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CONCERTO AL PIANO: A SUSTAINABLE URBAN DEMONSTRATION PROJECT

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SBE16 Towards Post-Carbon Cities

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SUSTAINABLE BUILT ENVIRONMENT TOWARDS POST-CARBON CITIES

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CONCERTO AL PIANO: A SUSTAINABLE URBAN DEMONSTRATION PROJECT

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Abstract

Urban pilot project is transforming micro-communities in the heart of Italy's Piedmont region. Concerto AL Piano is a European project aimed to demonstrate the economic and social benefits in investing in energy saving and renewable energy in the process of urban regeneration.
Thanks to the co-operation of the many players in this effort, as well as the support from the region, a previous project of a Photovoltaic Village was a success, and Alessandria became the largest PV village in Italy. Alessandria further promoted energy saving concepts, including encouraging sustainable construction under the banner of Concerto AL Piano.
The project includes a mix of interventions: the recovery of existing social housing, the construction of new eco-buildings and the provision of a district heating system in cogeneration. The project has been governed by a partnership between the local authority, public housing agencies, private building companies, universities and research centres. An urban regeneration process has been set-up to become a key action in the Strategic Energy Action Plan (SEAP) (1).
Concerto AL Piano in Alessandria has motivated many of the local residents to play a part in eco-construction and energy retrofit projects. Getting citizens involved in energy projects is proving to be the key to success for a region's effort to promote sustainable construction and energy saving systems.

1_Introduction

The Concerto district is an area of multiple and complex characteristics: a peculiar structure of the population, a diversified settlement system for quality and density, a socio economic transformation, all elements that constitute a framework marked by symptoms of the transition from an "industrial" condition to a "post-industrial", as well as a transition from a "modern" socio-cultural in a "post-modern". The neighbourhood is fragmented both socially and spatially, characterized by elements rooted in time, consisting of strong ties and constraints of the traditional type and the other, in a continuous redefinition, subject to intermittent use by the population. The relationships between individuals appear only partially characterized by individualistic attitude: anonymity is not the rule. Often, in everyday life, there is a special relationship with the place where the experiences, the symbols, the deepest values bind the individual to the community of origin. All agree in defining this district as "human scale", a place where life is good, where there are no frenetic rhythms and where, therefore, are less pressing and present the problems of large urban areas (2). The Concerto district does not seem to register particular problems or deficiencies. Services, infrastructure and public transport appear good and the commercial network meet the residents' daily needs. The traditional forms of belonging persist and play an important and reassuring role of bonding personal recognition with the area. The research of local identity is manifested in an attempt to return to the past through the recovery of memories, celebrations, traditions of the past, and in the desire to have a viable community. Belonging to the community is a source of local attachment even when this Northern Italian region is not the place of origin, but the area where social relationships become day-by-day satisfactory.

Concerto AL Piano has a strong effect on the urban regeneration of the whole district. Above others, the reduced environmental impact and the local micro-climatic control through greening and absorption by green surfaces. The use of environmental friendly materials, the reduced fossil fuels consumption for space heating and sanitary hot water, the implementation of a large set of technologies and measures to save and reuse water, recycle waste, enlarge green surfaces and limit the speed of cars improve the micro-climate and the local environment.

Given these premises, the planning goals of Concerto AL Piano can be summarised as follows:

- High reduction of fossil fuel consumption in building renovation;
- Integration of renewable energies at the urban village scale
- District heating and co-generation as a network for the urban village
- Local team to promote information campaign, energy conservation scheme
- Municipal energy management and retrofit programme

Three main demonstration actions are developed in Concerto AL Piano (fig.1):

a. RETROFIT _ Energy Retrofitting at the district level
b. RENEW _ Energy Renovation of the existing village
c. NEW _ New Construction of a low-energy village

Figure 1. Plan of Concerto Al Piano Design.

