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From energy renovation to urban renovation: tools for financing urban quality

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Abstract This paper focuses on studying the possibilities for intervention on public and private spaces within the urban fabric, considered an interconnected whole, by applying the lever of financing operations aimed at energy efficiency.

To date, most of the building stock in Europe and the United States has never been subjected to energy renovation processes, and thus presents unsuitable characteristics. To deal with this issue through energy renovation, a variety of financial instruments has been developed based on the principle of recovering the invested capital through savings on energy bills; this paper will analyze these financial instruments considered emerging in the current context.

It will also consider the impacts the set of these interventions may generate in the fabric of the city as a whole, by feeding urban development, by capitalizing on the specific cultures of communities and places, and by cross-breeding urban and natural aspects.

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INTRODUCTION

This article presents some initial elements of a research effort still underway, aimed at improving a methodology to orient financial resources for energy efficiency – sources that are currently available and enormous, through public programmes and, in a different form, through private initiatives – towards actions to improve urban quality. The research considers some modes of operation to take action on urban places whose management straddles public and private partnerships – tending in certain ways to complicate the distinction between the two types of spaces – through an approach aimed at bridging the gap between public finance and private investors through new forms of collaboration.

The research considers how this goal might be achieved, by making appropriate use of the lever of financing for energy efficiency, which is in fact the main financial opportunity available today on a large scale for interventions in the urban fabric, on the national and European levels.

Energy efficiency is commonly managed on the scale of a single building, essentially by focusing growing attention on containing energy consumption; this eminently technical approach is limited to the built environment. As an alternative to this, the research takes into consideration methodologies and instruments that – although relying on energy efficiency measures, at times in fact orient precisely towards obtaining benefits on the scale of the individual building – can consequently play a larger role in regenerating urban areas. An approach of this kind is presented as a genuine paradigm shift in the definition of energy efficiency, taking into consideration not only the buildings, but rather the whole urban environment on the local scale, including impacts on the quality of urban life.

It is important to cast light on some other aspects of the line of reasoning underlying the considerations to follow.

First, the problem of identifying new forms of support for urban renovation has been becoming increasingly important in recent years. This condition is determined by the budgetary constraints to which many public administrations are subjected, and by the diminishing means, in the current economic circumstances, of setting up public-private partnerships; this has drastically reduced the options for intervention, particularly on public spaces.

Second, the very definition "public space" in sharp opposition to "private space" appears increasingly blurring: public activities are carried out in private spaces and the other way around. While this lack of clarity emphasizes uncertainties, it is at the same time a mode that cannot currently be neglected, and that in the specific case may have beneficial implications.

Third, the lines of reasoning that have been set out privilege a small or medium-small intervention scale, with an awareness that the contemporary city is marked by the fragmentation of ownership and of design aptitudes, in the attempt to intercept and redirect this parcelization of players and beyond large-scale interventions, increasingly unlikely planning actions.

Lastly, and consequently, an initial approach is proposed to improving the financial mechanisms that facilitate the implementation of energy renovation interventions, so as to have an effect on public spaces as much as on private ones: in a word, on the city.

This paper will therefore argument starting from the analysis of the building stock in Europe and the United States, characterized by an increasingly complex articulation of differences between public and private, and by a multitude of situations involving the allocation of funds for retrofitting. Consideration will then be made of some ways to bring supply and demand in contact with one another in the area of financing the energy renovation of the privately-owned building stock. These interventions, on the different scales (HVAC, building, open space), will be considered from a technical and financial standpoint. Lastly, the conclusions will take stock of the consequences of the various possible interventions on the urban environment as a whole.

CONTEXT

In Europe and the United States, more than 60% of building stock was built after the Second World War and before the two oil crises of the 1970s, when building energy codes on reducing energy consumption began to be adopted. Therefore, to date, most of the buildings is not energy efficient, and from this standpoint its characteristics are marked by an increasingly clear and unsustainable inadequacy.

Built or open, urban spaces are one of the chief sources of direct or indirect energy consumption; direct consumption comes from the heating and cooling needs of the activities carried out in the enclosed spaces (buildings); indirect consumption derives largely from the islands of urban heat caused by the open spaces where roads, buildings, and any built surface in general absorb and release solar radiation.

