,16	-0,16	-0,15	-0,05
Imposta di registro e bollo	-0,45	-0,45	-0,45	-0,45	-0,05	-0,05
Totale	**-31,98**	**-36,27**	**-36,27**	**-36,27**	**-5,25**	**-1,92**

Alla copertura dei relativi oneri si provvede ai sensi dell'articolo 14.

Art. 10 (*Edilizia residenziale sociale)*

La disposizione prevede modifiche procedurali e ordinamentali volte a ridurre il disagio abitativo di individui e nuclei familiari svantaggiati attraverso l'aumento dell'offerta di alloggi sociali in locazione come definiti dal comma 3. L'ambito territoriale di applicazione della disposizione è definito dal comma 4.

Ai sensi del comma 5, sono ammessi interventi di:

a) ristrutturazione, restauro, manutenzione straordinaria ed adeguamento antisismico;
b) sostituzione edilizia;
c) variazione della destinazione d'uso senza opere;
d) creazione di servizi e funzioni connesse e complementari alla residenza e al commercio (ad esclusione delle grandi strutture di vendita);
e) creazione di quote di alloggi da destinare alla locazione temporanea dei residenti di immobili di ERP in corso di ristrutturazione o a soggetti sottoposti a procedure di sfratto.

Ai sensi del comma 10, al finanziamento degli interventi di cui alle lettere d) ed e), nonché di quelli per la realizzazione degli spazi pubblici o riservati alle attività collettive, a verde pubblico o a parcheggi, previste dal decreto del Ministero dei lavori pubblici 2 aprile 1968, n. 1444, sono destinati fino a 100 milioni di euro a valere sulle risorse derivanti dalle revoche, di cui all'articolo 4, comma 2. Tali risorse vengono ripartite con decreto del Ministero delle infrastrutture e dei trasporti, previa intesa della Conferenza unificata.
La disposizione, pertanto, non determina nuovi o maggiori oneri per la finanza pubblica.

Art. 11 (*Verifica dell'attuazione del provvedimento)*

Viene previsto che i provvedimenti di assegnazione delle risorse riferite agli articoli precedenti stabiliscano le modalità di utilizzo delle risorse assegnate, di monitoraggio dell'avanzamento degli interventi e di applicazione di misure di revoca. Inoltre si prevede che le risorse revocate restino finalizzate al contrasto del disagio abitativo.
L'articolo, recando disposizioni di carattere ordinamentale, non comporta nuovi o maggiori oneri per la finanza pubblica.

2. All'articolo 3, del decreto legislativo 14 marzo 2011, n. 23, dopo il comma 6 è inserito il seguente: «6-*bis*. L'opzione di cui al comma 1 può essere esercitata anche per le unità immobiliari abitative locate nei confronti di cooperative o enti senza scopo di lucro di cui al libro I, titolo II del codice civile, purché sublocate a studenti universitari con rinuncia all'aggiornamento del canone di locazione o assegnazione.».

Art. 10.

(Edilizia residenziale sociale)

1. In attuazione dell'articolo 117, secondo comma, lettera *m)*, della Costituzione, il presente articolo è finalizzato a perseguire la riduzione del disagio abitativo di individui e nuclei familiari svantaggiati attraverso l'aumento dell'offerta di alloggi sociali in locazione, senza consumo di nuovo suolo rispetto agli strumenti urbanistici vigenti, favorendo il risparmio energetico e la promozione, da parte dei Comuni, di politiche urbane mirate ad un processo integrato di rigenerazione delle aree e dei tessuti attraverso lo sviluppo dell'edilizia sociale.

2. Ai fini del perseguimento dell'obiettivo dell'aumento dell'offerta di alloggi sociali in locazione, i commi seguenti prevedono tempi e modalità di adozione delle procedure idonee a garantire, anche attraverso lo stanziamento di risorse pubbliche e l'accelerazione dell'utilizzo delle risorse di cui all'articolo 11, comma 3, del decreto-legge 25 giugno 2008, n. 112, convertito con modificazioni dalla legge 6 agosto 2008, n. 133, l'incremento degli alloggi sociali.

3. Si considera alloggio sociale, ai fini del presente articolo, l'unità immobiliare adibita ad uso residenziale, realizzata o recuperata da soggetti pubblici e privati, nonché dall'ente gestore comunque denominato, da concedere in locazione, per ridurre il disagio abitativo di individui e nuclei familiari svantaggiati che non sono in grado di accedere alla locazione di alloggi alle condizioni di mercato. Si considera altresì alloggio sociale l'unità abitativa destinata alla locazione, con vincolo di destinazione d'uso, comunque non inferiore a quindici anni, all'edilizia universitaria convenzionata oppure alla locazione con patto di futura vendita, per un periodo non inferiore ad otto anni. Le aree o gli immobili da destinare ad alloggio sociale non si computano ai fini delle quantità minime inderogabili di spazi pubblici o riservati alle attività collettive, a verde pubblico o a parcheggi, previste dal decreto del Ministro dei lavori pubblici del 2 aprile 1968, n. 1444, pubblicato nella *Gazzetta Ufficiale* n. 97 del 16 aprile 1968.

4. Il presente articolo si applica nei comuni di cui alla delibera CIPE 13 novembre 2003 al patrimonio edilizio esistente, ivi compresi gli immobili non ultimati e sugli interventi non ancora avviati provvisti di titoli abilitativi rilasciati entro il 31 dicembre 2013 ovvero regolati da conven-

zioni urbanistiche stipulate entro la stessa data e vigenti alla data di entrata in vigore del presente decreto.

5. Ai fini del presente articolo sono ammessi interventi di:

a) ristrutturazione edilizia, restauro o risanamento conservativo, manutenzione straordinaria, rafforzamento locale, miglioramento o adeguamento sismico;

b) sostituzione edilizia mediante anche la totale demolizione dell'edificio e la sua ricostruzione con modifica di sagoma o diversa localizzazione nel lotto di riferimento, nei limiti di quanto previsto dall'articolo 30 del decreto-legge 21 giugno 2013, n. 69, convertito, con modificazioni, dalla legge 9 agosto 2013, n. 98;

c) variazione della destinazione d'uso anche senza opere;

d) creazione di servizi e funzioni connesse e complementari alla residenza, al commercio con esclusione delle grandi strutture di vendita, necessarie a garantire l'integrazione sociale degli inquilini degli alloggi sociali, in misura comunque non superiore al 20 per cento della superficie complessiva comunque ammessa;

e) creazione di quote di alloggi da destinare alla locazione temporanea dei residenti di immobili di edilizia residenziale pubblica in corso di ristrutturazione o a soggetti sottoposti a procedure di sfratto.

6. Entro sessanta giorni dalla data di entrata in vigore della legge di conversione del presente decreto, le regioni definiscono, qualora non siano già disciplinati da norme vigenti e per i casi non disciplinati da convenzioni già stipulate, i requisiti di accesso e di permanenza nell'alloggio sociale, i criteri e i parametri atti a regolamentare i canoni minimi e massimi di locazione, di cui al decreto ministeriale in attuazione dell'articolo 5 della legge 8 febbraio 2007, n. 9, e i prezzi di cessione per gli alloggi concessi in locazione con patto di futura vendita. Le regioni, entro il medesimo termine, definiscono la durata del vincolo di destinazione d'uso, ferma restando la durata minima di quindici anni per gli alloggi concessi in locazione e di otto anni per gli alloggi concessi in locazione con patto di futura vendita o con patto di riscatto. Le regioni possono introdurre norme di semplificazione per il rilascio del titolo abilitativo edilizio convenzionato e ridurre gli oneri di urbanizzazione per gli interventi di cui al presente articolo.

