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Circular economy and regeneration of building stock in the Italian context: policies, partnership and tools

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Abstract. The paper presents a part of research focused on the definition of circular economy models in the regeneration of existing building stock in the Italian context, identifying policies improvements, strategic partnership and environmental and economic life cycle assessment tools for supporting decision.
Through direct-interviews to operators (investors, designers, manufacturers, etc.), the paper analyses the typical relationships and dynamics among them in the Italian building regeneration process. The operators' opinions and requests towards circular strategies (reuse/recycling at building and material levels) are pointed out, in order to highlight the obstacles and levers of circular economy application. The paper shows the strengths and the weaknesses for the regeneration of building stock by the application of circular economy, the opportunities and the threats for circular economy by its application in the regeneration of building stock. In order to achieve circular requalification processes, avoiding waste and enabling practices of reuse and recycling, the change of relationships, policies and business models are defined. Moreover, the paper discusses on the importance of environmental evaluation of circular practices, identifying the decision steps and operators which, with the support of environmental and economic life cycle assessment tools, can select circular strategies towards sustainable requalification process.

Keywords: end-of-life, requalification process, buildings' regeneration, life cycle sustainability approach, policies improvements, stakeholder opportunities.

1. Introduction

European Commission highlights that the renovation of existing buildings plays an important role in the delivery of the Europe 2020 Strategy and to follow the objective for 2050 (decarbonisation and resource conservations) [1,2]. Hence, circular economy strategies can find a useful application in urban regeneration, because of the necessity to renew the old and inefficient building stock. In fact, in

Europe almost 50% (in Italy more than 60%) of buildings have been built before 1970 [3,4]. Consequently, it is important to modify the dynamics of (re)construction activities, reinventing design strategies, material circularity and resource flows management through new business models, in order to achieve sustainable practices within circular economy perspectives. Currently many targets have been achieved regarding the reduction of energy consumption during the use phase (e.g. NZEB regulation), instead material efficiency of production and end-of-life phases (e.g. reduction of raw materials and waste) is still little treated. Otherwise the material consumption in construction sector is expected to further increase in the future [5]. Also the information management should be changed: no official data are available on the extraction of construction minerals (such as sand and gravel), even if the extraction of construction minerals represents a large share of overall global material extraction [6]. Moreover, it is important to verify the life cycle sustainability of the new circular strategies. In fact, resource efficiency and waste management in term of reduction of material flows, don't match inevitably with sustainability [7,8]. It is necessary that the impacts and benefits of new circular economy management models are assessed within the environmental, economic and social point of view, taking also into account the externalities.

At present time, good practices towards sustainable circularity are thwarted by political, economic barriers and lack of awareness. The research examines the Italian traditional process of building regeneration in order to identify the existing obstacles and the levers towards a sustainable and circular regeneration of building stock. The paper, also, provides a comprehensive approach to support this transition, through the identification of: i) Italian policies improvement, ii) strategic partnerships for circular networks, iii) environmental and economic life cycle assessment tools to support decision.

2. Methodology

Obstacles and levers towards circular processes in the regeneration of buildings come up through direct-interviews to operators. The significant operators in regeneration process are identified and for each operator's typology, the companies which operate in Italian building regeneration with attention to circular themes and environmental aspects (e.g. LEED certificated), have been interviewed. The operators interviewed are: investors (COIMA), manufacturers (Stalbau Pichler), designers (TEKNE), constructors (ANCE), demolishers (CORBAT) and waste managers (REMED). The research, through operators interviews, collects all different decisions step in requalification process.

The objective is to understand the current operators' relationships, practices, design choices and management choices accomplished at the building's regeneration. The choices are related to different possible end-of-life scenarios and different operators' decisions (requalification, demolition, deconstruction). The material and waste flows management and the interchange of information depend on different operators' relationship.

In particular, specific questions have been asked to operators: Which are the decision steps in requalification process? Which are the decision steps in waste management? Which are the legislative obstacles for reuse/recycling? Which are the policies in the Italian context? Are there incentives on requalification or reuse/recycling? Where you can identify potential avoidable waste during the regeneration process? Is your company interested in new business models, such as supply a service rather than sell a product?

3. Interviews to different operators

The same questions have been asked to different operators, in order to understand the decision-making regards regeneration strategies, the different approach to circular economy strategies, needs and requirements.