A valid operating definition of *energy efficiency* is "using less energy to provide the same or better service". Typically, energy efficiency is a subject dealt with from a merely technical standpoint, with an eye to reducing consumption (heating/cooling, lighting, transportation…). However, energy consumption may be configured as one of the final passages in a long process that starts with applying the quantity of human work needed to acquire the energy itself; it is, in the final analysis, a matter of transforming human energy into mechanical or electrical energy. From this standpoint, the subject of energy efficiency, even before touching on the issues of reducing pollutants and safeguarding the environment, directly regards the issue of the quality of life of the individual – and of urban life, the aggregation of individuals, in a broader sense.

Public space, private space, hybrid space

An important piece of the reasoning lies in the difference between – and coexistence of – public and private space within the urban fabric; the definition of the boundaries between private and "non-private" space is an issue that, on its own, informs the very essence of the European city. In the recent years of crisis, this subject has become more and more vital in the arrangement of intervention processes for cities whose administrations are grappling with increasingly straitened financial limits, along with fewer private financers, which places severe limits on the possibilities for intervening on public spaces.

It is not easy to define what a "good urban space" is: "*[it] is habitable. It generously accommodates life, supports its housed activities. It empowers, enables, encourages people to come and participate*" (White, 2007). In Bruno Zevi's notable definition (1948), "urban space" is space where, in the city, the relationship between people and the built environment takes place: in Zevi's organic vision, the empty space between buildings is a "engraved" space with respect to the closed/built space. The relationships that are carried out in this space shape its meaning, what makes the difference between a simply "empty" space and a space that is to all effects *public*, and that is to say, paradoxically, "full" of the life of the community that built it and that gives it meaning. "Engraved" space itself may be seen and treated as built space, considering it as an "architecture with zero volume" (Aymonino, Mosco, 2006).

The modes of interconnection between public and private were evoked as a key element in urban design, and fundamental for the quality of public life (Jacobs, 1961; Gehl, 2011); in Alexander's interpretation, for example, open spaces are dealt with as interconnections between public and private spaces (Alexander *et al.*, 1977).

The issue of attributing ownership is crucial in urban culture; the definition of the boundaries between types of space (public, semi-public/common, private) – and the relative possibility of interrelationships – is a subject acquiring increasing importance in reasoning about the city. The famed map of Rome by Giambattista Nolli (1736-48) shows publicly accessible space in white, and private space in black: it follows that the interior of churches, the atriums of the palazzos, and courtyards are shown in white. This exception to the usual rules of representation is significant of the custom of that time, which draws the distinction between the *use* of the space and its *ownership*, thereby introducing, in a striking way, the theme of privatization of space as opposed to the public use of private space. It is a theme that recent research has been dealing with increasingly often: "*Now, publicactivities often occur in privately owned and managed space, under the control of private regulations and security*" (Southworth, 2014).

While Venturi provocatively drew "*Nolli's Las Vegas*" (Venturi *et al.*, 1972), more recently Carmona *et al.* (2008) wrote of the process of privatizing space underway not only in the United States:

in the US, downtown urban design, because it is determined by private interests, has become reactive and opportunistic rather than proactive. At the same time, local and national governments are separating the ownership from the management, e.g. in the case of shopping malls or public-private led urban regeneration initiatives, where the security and maintenance is privately managed. In Minneapolis, for example, a number of community gardens are owned and managed by a coalition of not-for-profit organisations, whereas in Tokyo, the management of small public green spaces have recently been taken on board by voluntary organisations.

New uses of space like those described require us perfecting new definitions that go beyond the public/private dichotomy to meet new forms of *semi-public/private* use that are emerging in urban society. Oldenburg (1999), for example, proposes the definition of "third places" to categorize that type of place in which public life is led in private spaces: "*the British pub, French café, or American bar providing examples from the past that remain significant third places in the present. Today these have been supplemented with other forms of third place; the shopping centre, health clubs, video rental stores and a surfeit of new leisure spaces*."