7. Entro novanta giorni dalla data di entrata in vigore della legge di conversione del presente decreto e comunque anteriormente al rilascio del primo titolo abilitativo edilizio di pertinenza, i comuni approvano i criteri di valutazione della sostenibilità urbanistica, economica e funzionale dei progetti di recupero, riuso o sostituzione edilizia e determinano le superfici complessive che possono essere cedute in tutto o in parte ad altri operatori ovvero trasferite su altre aree di proprietà pubblica o privata, per le medesime finalità di intervento, con esclusione delle aree destinate all'agricoltura o non soggette a trasformazione urbanistica dagli strumenti

urbanistici, nonché di quelle vincolate ai sensi del decreto legislativo 22 gennaio 2004, n. 42.

8. Gli interventi di cui al comma 5 non possono riferirsi ad edifici abusivi o siti nei centri storici o in aree ad inedificabilità assoluta e possono essere autorizzati in deroga alle previsioni degli strumenti urbanistici, vigenti o adottati, e ai regolamenti edilizi ed alle destinazioni d'uso, nel rispetto delle norme e dei vincoli artistici, storici, archeologici, paesaggistici e ambientali, nonché delle norme di carattere igienico sanitario e degli obiettivi di qualità dei suoli. Gli interventi sono regolati da convenzioni sottoscritte dal comune e dal soggetto privato con la previsione di clausole sanzionatorie per il mancato rispetto del vincolo di destinazione d'uso.

9. I progetti degli interventi di cui al comma 5, ad eccezione di quelli di mutamento di destinazione d'uso senza opere, devono comunque assicurare la copertura del fabbisogno energetico necessario per l'acqua calda sanitaria, il riscaldamento e il raffrescamento, tramite impianti alimentati da fonti rinnovabili, nel rispetto delle quote previste ai sensi del decreto legislativo 3 marzo 2011, n. 28, allegato 3.

10. Al finanziamento degli interventi di cui al comma 5, lettere *d)* ed *e)*, nonché di quelli per la realizzazione degli spazi pubblici o riservati alle attività collettive, a verde pubblico o a parcheggi, previste dal decreto del Ministro dei lavori pubblici 2 aprile 1968, n. 1444, sono destinati fino a 100 milioni di euro a valere sulle risorse rese disponibili ai sensi dell'articolo 4, comma 2. Con decreto del Ministro delle infrastrutture e dei trasporti, previa intesa della Conferenza unificata, di cui all'articolo 8 del decreto legislativo 28 agosto 1997, n. 281, ai sensi dell'articolo 8, comma 6, della legge 5 giugno 2003 n.131, viene ripartito il predetto importo tra le regioni che hanno rispettato il termine di cui al comma 6, nonché definiti i criteri per il successivo riparto da parte delle regioni tra i Comuni che hanno siglato con gli operatori privati le convenzioni di cui al comma 8 ai fini della successiva formale stipula.

Art. 11.

(Verifica dell'attuazione del provvedimento)

1. Con i provvedimenti di assegnazione delle risorse di cui agli articoli 1, 4 e 10 sono stabilite le modalità di utilizzo delle risorse assegnate, di monitoraggio dell'avanzamento degli interventi e di applicazione di misure di revoca. Le risorse revocate restano destinate al contrasto del disagio abitativo e sono riprogrammate con decreto del Ministero delle infrastrutture e dei trasporti di concerto con il Ministero dell'economia e delle finanze. Entro il 31 dicembre 2014 il Ministro delle infrastrutture e dei trasporti riferisce al Consiglio dei Ministri in merito all'attuazione del presente decreto.

€ 2,00

ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ

ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ

ΤΕΥΧΟΣ ΠΡΩΤΟ **Αρ. Φύλλου 79**

9 Απριλίου 2012

ΝΟΜΟΣ ΥΠ' ΑΡΙΘ. 4067

Νέος Οικοδομικός Κανονισμός.

Ο ΠΡΟΕΔΡΟΣ
ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ

Εκδίδομε τον ακόλουθο νόμο που ψήφισε η Βουλή:

Άρθρο 1
Πεδίο Εφαρμογής

1. Σε περιοχές εντός εγκεκριμένου ρυμοτομικού σχεδίου εφαρμόζονται όλες οι διατάξεις του παρόντος.
2. Σε περιοχές εκτός εγκεκριμένου ρυμοτομικού σχεδίου εφαρμόζονται οι ακόλουθες διατάξεις του παρόντος:
α) το άρθρο 2,
β) οι παράγραφοι 2, 4 και 5 του παρόντος άρθρου,
γ) το άρθρο 4,
δ) το άρθρο 6,
ε) η παράγραφος 3 του άρθρου 8,
στ) το άρθρο 11 εκτός από την παράγραφο 2 και τις παραγράφους 6ιγ, 6ιζ, 6ιστ για το άρθρο 19 όπως αναφέρεται σε αυτήν,
ζ) οι παράγραφοι 3 και 4 του άρθρου 12, η παράγραφος 14η όταν δεν ορίζεται διαφορετικά από άλλες διατάξεις,
η) το άρθρο 13,
θ) το άρθρο 16,
ι) το άρθρο 17 εκτός από την παράγραφο 2α, 2β, 2στ, 6β και 8,
ια) το άρθρο 21,
ιβ) το άρθρο 23,
ιγ) το άρθρο 25,
ιδ) το άρθρο 26,
ιε) το άρθρο 28,
ιστ) τα άρθρα 29 έως 37.
3. Σε νομίμως υφιστάμενους οικισμούς χωρίς εγκεκριμένο ρυμοτομικό σχέδιο εφαρμόζονται οι ακόλουθες διατάξεις του παρόντος:
α) το άρθρο 2,
β) οι παράγραφοι 3, 4 και 5 του παρόντος άρθρου,
γ) το άρθρο 4,
δ) το άρθρο 5,
ε) το άρθρο 6,
στ) το άρθρο 9,
ζ) το άρθρο 11, εκτός από την παράγραφο 6ιζ,
η) οι παράγραφοι 3 και 4 του άρθρου 12,
θ) το άρθρο 13,
ι) το άρθρο 14 με τη διευκρίνιση ότι η αναφερόμενη απόσταση Δ ορίζεται σε 2,50 μ. ανεξάρτητα από το ύψος,
ια) το άρθρο 16,
ιβ) το άρθρο 17,
ιγ) το άρθρο 18,
ιδ) το άρθρο 19,
ιε) το άρθρο 23,
ιστ) το άρθρο 25,
ιζ) το άρθρο 26,
ιη) τα άρθρα 29 έως 37.
4. Όλα τα αριθμητικά μεγέθη που ορίζονται στις διατάξεις του παρόντος νόμου θεωρούνται ως τα ανώτατα επιτρεπόμενα.
5. α) Οι ειδικές πολεοδομικές διατάξεις, με την επιφύλαξη της επόμενης παραγράφου, κατισχύουν των γενικών διατάξεων, που περιέχονται στον παρόντα νόμο.
β) Οι διατάξεις του παρόντος κατισχύουν των κανονιστικών πράξεων της Διοίκησης (όπως αποφάσεις Νομάρχη, πράξεις Δημοτικού Συμβουλίου κ.λπ.), με τις οποίες θεσπίζονται όροι δόμησης (όπως ύψος, ποσοστό κάλυψης, αριθμός ορόφων, θέση υπογείου κ.λπ.), εκτός από: 1) οποιουδήποτε είδους διατάγματα και 2) πράξεις, με τις οποίες θεσπίζονται ειδικές και εντοπισμένες ρυθμίσεις (όπως για διατηρητέα κτίρια, μνημεία, ειδικά κτίρια κ.λπ.). Με απόφαση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής μπορεί να διαπιστώνεται η μη εφαρμογή των παραπάνω κανονιστικών πράξεων της διοίκησης.

Άρθρο 2
Ορισμοί

1. Αίθριο είναι το μη στεγασμένο τμήμα του κτιρίου που περιβάλλεται από όλες τις πλευρές του από το κτίριο ή τα όρια του οικοπέδου, στο οποίο μπορούν να έχουν ανοίγματα, χώροι κύριας χρήσης και εγγράφεται σε αυτό κύκλος διαμέτρου Δ.
2. Αιολικά ενεργειακά συστήματα είναι οι εγκαταστάσεις που επιτρέπουν την αξιοποίηση της αιολικής ενέργειας για την κάλυψη ενεργειακών αναγκών του κτιρίου.