3.1. Decision-making regarding regeneration strategies

The analysis of decision-making steps is fundamental because it identifies the operator's which have the potentiality to choose between different regeneration strategies and define the role of operator and their relationships. In order to understand the circular approach in the regeneration of building stock,

the investigation focuses on the cause of decision between demolishing or requalifying, the choice of demolition technique and the way to manage CDW. The main role regards the investor, who manages the financial capital and decides the typology of building and the investment destination (selling or renting). Moreover he decides to promote or not promote a design process aimed at achieving sustainability certification. The investor explains the crucial role of 'due diligence' phase for investment decisions and, consequently, for decision about buildings' end-of-life. At first the investor evaluates the residual value of building, analysing the residual quality of building's components and the potential utility floors. In this evaluation the fulfilment of the performances of the existing building's parts with new requirements must be considered, in particular: bearing structure must comply with seismic norms, the shell must comply with energy efficiency performance laws, the typological characteristics of the existing building have to be compliant with new functions. Investor evaluates if it is more advantageous, in economic terms, requalifying a building (maintaining the bearing structure and the other possible parts) or demolishing and rebuild a new one. However, in any case the building's parts that always change are: the interiors (stuff and space plan) and systems (heating water, air conditioning, lighting etc.).

The conducted interviews show the crucial role of LEED certification (the main Green Building Rating System used in the Italian context) in decision-making. Investors want to obtain a certificated building because of the sustainability certification increases the value of building (e.g. the rent can grow between +7% or +11%, with an increase of only +1% of construction cost). A lot of operators' actions depends on the decision to achieve sustainable certification.

The designer's decisions depend on the willingness to obtain LEED certification. The designer decides how to obtain the maximum evaluation level, choices the materials and defines sustainability strategy (respecting the investments fund decided by investor), in addition to the building's image, architectural aspects and, consequently, the utility spaces. On the base of residual performances of elements/components (e.g. mechanical and thermal performance), the parts of building to demolish are decided. However, during the design process, the relationships and interactions between different design teams, that lead the different design steps (preliminary, definitive and executive design) are continuous.

Nevertheless, in the demolition case, the demolition process is decided by demolishers, on the base of financial bid proposed. The demolisher decides the entire demolition: the demolition techniques (traditional demolition, selective demolition or deconstruction), the demolition-yard organization and the waste destination. He is related with waste manager, who collects the demolition waste (according to waste code) and transports (with a specific licence) the waste to landfill or sorting plant (for recycling waste). Among designer, demolisher and waste manager there are not information flows: consequently, the designer, generally, don't evaluate the potentiality of materials-waste generated by demolition process.

Moreover, between investor and demolisher there are financial flows, but there are not information flows. However, the investor's willingness to obtain sustainability certification, forces demolisher and waste manager to respect a sustainable waste management and to declare the waste percentage destined to recycling (in regards of CDW). Hence, the sustainability certification represents a link between the investor's decision and operators behaviour.

3.2. Obstacles for reuse/recycling of materials

The analysis investigates the obstacles on reuse or recycling of material. Resulting from operators interviews, the main obstacles to reuse materials and building elements is due to economic aspects, responsibility and aesthetic aspects. In fact, even if a material can be reused because it has kept the performances required by laws (thermal, mechanical etc.), the reuse process is expensive and it has logistic barriers.

To accomplish the phases of dismantling - storage - reconditioning - certification – reassembling, there is the necessity to pay expert operators for disassembling, reconditioning and reassembling the components, space to storage the materials, transport to reconditioning plant and to return on site and

expert operators for certification of performances of reconditioned components. Moreover, there are no operators which agree to take the responsibility to sign the 'declaration of conformity' (requested by Italian law and CE marking) of reused component.

According to the manufacturer, designer and demolisher, currently in Italy the reuse can concern only decorative components, which have not to satisfy particular mechanical and performance requirements. Moreover, reuse can be achieved in interventions that regards cultural heritage.

Instead, in Italy recycling is more practiced than reuse. However, also in recycling there are still economic, awareness and logistic barriers, as waste manager highlighted.

The main problem of Italian waste regards the recycling of inert aggregates because there is not market requests. Aggregates are also the heaviest demolition waste and the most quantitative waste, about 75-85% of Italian CDW is inert aggregates. In order to give a quantification, in Italy in 2016, 54.4 million ton of CDW was generated (it represents the 43.4% of total Italian special waste) [9]. According with operators interviewed, in Italy the raw materials are not so expensive to stimulate the secondary aggregates request: for example, natural sand costs about 15 €/ton and natural gravel costs about 10 €/ton, while the transport costs 6 €/ton until 50 km.