In the neo-capitalist city, the boundaries between the categories of public and private are becoming increasingly blurred: "*If public space as it exists today is not open and accessible to all, neither is it necessarily publicly owned*"; new categories of spaces are emerging, such as the so-called "POPS" (Privately Owned Public Spaces). In some cases, zoning regulations play a major role; for example, in the case of New York, "*POPS arose out of the 1961 New York City Zoning Resolution, which allowed developers to construct additional building floors if a public space was provided inside or in front of the building*" (Miller, 2007).

Giving shape to places: size and time

Defining the shape of urban places is anything but a linear process: the shape of the city has been seen from time to time, for example, as the outcome of a conflict between groups of citizens (Romano, 1993), as being between different communities of technicians (Zucconi, 1989). Not infrequently, current society shows itself to be too fragmented and structured to express a unitary will on defining a place (Bentley, 2004); moreover, certain social groups might be unable to express an awareness of their identity that can be transposed into the physical definition of an urban setting where they can be represented.

The size of the interventions in the urban fabric is further factor that influences the process: the more extended the individual intervention is, the more preponderant is the weight of the individuals that hold the resources, who inevitably claim a central role in defining the places, with immediate effects on the morphological aspects.

Small sites, hedged in by their neighbours, permit innovation only at the scale of the individual building; issues of how public access should be arranged, for example, are already fixed. As sites get larger, there are still fixes round their edges: any new development has to join up with the rest of the world, which is beyond the developer's own control. Larger sites, however, have a greater proportion of inner area which is under the developer's control, as compared with edge which is not. This allows for innovations far beyond the scale of the individual building; for example to encompass new ways of structuring the public spaces which are required within large sites. (Bentley, 2004, p. 72)

As it turns out, not all the players have the same power, awareness, or ability to express their aspirations and strategies, unlike, for example, major investors; this aspect may end up being a discriminating factor, particularly in the case of urban regeneration interventions, which often intervene in parcelled fabrics, and particularly in consolidated urban fabrics.

In most cases, the development of cities covers extremely long time frames; this allows a slow process of adapting the urban form to changeable identities and to the needs of the various social groups that make up the *civitas*. This ongoing process, one of changes coming one after the other, is eased by the reduced size of the individual urban elements, which may easily be shaped or adapted to changing needs and contexts: "*The importance of subdividing residential areas into smaller, better defined units as a link in more comprehensive hierarchical systems is increasingly recognized and is often used in new building projects. Several examples demonstrate that the residents in these small units are more quickly and more effectively able to organize themselves for group activities and to solve mutual problems*" (Gehl, 2011, p. 61).

On the other hand, much of the mass of post-War urban interventions, under the pressure of industrial development, was organized for large, single-function areas, often occupied by large buildings sometimes with no continuity with the historic city. Most of these major developments on the urban periphery carried out between the 1950s and the 1970s have yet to undergo to significant regeneration, which essentially means that many of these urban environments have a half-century of lifespan. It is precisely areas like these that could benefit by subdividing buildings into smaller and better defined units, so they might more easily adapt to the changed demands of society, both in terms of functions accommodated, and of environmental sustainability.

In this particular setting, it is proposed that processes be triggered to effectively regenerate parts of cities, using a methodology that starts from the idea of the possibility of an urban evolution as the sum of micro-situations, through micro-planning and micro-design actions; this approach, however, aims to be complementary, and not exclusively alternative, to large-scale urban planning. The regeneration process should therefore proceed through the gradual and minute development of urban fabrics, by considering public and private spaces synergically, and encouraging the functional mix. At the same time, by introducing a differentiation in dwelling types, these fabrics would more readily to respond to the social and demographic changes that characterize the current dynamics (smaller households, an ageing population, new forms of living together, greater demand for student housing); this set of actions leads to a new densification and greater complexity of buildings and of the urban fabric.

At least in certain cases, it is seen that urban systems tend to present phenomena of self-organization

(Portugali, 2000), such as to allow them to survive – within certain limits – disturbances not macroscopic in scope. While in certain cases “forcing” the urban system through large-scale renovation programmes can bring high costs (in the case of strong system resistance) or even be dangerous (in the case of unexpected “deviations” to be redressed), it might rather be more convenient to support and facilitate forms of self-organization of the system itself, through a crowd-oriented approach that leverages the community’s intrinsic and potential dynamics.