2_The demonstration district

2.1_Energy Retrofitting at the district level

The Energy Retrofit Programme aimed at providing the Concerto district with an energy conservation scheme for 3000 dwellings, based on announcements in local newspapers and letters addressed to the inhabitants. A 20% of the audited buildings (48,000 m^2) were retrofitted following the scheme.
Over the global retrofit investment, inhabitants were asked to contribute up to the 65% of their energy rehabilitation costs. This was organised through local community tenders that have increased the popularity and penetration of the Energy Retrofit Programme at the city level.
The model used for estimating the energy demand of residential building stocks is based on an original methodology, investigated in various settings by the authors (3). It is based on data made available by the Italian census of buildings and dwellings, a specific section of the *population census*. In the census database a number of residential building features are recorded, such as: building age, number of floors, number of dwellings, proximity of buildings. The model is based on a building classification method, that considers a limited number of homogeneous building categories, which are relevant for the assessment of building energy performances. The *National census database* delivers the number of buildings and the dwelling surface area, taking into consideration features, such as building age, number of dwellings, and building proximity. These parameters have been selected to disaggregate the whole building stock into 32 *energy categories*. Building age can be related to the envelope thermo-physical performances, to the ratio of windows, and to the average height of dwellings. In addition, the number of dwellings and the building proximity affect the external surface/volume ratio, an important parameter for the overall energy performance of buildings. The energy demand of the building stock is calculated by associating the consumption indicators or energy performance ratings (kWh/m^2y) to each building category.

2.2_Energy renovation of the existing village

The existing social housing village was needing an urgent energy retrofit, due to the absence of thermal insulation and a very degraded envelope. Then, a deep renovation of 300 dwellings and one school took place, with the aim of reaching up to 50% reduction of the specific energy consumption. The complete refurbishment of 11 buildings belonging to the Social Housing Agency incorporated a wide range of measures: high thermal insulation; air tight windows and ventilation control; greenhouses and glazed balconies; individual heat meters and thermostatic valves; co-generation district heating.
An improvement of the external area is given by the green public square: a new aggregation centre of the urban village. The building outdoors are upgraded by introducing green measures and trees, creating a link between private and public green areas. A visible refurbishment involves the building facades, retrofitted using external fibre-wood insulation. Existing windows are replaced with new double glass, low emission and high performance windows. The south exposures are equipped with passive greenhouses to provide solar gains in winter, thus reducing energy consumptions for space heating.

Figure 2. Social housing settlement before and after renovation.

2.3_New construction of a low-energy village

The new low-energy village includes 104 dwellings and the elderly house for other 50 dwellings, adopting minimal space heating and DHW standards. In addition these dwellings make use of renewable energy: 200 m^2 of water solar collectors; 50 kWp of photovoltaic systems.

The design of the micro-climatic buildings is based on the atrium solution: two building blocks are linked together by transparent atrium to determine an intermediate climate in winter (fig. 3, left side). During summer, the large openings at the ground level and at the upper level guarantee adequate natural ventilation and shadow. The adopted solutions for the overall energy efficiency contemplate the typical measures for eco-buildings: from the walls' extra insulation (fibre paper), to the efficient lighting and water systems. Photovoltaic modules are installed as flat roofing system to cover dwelling electricity needs: 50 kW provide the peak power for summer electricity use. Solar water collectors provide the domesic hot water needs. 200 m^2 of solar collectors are hosted on flat roofs of the new buildings, as well.

The Elderly House is a four floors building, south oriented, with access on the main street. The building design gives privilege to a balance between indoor and outdoor environments, adopting innovative residential solutions for aged people. The space heating consumption of the new social elderly building will provide a 45% reduction compared to the Italian code (fig. 3, right side).

A newly built District Heating Network provides the heating and electricity in co-generation. One of the demonstration issues consists of showing the inhabitants how a central power station could appropriately fit in a populated residential district. A continuous power co-generator (250 kWe), running all the year long, is dedicated to the production of the base load heat and power demand. Heat is produced by an exhaust-water heat exchanger, at a temperature of 85 C°, and delivered to the district heating pipeline. The overall efficiency of the co-generator is above 70%. A natural gas burner (1.250 kWt), running in winter, matches the specific heat demand of the cold season. A plant remote control system drives the co-generator to adapt its power output following the heat demand, granting the highest possible efficiency. A remote control room gets each day the production data, with 15 minutes scansion, as well as any eventual out of order signal.

Figure 3. New village: Microclimatic house (left) and New social Elderly (right).

3_A training opportunity

Thanks to the training programmes offered by the area universities (Politecnico Torino) and government, citizens could easily learn about options that exist for their energy retrofit projects. Advisors helped them plan, build and rebuild high-efficiency housing and buildings. The training sessions involved many levels of participants. To improve the design quality of projects, architects and energy experts worked side-by-side to counsel citizens (fig.4).