In practice, even if a better inert materials subdivision on demolition-site would lead to greater demand in recycling chains, the subdivision of the aggregates among different waste codes is very difficult in an Italian building where the main construction technique is represented by a load-bearing structure in reinforced concrete, integrated with bricks in the structural floors and walls in brick and plaster for finishing. Demolisher and waste manager say that, in order to subdivide the materials in the various waste codes, careful (and expensive) cleaning of the materials on site should be carried out for respecting the law on criminal-responsibility about subdivision and transport of materials (ruled by D.Lgs. 152/2006). Consequently, because of the difficult to careful subdivided different typology of waste, many demolishers and waste mangers generalise the waste in one code, which results a legal mix, but difficult to recycling. Statistics show that in Italy, 76% of CWD (soil excluded) is recycling or recovery. This is because the "preparation of recycling" is included. In fact, often the recycled aggregate remains unsold for a long period in sorting plants, decreasing its value. The plant of waste treatment has more gains to withdraw the waste (the gain is about 7 €/ton of mixed inert and 10 €/ton of soil) rather than sell (the gain is about 3-7 €/ton of secondary inert aggregate for road substratum). Differently, metals have a market demand and therefore recycling is practiced. However, in order to achieve efficient recycling process, waste manager says that each objects and materials should have a specific recycling chain and a specific waste code, but currently the waste codes are not so divided (the waste classification groups different metals in a unique waste code). It happens also for the code of insulation materials: there is a lot of type of insulating (fiberglass, mineral wool, wood fibre, etc.) but they can be transported together with a unique code. A lot of separations among waste are accomplished at sorting plant, but many separation processes are not requested by law in spite of their value (e.g. electric cable composed of PVC and copper), so their recycling process is not promoted. Moreover, recycling practices are thwarted by logistic barriers: collection and treatment plant are not widespread in the territory, leading to increase waste transport distances. The increase in distance leads to neutralise economic and environment benefit of recycling. Moreover, in particular for small amount of waste (generated in a medium or small demolition work) a long distance to treatment plant leads to prefer landfill if it is more near. Also because the landfill cost is quite cheap (in according to Italian law 549/1995 the landfill cost ranges from about 1€/ton to 10€/ton, based on different Regions). Regrettably, in Italy there is the problem of illegal disposal of waste, in particular regarding the CDW generated by small building-site. However, recycling practices are also thwarted by less awareness, that leads to prefer raw materials rather than secondary materials.

Another obstacle to recycling is the tendency to produce new products, composed by different coupled materials, difficult to separate. In order to improve recycling process, it is important to move towards the production of easy-disassembled products. Also the entire building should be design for disassembly. So, it is important to highlight the crucial role of designer, that can decide a design for disassembly, in order to forecast the demolition waste and promote recycling process. For this reason,

there is the necessity to create a relationship, based on information flows, between demolisher and designer, in order to define how to effectively manage a design for disassembly.

3.3. Levers for reuse / recycling of materials

The analysis focuses on the identification of levers of circular strategies. Regarding the levers for reuse and recycling of materials and building elements, the interviewed operators say that in Italy there are no incentives (e.g. economics such as tax deductions or bonus) regards the use of specific recycled/recyclable materials. However, the interviews highlight that the respect of LEED criteria represents a voluntary incentive for reuse and recycling. The maintenance of buildings' part, such as bearing structure, the utilisation of recycled materials and recyclable materials are some strategies awarded by sustainability protocols. Nevertheless, particular materials (such as cradle to cradle) are more expensive than others, so the decision to use it, depends not only on the objective to achieve credit in protocol, but also on the investments fund.

Demolisher and waste manager shows that the recycling dynamics has been increased after 2008, thanks to the minimum recycling percentages defined by Directive 2008/98/EC (in Italy D.Lgs. 205/2010). In fact, Directive establishes that, by 2020, the preparing for re-use, recycling and other material recovery, of non-hazardous CDW has increased at least to 70% in terms of weight. However currently, there are no laws that force the demolisher and waste manager to assign a minimum percentage of construction and demolition waste for recycling. The request of sustainable certification, such as LEED, is the unique reason to declare the percentage of waste destined to recycling.

Another lever for the recycling of building materials, in Italy is represented by the Green Public Procurement (D.Lgs. 50/2016), according to which the Public Administrations integrate environmental criteria (CAM: Criteri Ambientali Minimi) in all phases of the purchasing process. The environmental criteria in Italian construction concerns various indications regarding the minimum percentage of recycled materials: 15% by weight of the total of all the materials used, must contain recycled or recovered raw material, at least 50% of the building components have to be selective demolished at the end-of-life, 60% by weight of demolition non-hazardous waste must be prepared for re-use and recycling. Hence, GPP should provide a significant boost to the secondary raw materials market. However the operators have still many doubts about it, and currently there are a very few cases of their application.