Global financial resources for energy renovation

In 2007, the world population living in urban centres passed the 50% amount; by 2050, the urban population in Europe and North America should attain a steady equilibrium, while developing countries are expected to see this figure double by then, with an urban population climbing to 5 billion people. As things currently stand, cities cover about 2% of the earth’s surface while consuming about 70% of global resources (United Nations, 2014).

In this context, the pursuit of environmental sustainability is a global priority, and energy efficiency and renovation are among the tools that have thus far been most taken into consideration to achieve this. In Western countries, energy consumption by the building stock represents about 45% of the total energy bill: this percentage is higher than consumption by industry and transport. This figure refers first of all to components that may be directly involved in “traditional” energy efficiency processes, such as the building envelope and HVAC, but also indirectly, to the spaces surrounding the built environment.

A number of institutions, such as the United Nations Environment Programme Finance Initiative, the European Commission Directorate-General for Energy, and the President’s Climate Action Plan in the United States, have put together various programmes aimed at carrying out environmental improvement interventions, and have consequently allocated large financial resources: for example, the European Fund for Strategic Investments allocated € 315 billion; US Clean-Energy, US$ 90 billion; a part of the US$ 831 billion allocated by the American Recovery and Reinvestment Act was dedicated to the same purpose; lastly, a consortium of twenty countries, including the most populous ones, gave the Mission Innovation programme US$ 20 billion.

All these initiatives share the underlying reasoning that implementing urban renewal programmes is one of the cheapest and most promising ways to shrink pollutant emissions, cut the energy bill, and reduce dependence on fossil fuels. A further fundamental common element underlying these programmes is that not only are the costs for investing in the efficiency of urban spaces affordable, but that they are in fact *negative costs*, since the energy savings that are obtained through the interventions in question would be able, at current energy prices and over a given time frame (calculated as between 10 and 15 years for the average intervention), to pay back the investment.

BRIDGING THE GAP BETWEEN PUBLIC FINANCE AND PRIVATE INVESTMENT

Given a set of barriers and scepticisms identified in the literature (Würtenberger *et al.*, 2011; Næss-Schmidt *et al.*, 2012), that throw up obstacles to investment in energy efficiency and renovation, programmes like the European Fund for Strategic Investments and US Clean-Energy propose overcoming the traditional lack of financing for energy efficiency and renewal – a dearth due largely to the fact that these investments are often seen as risky, given the uncertainty and difficulty of predicting actual energy savings further to the interventions.

Ideally, a generic financial investment is expected to bring high returns quickly; this tends to orient investors, for example, towards hedge funds, instruments that generally require a large capital in order to be significant. Conversely, funds, including those cited, managed directly by public institutions, are expressly conceived to get the public sector involved in agreements to share risks, by significantly leveraging the financing of private investments: "*allocation of risk between the public and private partners consistent with their willingness and ability to mitigate risks, in order to encourage the private partner to mobilise financing*" (IEA, 2011).

These financial instruments are conceived to incentivize the financial leverage effect: by catalyzing additional financing from the public sector and resources from the private one, for example through co-investment and co-financing, they increase the total capital to implement energy efficiency measures.

Financial instruments help make it possible to implement national or regional supply chains for the energy renovation of building stock: the purpose is to permit long-term planning and economies of scale in supplies and services. Planning is essential, in order to be able to finance programmes to renovate buildings on a large scale, with the involvement of national and local financial institutions called upon to contribute towards making assessments, towards providing technical consulting, and lastly towards delivering the financing.

To finance the renovation of the building stock, a variety of instruments have been developed over time, based on the principle of recovering the capital invested in energy efficiency and renovation measures through savings on energy bills. Some of these instruments have been on the financial market since the dual oil crises of the 1970s (1973 and 1979), and consist mainly of subsidies, loans, funds, and tax incentives. Other more innovative instruments include energy performance contracts, third-party financing, and energy efficiency certificates (referred to as "white certificates"). All these instruments assume that the net cost of investing in energy renovation interventions on the building stock is negative, as it can produce a return for investors.