με αποφάσεις ή παραχωρητήρια, θεωρούνται άρτια και οικοδομήσιμα με όποιες διαστάσεις και εμβαδόν παραχωρήθηκαν ή με τις τυχόν μικρότερες ή μεγαλύτερες που έχουν στην πραγματικότητα, εφόσον η μεταβολή αυτή δεν οφείλεται σε μεταβιβάσεις.

Σε περίπτωση μείωσης των ανωτέρω οικοπέδων λόγω ρυμοτομίας, θεωρούνται άρτια και οικοδομήσιμα, εφόσον έχουν τα ελάχιστα όρια αρτιότητας που προβλέπονται, κατά τον κανόνα ή κατά παρέκκλιση, από τις διατάξεις που ισχύουν για την περιοχή ή εκείνα που προβλέπονται από το άρθρο 25 του ν. 1337/1983, όπως εκάστοτε ισχύει.

Οικόπεδα που δημιουργούνται από κατάτμηση παραχωρηθέντος οικοπέδου, που έγινε ύστερα από έγκριση της αρμόδιας για την παραχώρηση αρχής, θεωρούνται άρτια και οικοδομήσιμα εφόσον είναι άρτια, σύμφωνα με τις διατάξεις που ισχύουν για την περιοχή. Σε αντίθετη περίπτωση εφαρμόζονται οι διατάξεις του άρθρου 25 του ν. 1337/1983, όπως εκάστοτε ισχύει.

5. Αν η οδός που αποτελεί το ακραίο όριο εγκεκριμένου μέχρι τη δημοσίευση του παρόντος σχεδίου πόλης, τέμνει ιδιοκτησίες και δεν έχουν καταβληθεί οι οφειλόμενες αποζημιώσεις για την εφαρμογή του σχεδίου ως προς την οδό αυτή μπορεί να τροποποιείται και επεκτείνεται το σχέδιο με την μετατόπιση της οριακής αυτής οδού προς την εκτός σχεδίου περιοχή χωρίς πάντως να τέμνονται άλλες ιδιοκτησίες.

Το τμήμα που εντάσσεται στο σχέδιο πόλης από την καθεμία από τις παραπάνω ιδιοκτησίες δεν μπορεί να είναι εμβαδού μεγαλυτέρου του διπλάσιου των κατά τον κανόνα ορίων αρτιότητας που προβλέπονται από το ήδη εγκεκριμένο σχέδιο της περιοχής. Η μετατόπιση αυτή επιτρέπεται μόνον εφόσον εναρμονίζεται με τις κυκλοφοριακές και τις εν γένει πολεοδομικές συνθήκες και ανάγκες της περιοχής.

Σε περίπτωση εφαρμογής της παραγράφου αυτής μπορεί και να αυξάνεται ή να μειώνεται το πλάτος της μετατοπιζόμενης οδού. Για το τμήμα που εντάσσεται στο σχέδιο πόλης με βάση την παράγραφο αυτή, ισχύουν οι όροι δόμησης που θεσπίζονται από το ήδη εγκεκριμένο σχέδιο της περιοχής, όπως αυτοί κάθε φορά ισχύουν.

6. Σε περίπτωση εφαρμογής της προηγούμενης παραγράφου οι κύριοι των παραπάνω ιδιοκτησιών υπόκεινται σε εισφορά γης και χρήματος κατά τις διατάξεις των άρθρων 8 και 9 του ν. 1337/1983. Αν το εμβαδόν της έκτασης την οποία καταλαμβάνει η μετατοπιζόμενη οδός είναι ίσο ή μεγαλύτερο προς την κατά το προηγούμενο εδάφιο εισφορά σε γη δεν οφείλεται άλλη εισφορά σε γη ή αποζημίωση. Αν είναι μικρότερο οφείλεται η διαφορά της εισφοράς γης. Η έκταση αυτή αποκτά την ιδιότητα του κοινοχρήστου από τη δημοσίευση της υπουργικής απόφασης που προβλέπεται στην επόμενη παράγραφο 7.

7. Η τροποποίηση και η επέκταση του σχεδίου πόλης κατά την παράγραφο 5 του παρόντος άρθρου γίνεται με απόφαση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής, η οποία εκδίδεται κατά τη διαδικασία του άρθρου 3 του ν.δ. της 17.7.1923. Αν η διαδικασία αυτή έχει τηρηθεί μέχρι τη δημοσίευση του νόμου αυτού δεν απαιτείται επανάληψη για την έκδοση της απόφασης Υπουργού.

Άρθρο 9
Δουλείες σε ακίνητα

1. Απαγορεύεται η σύσταση δουλειών, οι οποίες συνεπάγονται περιορισμό της δυνατότητας ανέγερσης ή επέκτασης των κτιρίων ή εγκαταστάσεων, σύμφωνα με τις ισχύουσες πολεοδομικές διατάξεις.

Από την απαγόρευση αυτή εξαιρείται η δουλεία διόδου, εφόσον αποτελεί τη μοναδική δίοδο προς κοινόχρηστο χώρο οικοπέδου ή κτιρίου ή αυτοτελούς από πλευράς δόμησης ορόφου, η οποία μπορεί να περιορίζεται στη χρήση της στάθμης του ισογείου.

Δικαιοπραξίες που αντιβαίνουν στις διατάξεις της παραγράφου αυτής είναι απολύτως άκυρες.

2. Δουλείες που έχουν συσταθεί έως τη δημοσίευση του παρόντος νόμου δεν παρεμποδίζουν την έκδοση άδειας δόμησης, σύμφωνα με τις ισχύουσες διατάξεις. Οι δουλείες αυτές καταργούνται κατά τη διαδικασία των επόμενων παραγράφων, αν εκδοθεί νόμιμη οικοδομική άδεια για να γίνουν στο δουλεύον ακίνητο κατασκευές ή εγκαταστάσεις που καθιστούν αδύνατη, εν όλω ή εν μέρει, την άσκηση της δουλείας.

Κατ' εξαίρεση δεν υπάγονται στην παράγραφο αυτή η δουλεία κοινού σκελετού και η δουλεία διόδου, όπως αυτή ορίζεται στην προηγούμενη παράγραφο. Στα νέα κτίρια πρέπει να εξασφαλίζεται η δίοδος δουλείας στο επίπεδο του εδάφους και σε ύψος χώρου κύριας χρήσης.

3. Στον δικαιούχο της καταργούμενης δουλείας καταβάλλεται αποζημίωση. Ο καθορισμός του ποσού της αποζημίωσης, ανεξάρτητα από την αξία του αντικειμένου της διαφοράς, γίνεται από το ειρηνοδικείο, στην περιφέρεια του οποίου βρίσκεται το δουλεύον ακίνητο που δικάζει κατά τις σχετικές διατάξεις της Πολιτικής Δικονομίας, ύστερα από αίτηση του δικαιούχου της δουλείας ή εκείνου στον οποίο έχει χορηγηθεί νόμιμη άδεια δόμησης για την εκτέλεση εργασιών ασυμβίβαστων με την άσκηση της δουλείας.

4. Η δουλεία καταργείται με την καταβολή ή την κατάθεση στο Ταμείο Παρακαταθηκών και Δανείων της αποζημίωσης. Μετά την κατάργηση επιτρέπεται να εκτελεστούν, σύμφωνα με την άδεια δόμησης, οι εργασίες τις οποίες εμπόδιζε η δουλεία.