In addition to citizens' training, Concerto AL Piano became the topic of an intensive university training activity that involved the students of Politecnico Torino. This project was studied as a "best practice" and a reference for training different topics of sustainable architecture: energy saving, bioclimatic architecture, sustainable and natural building materials, involvement of inhabitants in urban retrofit process. The students were committed in a "learning by doing" experience aimed at re-think, re-design or extend Concerto AL Piano, and explore different possible solutions. The training method consisted in a number of Scenario Workshops, simulating in classroom the urban regeneration strategy. Students were divided into "role" groups: public administrators, inhabitants, experts-architects, builders-investors. Each thematic group analysed problems, opportunities, strengths and weaknesses concerning the urban regeneration of Concerto AL Piano. New groups were formed, mixing all roles and starting a discussion between different stakeholders, in order to establish guidelines and targets for the urban regeneration plan, shared and approved by administrators, inhabitants, experts and investors. Thanks to this kind of *role game* the students had the experience of the complexity of Concerto projects and understood the importance of cooperation in a sustainable urban re-development process. Finally, all students went back to their role of *young architects* to re-elaborate their individual energy regeneration project.

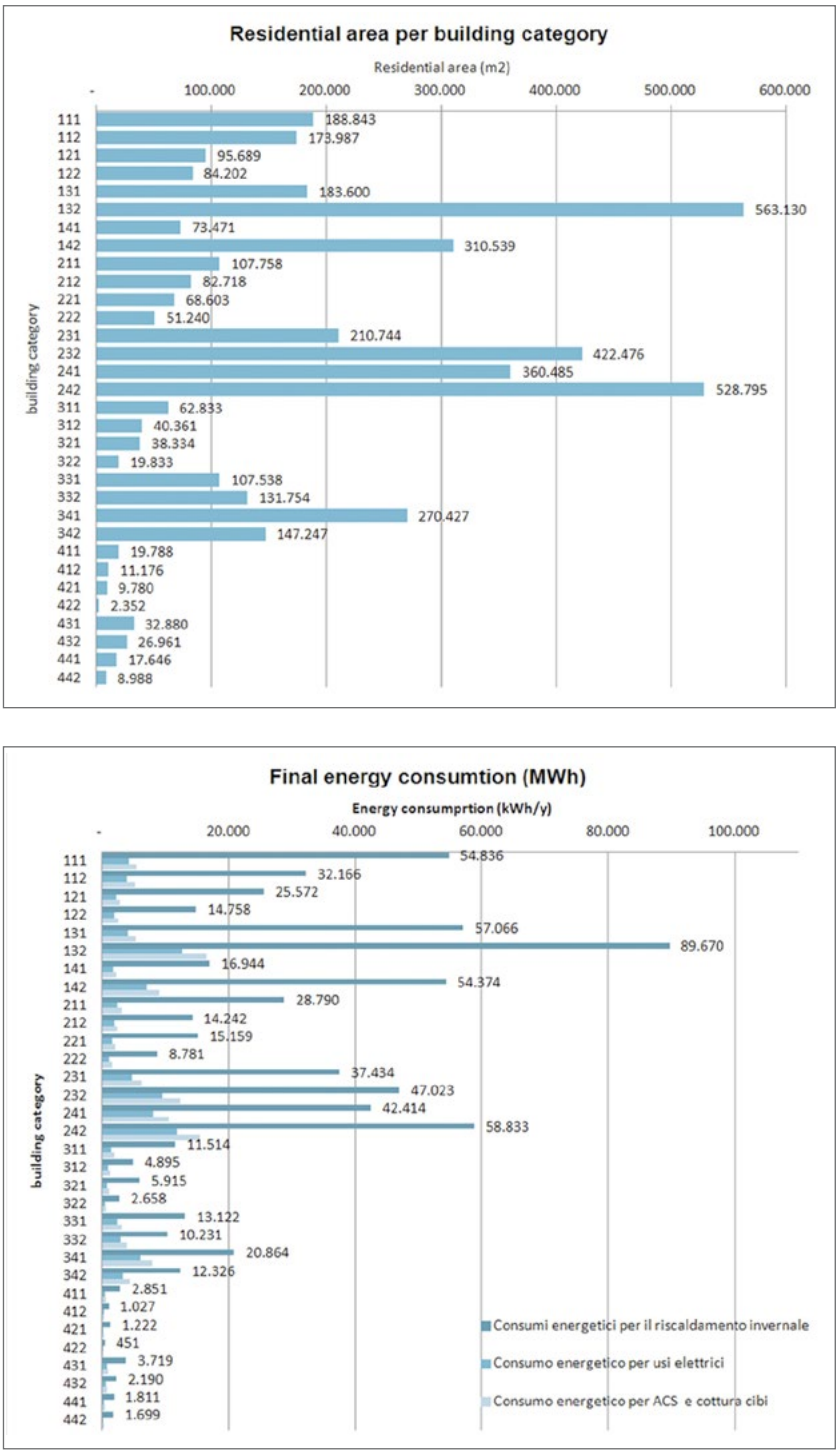
Figure 4. Training activities with students on project site and in the classroom.