3.4. Potential avoidable waste

The analysis investigates on the potential avoidable waste, identifying the steps of process during which, because of policies or linear dynamics, are generated waste which is possible to avoid.

The interviewed operators identify two main steps of regeneration process when it is possible avoiding waste. The first is the fit-out substitution stage in rented building (frequent in real estate). The second is the construction stage. Both stages generate waste that concerns new materials.

Regarding the fit-out, investor and designer show an Italian market peculiarity. In Italy, there is the obligation to declare a conformity of building when the building is finished (called the "End of work", DPR 380/2001 and relative modification). There is not the possibility to rent or sale a building if it is not "finished". The Italian legislation considers as "finished building", the building with finished "shell and core", floors, ceilings, and all systems (heating water, air conditioning, lighting etc.). Often, when the building is rented, the tenant (e.g. a company with strong corporate image), prefers to design the interior, modifying the fit-out in totally. This practice leads to waste new materials. The redesign of interior spaces modifies the placement of systems, consequently the ceilings and floors change. Currently, the fit-out is total conduct to disposal, because of plasterboards and floors have not a reuse/recycling value chain. This type of waste can be avoided if the Italian policies change or if there is the possibility to install fit-out elements which can be disassembled and reused in other places. However, this leads the needs of storage and a different manage of the site. Moreover, a flexible fit-out can reduce the generation of waste, thanks to the adaptability of spaces.

Regarding the construction stage, constructor and manufacturer show how an off-site construction process can avoid a lot of waste. Also in this case the role of designer is crucial, because all process is based on design for assembling. Manufacturer interviewed shows how the maximum industrialization of component and the easy assembling on site lead to increase the design phase (3D software) for modelling each component. The constructor highlights that the lack of off-site techniques in the "price list of construction works" is a barrier to the diffusion. This is because in Italy the "price list of construction works" (settled by L.R.38/2007) represent an economic benchmark for defining and verifying the public tenders.

3.5. Business models

The analysis explores if currently there are business dynamics aimed at achieving circular strategies, or if the operators are interested in new business models. In particular, a different business models based on supply services rather than purchase products are discussed. Investors and manufacturer agree on the potentiality of this different business models but they assert that the applications at building level are difficult, because of the buildings long lifespan and the current real estate market system based on properties. The potentiality of business approach is more accepted on component and elements with short lifespan, such as stuff (e.g. furniture) or systems (heating water, air conditioning, lighting etc.). However, currently, also regarding cradle to cradle certification objects (e.g. chairs), there is not an 'operator' that manage an element/product recovery at the end of its service life, supplying a substitution of it (as a service). According to investor, it is difficult to think a product-service-system about a building element with a long lifespan (such as facades). Nevertheless, if in a future the building will be a "service" (with also long-life-span components supplied as a service) the real estate market can be continue, based on the sale of possibility to built a determined volume and square meters of building on specific site. No longer a trade of building as a "real object", but only a trade of space and the right to build. However, the customer awareness and market evaluation system have to radically change.

4. Proposal of policies improvements, strategic partnership, life cycle tools to support decision

On the base of interviews, policies, strategic partnership for circular networks and environmental and economic life cycle assessment tools to support decision, are discussed.

4.1. Policies improvement

The research shows how it is important to improve policies in order to force or incentive (top-down strategies) circular strategies at materials level (e.g. reuse and recycling) and at building level (e.g. design for disassembly, demolition and construction techniques).

Firstly regarding European policies improvements, it is important:

- *to improve the limits of resource consumption*: "land consumption containment" laws can create a market demand towards building stock regeneration and, therefore, towards the availability of resources stored in buildings; "prohibition extraction of raw materials" laws (e.g. forbidding new quarries) can create a claim towards the use of secondary materials;
- *to promote a Waste Framework Directive more ambitious*: law have to look at quality rather than quantity to recycling of waste, considering the best material to be recycled in terms of effectiveness and sustainability, not heavier ones.
- *to improve the classification of waste code* in order to stimulate a better waste separation and collection towards a value chain for recycling;

Regarding Italian policies improvements, it's important:

- *to clarify policy regarding reuse*, establishing the responsibility of certifications and declaration on conformity in order to improve awareness and confident on reuse of materials;
- *to change policy on "conformity test" and declaration of "end of work"*, in order to change the steps of regeneration process (fit-out) that generated avoidable waste.