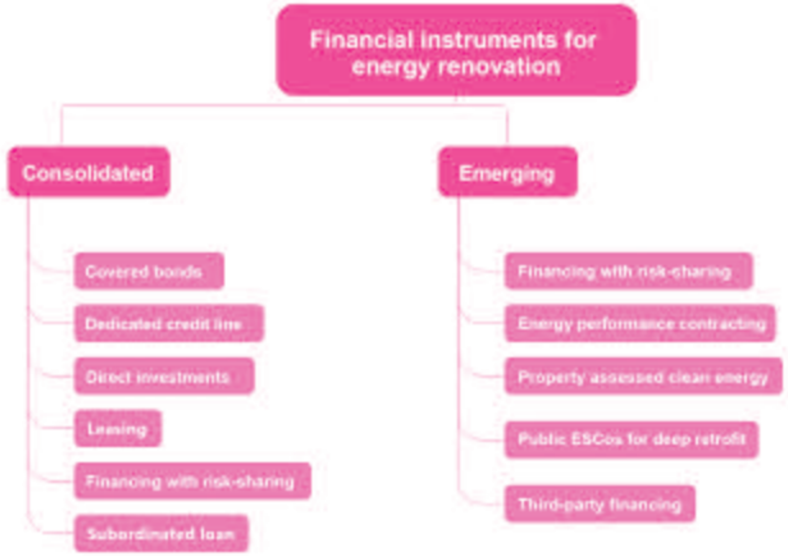

Figure 1 Financial instruments for energy renovation. Besides the established instruments that have yet to show great effectiveness, emerging instruments are coming onto the market.

Emerging financial instruments

To date, established financial instruments have shown limitations in supporting retrofitting measures; in particular, they have failed to offer solutions to the needs of institutional investors, and to the technical complexity and the fragmentation of the majority of interventions on residential buildings. The scale and extent of these interventions require private finance greater involvement.
The financing of deep retrofits has shown to be particularly demanding for financial institutions, given the long (usually multi-decade) payback period, the specific technical skills for their assessment, and the high administrative costs due to the specific size and amount.
This paper considers some financial instruments for which there are expectations, given their capability to attract both investors and building owners.

Energy efficiency investment funds

Funds dedicated to energy efficiency are one of the models implemented through investment instruments. They offer medium- and long-term loans at low interest rates, as they are targeted to building renovation, and are granted mainly to third-party investors or to owners. They have proven attractive to socially responsible investors (SRI) that intend to combine their financial objectives with attention to the issues of environmental sustainability (sustainable finance), and to investors interested in the energy efficiency markets.
These funds ensure a financial critical mass, the absence of which hinders energy efficiency investments, particularly in residential and commercial buildings, because of their complexity and pervasiveness, and the small size of the individual projects.
Case study: in Germany, the national action plan on energy efficiency (BMWi, 2014) calls for an innovative approach to integrating financing and interventions into the scale of neighbourhoods.

Energy Performance Contracting

This is a contract by which an utility finances, develops, and distributes efficiency measures. It makes it possible to manage interventions as a service that the building owners pay for through energy savings, with no initial costs for the owners. It was developed as an alternative to using own financing or capital dedicated to energy renovation.

The energy services agreement is a slightly different contractual type, in which the utility takes over paying the building owner's bills, while the owner pays a yearly commission, generally an amount agreed upon on the basis of historic energy consumption.

Case study: in the United States, RF & DBCCA (2012) has estimated that about one hundred energy services contracts were signed as of 2012.

Property Assessed Clean Energy

Property Assessed Clean Energy, or PACE, was initially introduced in the city of Berkeley to allow the municipal government to provide the financial resources for retrofitting measures. It offers the possibility for building owners to link financing, in whole or in part, to the property assessment. The financing that is delivered is recovered through an agreed-upon increase in the assessment of the property that is the object of the intervention, usually over a 20-year period.

Case study: PACE, an innovative tax financing model, has spread to 26 states in the United States. Owners can apply the PACE model to finance 100% of the costs for energy renovation projects over a period of up to 20 years, via an assessment on their property tax. It allows owners to access financing without requiring initial liquidity. The improvement measures are typically financed by the private sector, such as financial institutions, banks, and insurance companies, for example.

On-Bill Repayment

Repayment through the energy bill corresponds to the amount owed to finance the interventions. The improvement measures are usually financed by utility companies, by multi-utilities, or by a third-party institution, where the repayment is automatically charged to the energy bill.