4_Monitoring and assessment

4.1_Results of retrofitting

Thanks to a public funding announcement, 42 energy retrofit interventions on residential buildings were funded, corresponding to 239 dwellings with an average area of 90 m^2 each. The total retrofitted surface was 21583 m^2, the total contribution disbursed amounted to EUR 269.760,00 with an average of 12,30 EUR/m^2. For each building a form was completed, with the main information concerning age of building, area, number of dwellings, description of energy retrofit interventions, photographs before and after refurbishment. An energy audit was also performed for each building, following the specific indication of national regulations for energy certification of buildings. The association to each building code of standard assessments of energy performance for heating, electrical components, hot water, and cooking uses, allows to estimate the energy consumption of the whole residential building stock. The simplified descriptive model allows a variety of analyses concerning the energy consumption of buildings, providing the indicators of average consumption for specific portions of the building stock or the distribution of

Figure 5. Retrofit analysis: assessment of residential area per building category (left) and final energy consumption of each building category.



buildings for different performance categories. The energy performance indicators are calculated by matching each category to a virtual building with standard characteristics that were established on the basis of a variety of sources (4-5).

4.2_Results of renovation

The instrumental monitoring under Concerto AL Piano on the RENEW component of demonstration involved the recording of temperature, humidity and natural lighting in a dwelling at the first floor of the building located in via Gandolfi No.15.

For this purpose four dataloggers have been used to survey and record the internal temperature, the relative humidity and the natural lighting levels of rooms and one datalogger to register the same measures outside the rooms. The test dwelling has a net surface of 96.8 m^2 and consists of: kitchen with adjoined greenhouse, living room facing South-West, three bedrooms, two bathrooms.

The monitoring results show some discomfort due to the high indoor temperatures, caused by an excessive supply of heat from boiler. The greenhouses return appropriate data, both in terms of temperature and humidity. The seasonal graphs identify a clear difference between greenhouse temperatures and outside temperatures during the heating season (until April 15). The analysis of temperatures in the summer period shows the alignment between the two temperatures, mainly determined by the tenants opening of greenhouses at the increase of internal temperature. During the heating season the trend lines point out a difference between the inside and outside temperatures of about 5-10 °C, showing that the greenhouse is working properly, leading to energy savings. The kitchen temperature is similar to the greenhouse temperature (6).

As a conclusion, the greenhouse solution applied in a such renovated dwelling provides suitable results. The comparison between the relative humidity values shows the absence of condensation and the acceptable range of relative humidity for the kitchen.

The energy consumption of the eleven existing buildings were evaluated during the design phase of Concerto AL Piano, and assessed after renovation, through energy bills and monitoring. This assessment took into consideration a value of 0,65 as efficiency coefficient of the original heating systems. After retrofitting, both district heating and the temperature control via thermostatic valves played a role in increasing the overall efficiency in energy use, raising from 0,65 to an overall value of 0,87.

Concerning domestic hot water, consumption data of natural gas were collected. These data did incorporate the consumption for cooking, estimated as the 7.1% of the total.

The final results highlighted the large variations among the buildings of RENEW, due to the different state of maintenance of buildings and to the original conditions of envelopes, some without thermal insulation and some others limited to 4 cm. The average energy saving of all buildings is 34%, the maximum is 48% and the minimum is 19% (Fig.6).