Regarding top-down incentives it is fundamental:

- *to promote the use of recycled/recyclable materials*, increasing the percentage in GPP and giving economics incentives or building square meters bonus (such as in the case of energy efficient buildings);
- *to promote the design for disassembly and off-site construction* through the implementation of GPP requirements and adding the techniques in the "price list of construction works", in order to avoid construction waste;
- *to support the creation of operators chain* and network for reusing/recycling materials with economic aid, in order to complete the chains and increase the traceability of waste;
- *to stimulate the use of secondary materials* (in particular for aggregates) in order to reduce the consumption of raw materials, with economic incentives (e.g. tax reduction) for using of secondary materials;

Moreover, regarding bottom-up incentives it is fundamental:

- *improve sustainability certification* (Green Building Rating System) with criteria useful to evaluate the potentiality of design to disassembly.

4.2. Strategic partnership and business models

The interviews show how the difficulties on cooperation among different operators, the lack of specific operators and the difficult to find new business models, are obstacles towards circular economy application. Consequently, the research shows how, in the Italian context, in the waste management chain is fundamental:

- *to define expert operators and space to reuse process* to accomplish the phases of disassembling - reconditioning - reassembly.
- *to define spaces to collect waste for recycling*, in order to facilitate the logistics (collection and transport) of waste to sorting plant also for small amount of waste.

Moreover, the research shows the opportunities to create a link between:

- *designer and demolisher*, also utilising new tools like pre-demolition audit, to have an information sharing about the consistency and quality of materials evaluating possible reuse and recycling of component and materials;
- *designer and manufacturer*, in order to enable the sharing information and needs, also utilising BIM software, defining materials and elements easy to disassemble, enabling reuse;
- *investors and waste manager,* in order to achieve an investors' awareness of value of waste/materials and promote the durability and a second life (trough reuse/recycling process) of materials.

Therefore, the research shows the opportunity to open up new business models:

- *to promotes a supply service chain* (starting from short life span component), in order to recovery materials and activates new business of reused and remanufactured products.

4.3. Environmental and economic life cycle assessment tools to support decision

In order to achieve sustainable circular practices, each decision and process should be assessed with the support of environmental and economic life cycle assessment tools, able to quantify the real impacts, as Life cycle assessment (LCA) and life cycle cost (LCC). The research shows who are the operators that can play the crucial role in decision, and in which decision steps it is fundamental to evaluate the sustainability of different choice. In particular, the analysis identifies two crucial decision-making phase and relative operators:

- *the design phase* among *designer* and *investors*: to evaluate the environment impact with a Life Cycle Assessment and the market opportunities with Life Cycle Costing approach during decision-making on demolish or deconstruct a building. Thus preventing unnecessary waste and maximizing the value and sustainable use of materials;
- *the waste management phase* among *designer*, *demolisher* and *waste manager*: to evaluate the environment impact with a Life Cycle Assessment and the market opportunities with Life

Cycle Costing approach during decision-making on recycling or landfill the waste, in order to drive resource efficiency and sustainable waste treatment.

5. Conclusion

The paper gives a critical overview towards circular economy applied to building regeneration, analysing the current relationships between the operators, policies and practices in regards to Italian building regeneration process. Consequently, it is possible to show the strengths, the weaknesses, the opportunities and the threats of circular processes and regeneration of Italian buildings.

The strengths for the regeneration of building stock by the application of circular economy concern the limitation on resource extraction (currently in Italy about 50 million m^3 of inert are extracted every year) and waste landfill, reducing environmental impacts and obtaining economic benefits both to manufacturers and builders. The weaknesses for the regeneration of building stock by the application of circular economy are represented by the industrial character of 'closing loop system'. Circular economy is easily applied to industrial and standardized process, where the generation of waste and processes are constant. Instead circular economy is applied to regeneration of building stock with difficulties, because the circular strategies are hardly applied on complex systems, heterogeneous processes with dynamic relationships, such as the building stock. In particular, in Italy the traditional construction techniques are difficult to disassembly and the CDW are characterized by heterogeneous aggregates. On the other hand, the opportunities for circular economy by the application in the regeneration of building stock, regards the great potentiality of buildings as material banks. In Italy more than 60% of buildings needs renovation and the buildings represent a stock of resource available to reuse/recycling as materials, in order to provide the need of resources of construction sector, avoiding the extraction of raw materials, and the waste generation. The threats for circular economy by the application in the regeneration of building stock, are constituted by the longevity of building which do not match with circular strategies (e.g. waste forecasting aimed at end-of-life recycling). The regeneration of building stock causes heterogeneous waste widespread in the territory very difficult to monitor. In particular, in Italy there is a lack of business models that promote reuse and recycling waste. Moreover, the regeneration of building stock is accomplished throughout long processes and articulated networks of different operators which are not related each other in continuous way.

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