Άρθρο 10
Κίνητρα για την περιβαλλοντική αναβάθμιση και βελτίωση της ποιότητας ζωής σε πυκνοδομημένες και αστικές περιοχές

1. Σε περίπτωση οικοπέδων (αυτοτελών ή εκ συνενώσεως), που βρίσκονται εντός σχεδίου πόλεως στις γεωγραφικές περιφέρειες: α) των Δήμων του Νομού Αττικής και β) των αναφερόμενων στο άρθρο 1 παρ. 2 του ν. 1561/1985 (Α΄ 148), Δήμων του Νομού Θεσσαλονίκης, όπως και στις δύο περιπτώσεις, καθορίζονταν πριν την έναρξη ισχύος του ν. 2539/1997 (Α΄ 244), και οι οποίοι είχαν κατά την απογραφή του 1991 πληθυσμό μεγαλύτερο των 25.000 κατοίκων, και γ) των Δήμων Πάτρας, Λάρισας, Ηρακλείου, Βόλου, Νέας Ιωνίας Μαγνησίας, Ιωαννίνων, όπως καθορίζονταν πριν την έναρξη ισχύος του ν. 2539/1997, και (τα οικόπεδα σε καθεμία από τις υπό α΄, β΄ και γ΄ περιπτώσεις) δεν εμπίπτουν σε παραδοσιακούς οικισμούς και παραδοσιακά τμήματα πόλης ή σε ιστορικούς τόπους ή σε περιοχές με αποκλειστική χρήση κατοικίας και όταν το εμβαδόν

τους είναι μεγαλύτερο της κατά κανόνα αρτιότητας της περιοχής, κατόπιν σύμφωνης γνώμης του Συμβουλίου Αρχιτεκτονικής, παρέχονται τα ακόλουθα κατά περίπτωση πολεοδομικά κίνητρα, εφόσον τηρούνται οι ακόλουθες κατά περίπτωση προϋποθέσεις και σε κάθε περίπτωση με την προϋπόθεση ο αριθμός των κτιρίων που δημιουργούνται να είναι μικρότερος του Β/2 και ίσος με τη μικρότερη προκύπτουσα ακέραιη μονάδα με ελάχιστο το ένα:

α. Με την προϋπόθεση:

- ποσοστιαίας μείωσης του επιτρεπόμενου ποσοστού κάλυψης του οικοπέδου κατά ΑΧ10%,

δίνεται το κίνητρο:

- ποσοστιαίας αύξησης του επιτρεπόμενου συντελεστή δόμησης του οικοπέδου κατά ΑΧ10%.

β. Με τις προϋποθέσεις:

- ποσοστιαίας μείωσης του επιτρεπόμενου ποσοστού κάλυψης του οικοπέδου κατά ΑΧ15%,

- απόσυρσης κτιρίου κύριας χρήσης εμβαδού τουλάχιστον ενός τετάρτου του υπάρχοντος επιτρεπόμενου συντελεστή δόμησης της περιοχής,

δίνεται το κίνητρο:

- ποσοστιαίας αύξησης του επιτρεπόμενου συντελεστή δόμησης του οικοπέδου κατά ΑΧ15%.

γ. Με τις προϋποθέσεις:

- ποσοστιαίας μείωσης του επιτρεπόμενου ποσοστού κάλυψης του οικοπέδου κατά ΑΧ20%,

- απόδοσης σε κοινή δημόσια χρήση επιφάνειας ίσης με την αύξηση της επιφάνειας δόμησης δια του συντελεστή δόμησης,

δίνεται το κίνητρο:

- ποσοστιαίας αύξησης του επιτρεπόμενου συντελεστή δόμησης του οικοπέδου κατά ΑΧ20%.

δ. Με τις προϋποθέσεις:

- ποσοστιαίας μείωσης του επιτρεπόμενου ποσοστού κάλυψης του οικοπέδου κατά ΑΧ25%,

- απόδοσης σε κοινή δημόσια χρήση επιφάνειας ίσης με την αύξηση της επιφάνειας δόμησης δια του συντελεστή δόμησης,

- απόσυρσης κτιρίου κύριας χρήσης εμβαδού τουλάχιστον ενός τετάρτου του υπάρχοντος επιτρεπόμενου συντελεστή δόμησης της περιοχής,

δίνεται το κίνητρο:

- ποσοστιαίας αύξησης του επιτρεπόμενου συντελεστή δόμησης του οικοπέδου κατά ΑΧ25%.

Σε κάθε περίπτωση δίνεται κίνητρο προσαύξησης του επιτρεπόμενου ύψους, έως το ανώτατο επιτρεπόμενο κατά το άρθρο 15 ύψος, για τον προσαυξημένο συντελεστή δόμησης.

Η επιφάνεια που αποδίδεται σε κοινή δημόσια χρήση, συνέχεται με κοινόχρηστο χώρο του ρυμοτομικού σχεδίου και η μία πλευρά της ταυτίζεται με όλο το μήκος του προσώπου του οικοπέδου με την προϋπόθεση ότι έχει βάθος τουλάχιστον 1,5 μ.. Σε περίπτωση που η παραχωρούμενη επιφάνεια δεν επαρκεί για να αποδοθεί σε όλο το μήκος του προσώπου του οικοπέδου με ελάχιστο βάθος 1,5 μ., η μια πλευρά της ταυτίζεται κατ' ελάχιστο με το 1/3 του μήκους του προσώπου του οικοπέδου με τρόπο ώστε το βάθος της να είναι μικρότερο του πλάτους.

Σε κάθε περίπτωση το Συμβούλιο Αρχιτεκτονικής για τη διατύπωση της γνώμης του λαμβάνει υπόψη του ιδίως τα κριτήρια του περιβαλλοντικού οφέλους και της βέλτιστης απόδοσης σε κοινή χρήση.

ε. Για τις ανωτέρω περιπτώσεις α΄, β΄, γ΄, δ΄ με Β>2, η διαμόρφωση τυφλών όψεων επιτρέπεται μόνον κατόπιν γνωμοδότησης του Συμβουλίου Αρχιτεκτονικής το οποίο πιστοποιεί την αδυναμία ανέγερσης της οικοδομής χωρίς τυφλές όψεις, εξαντλουμένων των όρων και περιορισμών δόμησης.

Επίσης, σε περίπτωση οικοπέδου με Β>5 οι διατάξεις των ανωτέρω περιπτώσεων α΄, β΄, γ΄, δ΄ εφαρμόζονται μόνο μετά από σύμφωνη γνώμη του Κεντρικού Συμβουλίου Αρχιτεκτονικής.

στ. Όταν τα οικόπεδα των παραπάνω περιπτώσεων α΄, β΄, γ΄, δ΄ δημιουργούνται από συνένωση οικοπέδων εκ των οποίων τουλάχιστον το ένα είναι άρτιο κατά παρέκκλιση ή ρυμοτομούμενο ή τυφλό ή μη οικοδομήσιμο, παρέχονται τα παραπάνω κίνητρα με εφαρμογή των αντίστοιχων τύπων όπου Α=1 για κάθε λόγο Β.

ζ. Σε περίπτωση οικοπέδων τουλάχιστον 4.000 τ.μ. με απόδοση σε κοινή δημόσια χρήση του 100% του ακαλύπτου παρέχεται το εξής κίνητρο: αύξηση της επιτρεπόμενης δόμησης του προκύπτοντος οικοπέδου κατά 35% με προσθήκη καθ' ύψος μέχρι 30% επιπλέον του επιτρεπόμενου της περιοχής με τις προϋποθέσεις ποσοστιαίας μείωσης του επιτρεπόμενου ποσοστού κάλυψης του οικοπέδου κατά ΑΧ35% και αριθμού των κτιρίων που δημιουργούνται μικρότερου του Β/2 και ίσο με τη μικρότερη προκύπτουσα ακέραιη μονάδα με ελάχιστο το ένα.

Στην περίπτωση αυτή απαγορεύεται η διαμόρφωση τυφλών όψεων των κτιρίων με κατάλληλη χωροθέτησή τους στο οικόπεδο.

η. Με απόφαση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής μετά από γνώμη του Κεντρικού Συμβουλίου Αρχιτεκτονικής, είναι δυνατή η έγκριση της γενικής διάταξης και ογκοπλαστικής διαμόρφωσης κτιρίων σε οικόπεδα ελάχιστου εμβαδού 3.000 τ.μ., κατά παρέκκλιση των διατάξεων του παρόντος νόμου, με προϋπόθεση την τήρηση του ισχύοντος σ.δ. της περιοχής, ο οποίος πρέπει να είναι τουλάχιστον 1.6 και του ανώτατου επιτρεπόμενου ύψους κτιρίων που ορίζεται με τον παρόντα νόμο. Η παρούσα διάταξη ισχύει και για την υλοποίηση μελέτης που έχει βραβευθεί σε αρχιτεκτονικό διαγωνισμό ανεξαρτήτως εμβαδού του οικοπέδου.