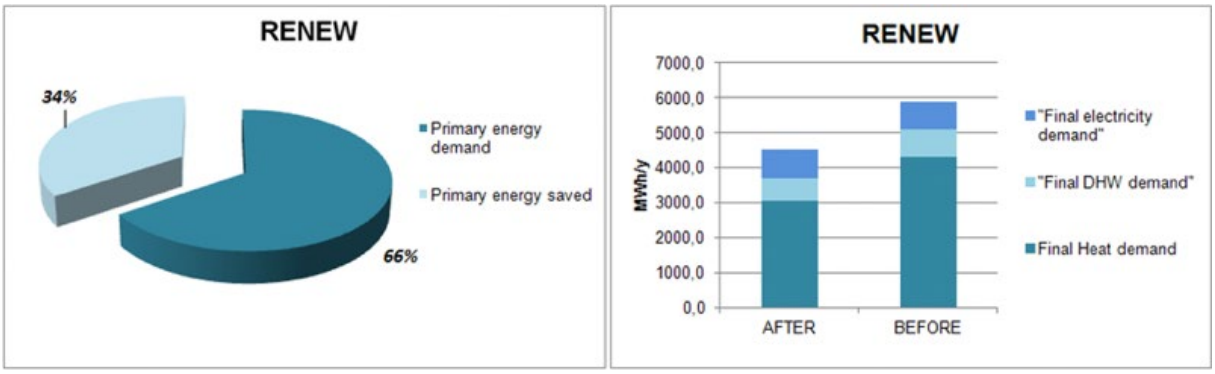


Figure 6. Expected consumption of Social Housing settlement after renovation: Primary energy demand (left) and final energy demand.

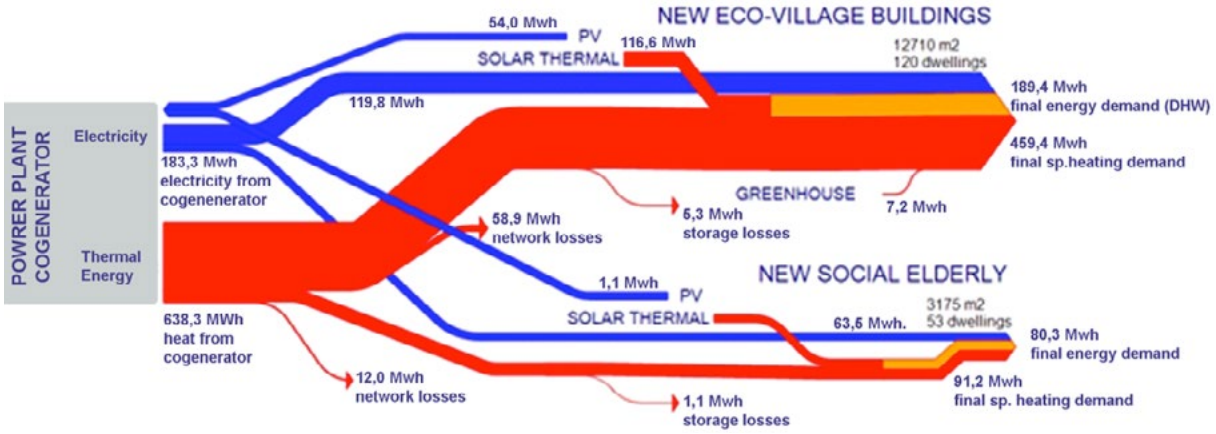
4.3_Results of new construction

Concerto AL Piano process started in 2005. While feeling that the market sooner or later would have required a significant quality improvement, the Italian builders appeared undecided on the energy consumption target values to be adopted. Between 2005 and 2010 in Italy a sudden alignment with low energy standards started, both in legislation, and in the market.

For the building partners of Alessandria, Concerto AL Piano represented an opportunity to tackle innovation, almost simultaneously to the legislative improvements. Nowadays, the energy targets for new buildings are much stricter compared with 2005, thus the results of this demonstration risk to be underestimated.

For the new buildings, the final energy consumption for heating and hot water, and the overall energy demand of housing were assessed. Electricity demand, assessed at 20 kWh/m² per year, corresponds to the average consumption for new buildings in Italy. Production of heat and electricity from solar energy is the result of a simulation, since users are not installed yet. The primary energy consumption has been worked out from the final energy of the buildings, taking into account the energy production by CHP plant and all production and distribution losses (fig 7).