Στις ανωτέρω περιπτώσεις απαγορεύεται η διαμόρφωση τυφλών όψεων των κτιρίων με κατάλληλη χωροθέτησή τους στο οικόπεδο.

2. Η απόδοση σε κοινή δημόσια χρήση γίνεται με συμβολαιογραφική πράξη, η οποία υποβάλλεται στην αρμόδια υπηρεσία δόμησης πριν την έκδοση της άδειας δόμησης. Με προεδρικό διάταγμα που εκδίδεται μετά από πρόταση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής, μπορεί να καθορίζεται η διαδικασία απόδοσης σε κοινή χρήση, καθώς και κάθε λεπτομέρεια για την εφαρμογή των παραγράφων 1 και 2 του παρόντος.

3. Στους παραχωρημένους σε δημόσια χρήση χώρους του οικοπέδου επιτρέπεται η διαμόρφωση από τον οικείο δήμο χώρου πρασίνου και η τοποθέτηση κατασκευών στοιχείων αστικού εξοπλισμού και η συντήρησή τους βαρύνει το Δήμο. Δεν επιτρέπεται εγκατάσταση συλλογής σκουπιδιών, περιπτέρων ή παιδικής χαράς.

4. Για την έκδοση άδειας δόμησης, σύμφωνα με την παράγραφο 1, επί οικοπέδου που αποτελεί οικοδομικό τετράγωνο απαιτείται έγκριση του Κεντρικού Συμβουλίου Αρχιτεκτονικής.

5. Επιτρέπεται η ενοποίηση των υποχρεωτικών ακάλυπτων χώρων των οικοπέδων ενός οικοδομικού τετραγώνου ή μέρους του, προς κοινή χρήση των ενοίκων του οικοδομικού τετραγώνου ή μέρους του, χωρίς να θίγονται τα δικαιώματα κυριότητας.

6. Για την εφαρμογή της προηγούμενης παραγράφου απαιτείται απόφαση πλειοψηφίας της συνέλευσης των ιδιοκτητών των ακινήτων που βρίσκονται στο οικοδομικό τετράγωνο, η οποία λαμβάνεται με πλειοψηφία του 66% των ψήφων του κάθε οικοπέδου, και με την οποία καθορίζονται οι ειδικότεροι όροι και ο τρόπος ενοποίησης, διαμόρφωσης και χρήσης των ακάλυπτων χώρων, καθώς και τα αναγκαία μέτρα, ώστε να εξασφαλίζεται η ασφαλής προσπέλαση στους χώρους αυτούς.

7. Κατά την έγκριση, επέκταση, αναθεώρηση ή τροποποίηση ρυμοτομικού σχεδίου μπορεί να προβλέπεται:

α) Η ενοποίηση των ακάλυπτων χώρων των οικοπέδων κάθε οικοδομικού τετραγώνου και η θέση των χώρων αυτών στη χρήση όλων των ενοίκων των κτιρίων του τετραγώνου αυτού. Στην περίπτωση αυτή η ενοποίηση γίνεται σύμφωνα με τους όρους που θεσπίζονται με το ρυμοτομικό σχέδιο.

β) Η δημιουργία δικτύου ελεύθερων δημόσιων προσβάσιμων κοινόχρηστων χώρων αποκλειστικά για πεζούς, με χρήση των ακάλυπτων χώρων των οικοπέδων και με κίνητρο την αύξηση μέχρι και 20% της επιτρεπόμενης δόμησης, με ταυτόχρονη διατήρηση των προβλεπόμενων υποχρεωτικών ακάλυπτων χώρων.

γ) Για περιπτώσεις περιοχών εντός πόλεων όπως ορίζεται στην παράγραφο 1, η οριοθέτηση περιοχής εντός της οποίας είναι δυνατή η οικοδόμηση στο πλαίσιο του ισχύοντος συντελεστή δόμησης και κατά παρέκκλιση των υπολοίπων διατάξεων του παρόντος νόμου, προκειμένου να διασφαλίζεται διάταξη κτιρίων και συνέχεια των ακαλύπτων, κατά τρόπο ώστε να μεγιστοποιείται το δημόσιο περιβαλλοντικό όφελος για την περιοχή, ή και να δημιουργείται μητροπολιτικός πόλος πολλαπλών λειτουργιών ή και να εφαρμόζονται πρότυπα προγράμματα αστικής ανάπτυξης ή ανασυγκρότησης. Η κατά τα ως άνω γενική διάταξη των κτιρίων και η ογκοπλαστική διαμόρφωσή τους εγκρίνεται με απόφαση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής μετά από γνώμη του Κεντρικού Συμβουλίου Αρχιτεκτονικής. Κατά την εφαρμογή της παρούσας διάταξης είναι δυνατή η κατά παρέκκλιση θέσπιση σ.δ. με προσαύξηση 50% από τον ισχύοντα για ιδιοκτησίες του Δημοσίου ή του δήμου.

δ) Για περιπτώσεις περιοχών εντός πόλεων όπως ορίζεται στην παράγραφο 1, η οριοθέτηση περιοχής εντός της οποίας είναι δυνατή η οικοδόμηση κατά παρέκκλιση των διατάξεων που αφορούν στο συντελεστή δόμησης, ποσοστό κάλυψης, ύψος κτιρίου, θέση και χρήση κτιρίου, προκειμένου να δημιουργείται μητροπολιτικός πόλος πολλαπλών λειτουργιών ή και να εφαρμόζονται πρότυπα προγράμματα αστικής ανάπτυξης ή ανασυγκρότησης. Η κατά τα ως άνω γενική διάταξη των κτιρίων και η ογκοπλαστική διαμόρφωσή τους εγκρίνεται με απόφαση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής μετά από γνώμη του Κεντρικού Συμβουλίου Αρχιτεκτονικής.

8. Με απόφαση των Υπουργών Οικονομικών, Δικαιοσύνης, Διαφάνειας και Ανθρωπίνων Δικαιωμάτων και Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής, ρυθμίζονται όλα τα θέματα, που σχετίζονται με τη σύγκληση της συνέλευσης των ιδιοκτητών, την πρόσκληση των μελών, τη λήψη και γνωστοποίηση των αποφάσεων, τον τρόπο καθορισμού του συνολικού αριθμού των ψήφων και της κατανομής τους στους ιδιοκτήτες, η οποία γίνεται με βάση το εμβαδόν της ιδιοκτησίας και το ποσοστό συμμετοχής σε αυτή σε σχέση με το ολικό εμβαδόν του οικοδομικού τετραγώνου.

9. Με προεδρικό διάταγμα, που εκδίδεται με πρόταση του Υπουργού Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής, μετά από σύμφωνη γνώμη του Κεντρικού Συμβουλίου Αρχιτεκτονικής, η οποία διατυπώνεται κατόπιν εισήγησης του οικείου Δήμου, μπορούν να καθορίζονται περιοχές στις γεωγραφικές περιφέρειες των Δήμων, όπως καθορίζονταν πριν την έναρξη ισχύος του ν. 2539/1997 (Α΄ 244), οι οποίοι δεν περιλαμβάνονται στην παράγραφο 1 του παρόντος και βρίσκονται στην ηπειρωτική Ελλάδα, την Κρήτη και την Εύβοια, όπου εφαρμόζονται οι διατάξεις των παραγράφων 1 έως 4 του παρόντος.

Άρθρο 11
Συντελεστής δόμησης

1. Κατά τη θέσπιση ή μεταβολή όρων δόμησης ο συντελεστής δόμησης των οικοπέδων ορίζεται αριθμητικά. Συντελεστές δόμησης που προκύπτουν έμμεσα από διατάξεις προγενέστερες της δημοσίευσης του νόμου αυτού, εξακολουθούν να ισχύουν έως ότου καθοριστούν αριθμητικά.

2. Ο συντελεστής δόμησης που εφαρμόζεται σε οικόπεδο με πρόσωπο σε περισσότερους κοινόχρηστους χώρους, για τους οποίους ισχύουν διαφορετικοί συντελεστές, είναι ο λόγος του αθροίσματος των γινομένων του μήκους κάθε προσώπου του οικοπέδου επί τον αντίστοιχο συντελεστή δόμησης προς το άθροισμα των μηκών των προσώπων.

3. Σε συνιδιόκτητα οικόπεδα με κάθετη ή οριζόντια ιδιοκτησία που έχει συσταθεί κατά τις διατάξεις του ν. 1024/1971 (Α΄ 232) και έχει εκδοθεί άδεια πριν από τη μεταβολή γενικών ή ειδικών διατάξεων που αφορούν την επιτρεπόμενη δόμηση, προκειμένου για έκδοση άδειας δόμησης ο κάθε συνιδιοκτήτης χρησιμοποιεί το ποσοστό δόμησης που του αναλογεί σύμφωνα με το συντελεστή δόμησης που ισχύει κατά το χρόνο έκδοσης της άδειας δόμησης.

4. Για τον υπολογισμό της μέγιστης επιτρεπόμενης δόμησης που μπορεί να πραγματοποιηθεί σε ένα οικόπεδο πολλαπλασιάζεται η επιφάνειά του επί το σ.δ. που ισχύει.

5. Στο σ.δ. προσμετρώνται:

α. Οι επιφάνειες των στεγασμένων και κλειστών από όλες τις πλευρές χώρων του κτιρίου.

β. Οι επιφάνειες των μη θερμαινόμενων στεγασμένων χώρων που διαθέτουν τουλάχιστον μία ανοιχτή πλευρά προς οποιονδήποτε ανοιχτό χώρο του οικοπέδου ή του κτιρίου και το μήκος του ανοίγματος είναι μικρότερο του 35% του συνολικού μήκους του περιγράμματος του χώρου αυτού.

Baugesetzbuch (BauGB)

BauGB

Ausfertigungsdatum: 23.06.1960

Vollzitat:

"Baugesetzbuch in der Fassung der Bekanntmachung vom 23. September 2004 (BGBl. I S. 2414), das zuletzt durch Artikel 6 des Gesetzes vom 20. Oktober 2015 (BGBl. I S. 1722) geändert worden ist"

Stand:	Neugefasst durch Bek. v. 23.9.2004 I 2414;
	Zuletzt geändert durch Art. 6 G v. 20.10.2015 I 1722

Fußnote

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(+++ Textnachweis Geltung ab: 1.8.1979 +++)
(+++ Änderungen aufgrund EinigVtr vgl. § 246a +++)
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Überschrift: IdF d. Art. 1 Nr. 1 G v. 8.12.1986 I 2191 mWv 1.7.1987

Inhaltsübersicht

§ 34 Zulässigkeit von Vorhaben innerhalb der im Zusammenhang bebauten Ortsteile

(1) Innerhalb der im Zusammenhang bebauten Ortsteile ist ein Vorhaben zulässig, wenn es sich nach Art und Maß der baulichen Nutzung, der Bauweise und der Grundstücksfläche, die überbaut werden soll, in die Eigenart der näheren Umgebung einfügt und die Erschließung gesichert ist. Die Anforderungen an gesunde Wohn- und Arbeitsverhältnisse müssen gewahrt bleiben; das Ortsbild darf nicht beeinträchtigt werden.

(2) Entspricht die Eigenart der näheren Umgebung einem der Baugebiete, die in der auf Grund des § 9a erlassenen Verordnung bezeichnet sind, beurteilt sich die Zulässigkeit des Vorhabens nach seiner Art allein danach, ob es nach der Verordnung in dem Baugebiet allgemein zulässig wäre; auf die nach der Verordnung ausnahmsweise zulässigen Vorhaben ist § 31 Abs. 1, im Übrigen ist § 31 Abs. 2 entsprechend anzuwenden.

(3) Von Vorhaben nach Absatz 1 oder 2 dürfen keine schädlichen Auswirkungen auf zentrale Versorgungsbereiche in der Gemeinde oder in anderen Gemeinden zu erwarten sein.

(3a) Vom Erfordernis des Einfügens in die Eigenart der näheren Umgebung nach Absatz 1 Satz 1 kann im Einzelfall abgewichen werden, wenn die Abweichung

1. der Erweiterung, Änderung, Nutzungsänderung oder Erneuerung eines zulässigerweise errichteten Gewerbe- oder Handwerksbetriebs, einschließlich der Nutzungsänderung zu Wohnzwecken, oder der Erweiterung, Änderung oder Erneuerung einer zulässigerweise errichteten, Wohnzwecken dienenden baulichen Anlage dient,
2. städtebaulich vertretbar ist und
3. auch unter Würdigung nachbarlicher Interessen mit den öffentlichen Belangen vereinbar ist.

Satz 1 findet keine Anwendung auf Einzelhandelsbetriebe, die die verbrauchernahe Versorgung der Bevölkerung beeinträchtigen oder schädliche Auswirkungen auf zentrale Versorgungsbereiche in der Gemeinde oder in anderen Gemeinden haben können.

(4) Die Gemeinde kann durch Satzung

1. die Grenzen für im Zusammenhang bebaute Ortsteile festlegen,
2. bebaute Bereiche im Außenbereich als im Zusammenhang bebaute Ortsteile festlegen, wenn die Flächen im Flächennutzungsplan als Baufläche dargestellt sind,
3. einzelne Außenbereichsflächen in die im Zusammenhang bebauten Ortsteile einbeziehen, wenn die einbezogenen Flächen durch die bauliche Nutzung des angrenzenden Bereichs entsprechend geprägt sind.

Die Satzungen können miteinander verbunden werden.

(5) Voraussetzung für die Aufstellung von Satzungen nach Absatz 4 Satz 1 Nr. 2 und 3 ist, dass

1. sie mit einer geordneten städtebaulichen Entwicklung vereinbar sind,
2. die Zulässigkeit von Vorhaben, die einer Pflicht zur Durchführung einer Umweltverträglichkeitsprüfung nach Anlage 1 zum Gesetz über die Umweltverträglichkeitsprüfung oder nach Landesrecht unterliegen, nicht begründet wird und
3. keine Anhaltspunkte für eine Beeinträchtigung der in § 1 Abs. 6 Nr. 7 Buchstabe b genannten Schutzgüter bestehen.

In den Satzungen nach Absatz 4 Satz 1 Nr. 2 und 3 können einzelne Festsetzungen nach § 9 Abs. 1 und 3 Satz 1 sowie Abs. 4 getroffen werden. § 9 Absatz 6 und § 31 sind entsprechend anzuwenden. Auf die Satzung nach Absatz 4 Satz 1 Nr. 3 sind ergänzend § 1a Abs. 2 und 3 und § 9 Abs. 1a entsprechend anzuwenden; ihr ist eine Begründung mit den Angaben entsprechend § 2a Satz 2 Nr. 1 beizufügen.

(6) Bei der Aufstellung der Satzungen nach Absatz 4 Satz 1 Nr. 2 und 3 sind die Vorschriften über die Öffentlichkeits- und Behördenbeteiligung nach § 13 Abs. 2 Satz 1 Nr. 2 und 3 sowie Satz 2 entsprechend anzuwenden. Auf die Satzungen nach Absatz 4 Satz 1 Nr. 1 bis 3 ist § 10 Abs. 3 entsprechend anzuwenden.