Figure 7. Energy balance of New buildings in Concerto AL Piano project.



4.4_Energy balance of Concerto AL Piano district

The new cogeneration power plant fuelled by natural gas, using typical rates of the plant, provides an overall energy production efficiency of 86.5%, of which 39.6% dedicated to the production of electricity and 46.9% to thermal energy. The evaluation of primary energy consumption for the existing settlement, before refurbishment, was converted from final energy into primary energy using the multiplier of 0.46, which corresponds to the overall efficiency of the Italian national electricity mix efficiency.

Heat losses from district heating networks are ranging between 10% to 16% (7) according to the length of the network. The value of 10% was adopted, based on the reduced size of the network. All buildings are then connected to the new district-heating network through heat exchangers that replace the old boilers, with extra losses estimated at 1%.

The energy consumption monitoring of each building has been performed, efficiency assessments of heating and electrical generation, of the district

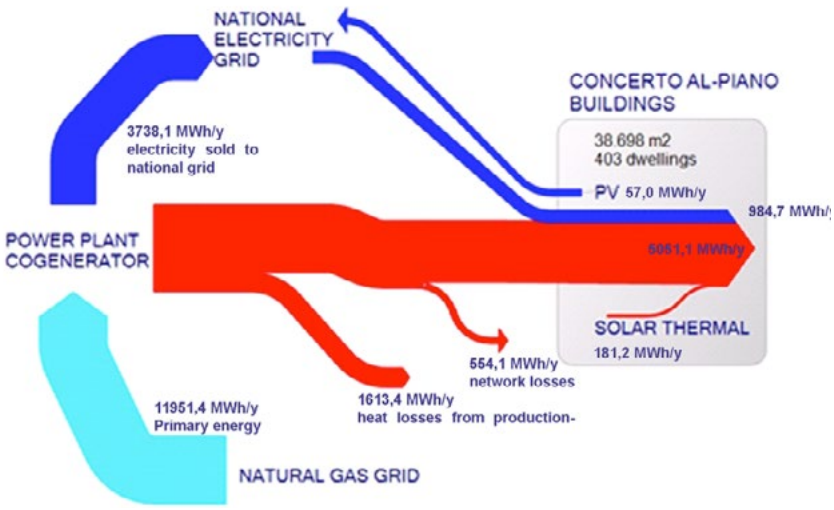


Figure 8. Concerto AL Piano Energy balance.

heating network, and of the cogeneration plant were performed with direct and indirect data (8). As shown in figure 8, the energy balance of the neighbourhood, supplied by the local district heating network, demonstrates a significant reduction in final energy consumptions.

5_Conclusions

This district of Alessandria is deeply renovated by Concerto AL Piano. The transformation is the result of a general improvement of social, urban and architectural environment of the area. The completion of urban voids, with the creation of the New Eco-Village and the New Social Elderly housing, improves the perception and the endowment of the district, otherwise incomplete. What undoubtedly has undergone significant transformation is the energy balance of the neighbourhood: the energy consumption of existing buildings was reduced of an average of 32%, with a potential of 48% that could be obtained with fine-tuning of the systems. New buildings represent the next generation in Alessandria aiming to reduce energy consumption even with unusual typological solutions for housing (building atrium).
Concerto AL Piano clearly shows that:

- the principle of *deep renovation* was applied, with the feasibility constraints related to a public housing market: the retrofitting performed by the Social Housing Agency was the most achievable, both in terms of technology and finance;
- the deep renovation of the existing building stock strongly affects the social and environmental quality of the area, much beyond a few high-quality new housing, that would make even more marked the difference between the old widespread housing and the new construction;
- the extensive energy savings over a large portion of building stock rises the awareness on environmental sustainability concepts, due to the bigger number of families involved;
- in a stagnant housing market, the *deep renovation* of the existing stock becomes a focus for building companies. The initial capital for refurbishment is lower and allows owners to invest even when flats and buildings are not completely deteriorated;

- since a deep building renovation is carried out with rather long cycles – ranging from 40-50 years – when starting a retrofitting one should always maximize the approach: quality, efficiency, saving. Having limited ambitions means that higher targets are compromised until another renovation cycle.

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