§ 35 Bauen im Außenbereich

(1) Im Außenbereich ist ein Vorhaben nur zulässig, wenn öffentliche Belange nicht entgegenstehen, die ausreichende Erschließung gesichert ist und wenn es

1. einem land- oder forstwirtschaftlichen Betrieb dient und nur einen untergeordneten Teil der Betriebsfläche einnimmt,
2. einem Betrieb der gartenbaulichen Erzeugung dient,
3. der öffentlichen Versorgung mit Elektrizität, Gas, Telekommunikationsdienstleistungen, Wärme und Wasser, der Abwasserwirtschaft oder einem ortsgebundenen gewerblichen Betrieb dient,
4. wegen seiner besonderen Anforderungen an die Umgebung, wegen seiner nachteiligen Wirkung auf die Umgebung oder wegen seiner besonderen Zweckbestimmung nur im Außenbereich ausgeführt werden soll, es sei denn, es handelt sich um die Errichtung, Änderung oder Erweiterung einer baulichen Anlage zur Tierhaltung, die dem Anwendungsbereich der Nummer 1 nicht unterfällt und die einer Pflicht zur Durchführung einer standortbezogenen oder allgemeinen Vorprüfung oder einer Umweltverträglichkeitsprüfung nach dem Gesetz über die Umweltverträglichkeitsprüfung unterliegt, wobei bei kumulierenden Vorhaben für die Annahme eines engen Zusammenhangs diejenigen Tierhaltungsanlagen zu berücksichtigen sind, die auf demselben Betriebs- oder Baugelände liegen und mit gemeinsamen betrieblichen oder baulichen Einrichtungen verbunden sind,
5. der Erforschung, Entwicklung oder Nutzung der Wind- oder Wasserenergie dient,
6. der energetischen Nutzung von Biomasse im Rahmen eines Betriebes nach Nummer 1 oder 2 oder eines Betriebes nach Nummer 4, der Tierhaltung betreibt, sowie dem Anschluss solcher Anlagen an das öffentliche Versorgungsnetz dient, unter folgenden Voraussetzungen:
   a) das Vorhaben steht in einem räumlich-funktionalen Zusammenhang mit dem Betrieb,
   b) die Biomasse stammt überwiegend aus dem Betrieb oder überwiegend aus diesem und aus nahe gelegenen Betrieben nach den Nummern 1, 2 oder 4, soweit letzterer Tierhaltung betreibt,
   c) es wird je Hofstelle oder Betriebsstandort nur eine Anlage betrieben und
   d) die Kapazität einer Anlage zur Erzeugung von Biogas überschreitet nicht 2,3 Millionen Normkubikmeter Biogas pro Jahr, die Feuerungswärmeleistung anderer Anlagen überschreitet nicht 2,0 Megawatt,
7. der Erforschung, Entwicklung oder Nutzung der Kernenergie zu friedlichen Zwecken oder der Entsorgung radioaktiver Abfälle dient, mit Ausnahme der Neuerrichtung von Anlagen zur Spaltung von Kernbrennstoffen zur gewerblichen Erzeugung von Elektrizität, oder
8. der Nutzung solarer Strahlungsenergie in, an und auf Dach- und Außenwandflächen von zulässigerweise genutzten Gebäuden dient, wenn die Anlage dem Gebäude baulich untergeordnet ist.

(2) Sonstige Vorhaben können im Einzelfall zugelassen werden, wenn ihre Ausführung oder Benutzung öffentliche Belange nicht beeinträchtigt und die Erschließung gesichert ist.

(3) Eine Beeinträchtigung öffentlicher Belange liegt insbesondere vor, wenn das Vorhaben

1. den Darstellungen des Flächennutzungsplans widerspricht,
2. den Darstellungen eines Landschaftsplans oder sonstigen Plans, insbesondere des Wasser-, Abfall- oder Immissionsschutzrechts, widerspricht,
3. schädliche Umwelteinwirkungen hervorrufen kann oder ihnen ausgesetzt wird,
4. unwirtschaftliche Aufwendungen für Straßen oder andere Verkehrseinrichtungen, für Anlagen der Versorgung oder Entsorgung, für die Sicherheit oder Gesundheit oder für sonstige Aufgaben erfordert,
5. Belange des Naturschutzes und der Landschaftspflege, des Bodenschutzes, des Denkmalschutzes oder die natürliche Eigenart der Landschaft und ihren Erholungswert beeinträchtigt oder das Orts- und Landschaftsbild verunstaltet,
6. Maßnahmen zur Verbesserung der Agrarstruktur beeinträchtigt, die Wasserwirtschaft oder den Hochwasserschutz gefährdet,
7. die Entstehung, Verfestigung oder Erweiterung einer Splittersiedlung befürchten lässt oder
8. die Funktionsfähigkeit von Funkstellen und Radaranlagen stört.

Raumbedeutsame Vorhaben dürfen den Zielen der Raumordnung nicht widersprechen; öffentliche Belange stehen raumbedeutsamen Vorhaben nach Absatz 1 nicht entgegen, soweit die Belange bei der Darstellung dieser Vorhaben als Ziele der Raumordnung abgewogen worden sind. Öffentliche Belange stehen einem

Vorhaben nach Absatz 1 Nr. 2 bis 6 in der Regel auch dann entgegen, soweit hierfür durch Darstellungen im Flächennutzungsplan oder als Ziele der Raumordnung eine Ausweisung an anderer Stelle erfolgt ist.

(4) Den nachfolgend bezeichneten sonstigen Vorhaben im Sinne des Absatzes 2 kann nicht entgegengehalten werden, dass sie Darstellungen des Flächennutzungsplans oder eines Landschaftsplans widersprechen, die natürliche Eigenart der Landschaft beeinträchtigen oder die Entstehung, Verfestigung oder Erweiterung einer Splittersiedlung befürchten lassen, soweit sie im Übrigen außenbereichsverträglich im Sinne des Absatzes 3 sind:

1. die Änderung der bisherigen Nutzung eines Gebäudes im Sinne des Absatzes 1 Nr. 1 unter folgenden Voraussetzungen:
   a) das Vorhaben dient einer zweckmäßigen Verwendung erhaltenswerter Bausubstanz,
   b) die äußere Gestalt des Gebäudes bleibt im wesentlichen gewahrt,
   c) die Aufgabe der bisherigen Nutzung liegt nicht länger als sieben Jahre zurück,
   d) das Gebäude ist vor mehr als sieben Jahren zulässigerweise errichtet worden,
   e) das Gebäude steht im räumlich-funktionalen Zusammenhang mit der Hofstelle des land- oder forstwirtschaftlichen Betriebs,
   f) im Falle der Änderung zu Wohnzwecken entstehen neben den bisher nach Absatz 1 Nr. 1 zulässigen Wohnungen höchstens drei Wohnungen je Hofstelle und
   g) es wird eine Verpflichtung übernommen, keine Neubebauung als Ersatz für die aufgegebene Nutzung vorzunehmen, es sei denn, die Neubebauung wird im Interesse der Entwicklung des Betriebs im Sinne des Absatzes 1 Nr. 1 erforderlich,
2. die Neuerrichtung eines gleichartigen Wohngebäudes an gleicher Stelle unter folgenden Voraussetzungen:
   a) das vorhandene Gebäude ist zulässigerweise errichtet worden,
   b) das vorhandene Gebäude weist Missstände oder Mängel auf,
   c) das vorhandene Gebäude wird seit längerer Zeit vom Eigentümer selbst genutzt und
   d) Tatsachen rechtfertigen die Annahme, dass das neu errichtete Gebäude für den Eigenbedarf des bisherigen Eigentümers oder seiner Familie genutzt wird; hat der Eigentümer das vorhandene Gebäude im Wege der Erbfolge von einem Voreigentümer erworben, der es seit längerer Zeit selbst genutzt hat, reicht es aus, wenn Tatsachen die Annahme rechtfertigen, dass das neu errichtete Gebäude für den Eigenbedarf des Eigentümers oder seiner Familie genutzt wird,
3. die alsbaldige Neuerrichtung eines zulässigerweise errichteten, durch Brand, Naturereignisse oder andere außergewöhnliche Ereignisse zerstörten, gleichartigen Gebäudes an gleicher Stelle,
4. die Änderung oder Nutzungsänderung von erhaltenswerten, das Bild der Kulturlandschaft prägenden Gebäuden, auch wenn sie aufgegeben sind, wenn das Vorhaben einer zweckmäßigen Verwendung der Gebäude und der Erhaltung des Gestaltwerts dient,
5. die Erweiterung eines Wohngebäudes auf bis zu höchstens zwei Wohnungen unter folgenden Voraussetzungen:
   a) das Gebäude ist zulässigerweise errichtet worden,
   b) die Erweiterung ist im Verhältnis zum vorhandenen Gebäude und unter Berücksichtigung der Wohnbedürfnisse angemessen und
   c) bei der Errichtung einer weiteren Wohnung rechtfertigen Tatsachen die Annahme, dass das Gebäude vom bisherigen Eigentümer oder seiner Familie selbst genutzt wird,
6. die bauliche Erweiterung eines zulässigerweise errichteten gewerblichen Betriebs, wenn die Erweiterung im Verhältnis zum vorhandenen Gebäude und Betrieb angemessen ist.

In begründeten Einzelfällen gilt die Rechtsfolge des Satzes 1 auch für die Neuerrichtung eines Gebäudes im Sinne des Absatzes 1 Nummer 1, dem eine andere Nutzung zugewiesen werden soll, wenn das ursprüngliche Gebäude vom äußeren Erscheinungsbild auch zur Wahrung der Kulturlandschaft erhaltenswert ist, keine stärkere Belastung des Außenbereichs zu erwarten ist als in Fällen des Satzes 1 und die Neuerrichtung auch mit nachbarlichen Interessen vereinbar ist; Satz 1 Nummer 1 Buchstabe b bis g gilt entsprechend. In den Fällen des Satzes 1 Nummer 2 und 3 sowie des Satzes 2 sind geringfügige Erweiterungen des neuen Gebäudes gegenüber dem beseitigten oder zerstörten Gebäude sowie geringfügige Abweichungen vom bisherigen Standort des Gebäudes zulässig.

(5) Die nach den Absätzen 1 bis 4 zulässigen Vorhaben sind in einer flächensparenden, die Bodenversiegelung auf das notwendige Maß begrenzenden und den Außenbereich schonenden Weise auszuführen. Für Vorhaben nach Absatz 1 Nr. 2 bis 6 ist als weitere Zulässigkeitsvoraussetzung eine Verpflichtungserklärung abzugeben, das Vorhaben nach dauerhafter Aufgabe der zulässigen Nutzung zurückzubauen und Bodenversiegelungen zu beseitigen; bei einer nach Absatz 1 Nr. 2 bis 6 zulässigen Nutzungsänderung ist die Rückbauverpflichtung zu übernehmen, bei einer nach Absatz 1 Nr. 1 oder Absatz 2 zulässigen Nutzungsänderung entfällt sie. Die Baugenehmigungsbehörde soll durch nach Landesrecht vorgesehene Baulast oder in anderer Weise die Einhaltung der Verpflichtung nach Satz 2 sowie nach Absatz 4 Satz 1 Nr. 1 Buchstabe g sicherstellen. Im Übrigen soll sie in den Fällen des Absatzes 4 Satz 1 sicherstellen, dass die bauliche oder sonstige Anlage nach Durchführung des Vorhabens nur in der vorgesehenen Art genutzt wird.

(6) Die Gemeinde kann für bebaute Bereiche im Außenbereich, die nicht überwiegend landwirtschaftlich geprägt sind und in denen eine Wohnbebauung von einigem Gewicht vorhanden ist, durch Satzung bestimmen, dass Wohnzwecken dienenden Vorhaben im Sinne des Absatzes 2 nicht entgegengehalten werden kann, dass sie einer Darstellung im Flächennutzungsplan über Flächen für die Landwirtschaft oder Wald widersprechen oder die Entstehung oder Verfestigung einer Splittersiedlung befürchten lassen. Die Satzung kann auch auf Vorhaben erstreckt werden, die kleineren Handwerks- und Gewerbebetrieben dienen. In der Satzung können nähere Bestimmungen über die Zulässigkeit getroffen werden. Voraussetzung für die Aufstellung der Satzung ist, dass

1. sie mit einer geordneten städtebaulichen Entwicklung vereinbar ist,
2. die Zulässigkeit von Vorhaben, die einer Pflicht zur Durchführung einer Umweltverträglichkeitsprüfung nach Anlage 1 zum Gesetz über die Umweltverträglichkeitsprüfung oder nach Landesrecht unterliegen, nicht begründet wird und
3. keine Anhaltspunkte für eine Beeinträchtigung der in § 1 Abs. 6 Nr. 7 Buchstabe b genannten Schutzgüter bestehen.

Bei Aufstellung der Satzung sind die Vorschriften über die Öffentlichkeits- und Behördenbeteiligung nach § 13 Abs. 2 Satz 1 Nr. 2 und 3 sowie Satz 2 entsprechend anzuwenden. § 10 Abs. 3 ist entsprechend anzuwenden. Von der Satzung bleibt die Anwendung des Absatzes 4 unberührt.

§ 36 Beteiligung der Gemeinde und der höheren Verwaltungsbehörde

(1) Über die Zulässigkeit von Vorhaben nach den §§ 31, 33 bis 35 wird im bauaufsichtlichen Verfahren von der Baugenehmigungsbehörde im Einvernehmen mit der Gemeinde entschieden. Das Einvernehmen der Gemeinde ist auch erforderlich, wenn in einem anderen Verfahren über die Zulässigkeit nach den in Satz 1 bezeichneten Vorschriften entschieden wird; dies gilt nicht für Vorhaben der in § 29 Abs. 1 bezeichneten Art, die der Bergaufsicht unterliegen. Richtet sich die Zulässigkeit von Vorhaben nach § 30 Abs. 1, stellen die Länder sicher, dass die Gemeinde rechtzeitig vor Ausführung des Vorhabens über Maßnahmen zur Sicherung der Bauleitplanung nach den §§ 14 und 15 entscheiden kann. In den Fällen des § 35 Abs. 2 und 4 kann die Landesregierung durch Rechtsverordnung allgemein oder für bestimmte Fälle festlegen, dass die Zustimmung der höheren Verwaltungsbehörde erforderlich ist.

(2) Das Einvernehmen der Gemeinde und die Zustimmung der höheren Verwaltungsbehörde dürfen nur aus den sich aus den §§ 31, 33, 34 und 35 ergebenden Gründen versagt werden. Das Einvernehmen der Gemeinde und die Zustimmung der höheren Verwaltungsbehörde gelten als erteilt, wenn sie nicht binnen zwei Monaten nach Eingang des Ersuchens der Genehmigungsbehörde verweigert werden; dem Ersuchen gegenüber der Gemeinde steht die Einreichung des Antrags bei der Gemeinde gleich, wenn sie nach Landesrecht vorgeschrieben ist. Die nach Landesrecht zuständige Behörde kann ein rechtswidrig versagtes Einvernehmen der Gemeinde ersetzen.

§ 37 Bauliche Maßnahmen des Bundes und der Länder

(1) Macht die besondere öffentliche Zweckbestimmung für bauliche Anlagen des Bundes oder eines Landes erforderlich, von den Vorschriften dieses Gesetzbuchs oder den auf Grund dieses Gesetzbuchs erlassenen Vorschriften abzuweichen oder ist das Einvernehmen mit der Gemeinde nach § 14 oder § 36 nicht erreicht worden, entscheidet die höhere Verwaltungsbehörde.

(2) Handelt es sich dabei um Vorhaben, die der Landesverteidigung, dienstlichen Zwecken der Bundespolizei oder dem zivilen Bevölkerungsschutz dienen, ist nur die Zustimmung der höheren Verwaltungsbehörde erforderlich. Vor Erteilung der Zustimmung hat diese die Gemeinde zu hören. Versagt die höhere Verwaltungsbehörde ihre Zustimmung oder widerspricht die Gemeinde dem beabsichtigten Bauvorhaben,