Case study: in the United Kingdom, repayments through the energy bill were an important part of "Green Deal." Green Deal became operative on 2013, with the purpose of financing energy efficiency measures in residential buildings through financing. Repayment was charged to the electric bill. The programme was scrapped in 2015, because it failed to gain widespread participation (Chandler, 2015; Rosenow & Eyre, 2016).

Public ESCos for deep retrofit

Financing the deep retrofit of buildings requires decades of payback, usually between 15 and 25 years. These periods are not easily handled by private financial institutions, mainly because of issues of liquidity, profitability, and risk. Consequently, public ESCos have been set up as an instrument to provide integrated consulting, design, and financing for owners.

Case study: in France, Energies POSIT'IF is a public/private company, prevalently public, incorporated in 2013 by the Ile-de-France Region with Caisse des Dépôts et Consignations and Caisse d'Epargne to promote the deep retrofit of residential buildings through integration between technical measures for interventions and financing paid out directly.

Third-party financing

This financial mechanism, based on a stable cash flow, is done via the energy savings achieved, usually withdrawn directly from the bill by the energy provider (Energy Charter Secretariat, 2003). There are two contractual arrangements of reference, depending on who is doing the financing and taking the risk – the property owner or the ESCo.

In the first arrangement, it is the owner that takes out the financing and is exposed to the risk of not achieving the expected energy savings. This is the emerging arrangement, and the one of reference in residential interventions. Since the residents' behaviour is an unknown that can impact the savings brought by efficiency interventions, the risk is borne by the owner, which can share it with any tenants, to offset the differences between certified performance and the savings actually achieved.

In the second contractual arrangement, the ESCo borrows the financial resources for the interventions and collects on the energy savings for the measures' amortization period. The ESCo or financial institution takes on the risk of not achieving the planned savings.

Case study: in Spain, the IDAE programme has been financing efficiency projects since 1980. The programme finances all the costs and assumes both technical responsibility and liability for the investment risks. "*In most instances the government agency IDAE works as an ESCo and has invested 95 M€ in renewable energy projects and leveraged another 104 M€ for 144 projects under the third-party finance mechanism*" (European Commission, 2010).

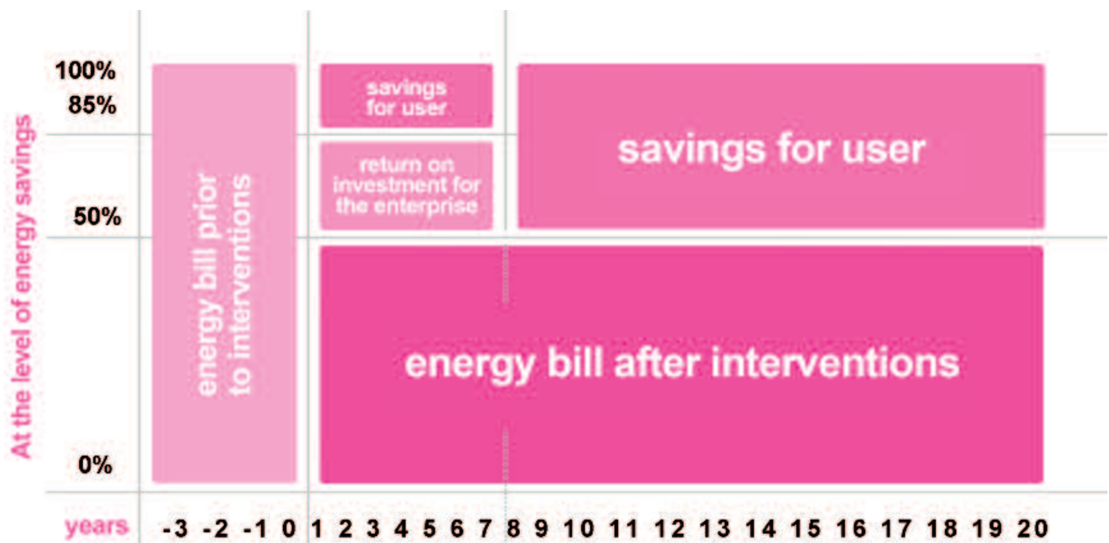

Figure 2 Scheme of third-party financing of an energy renovation intervention on private housing stock

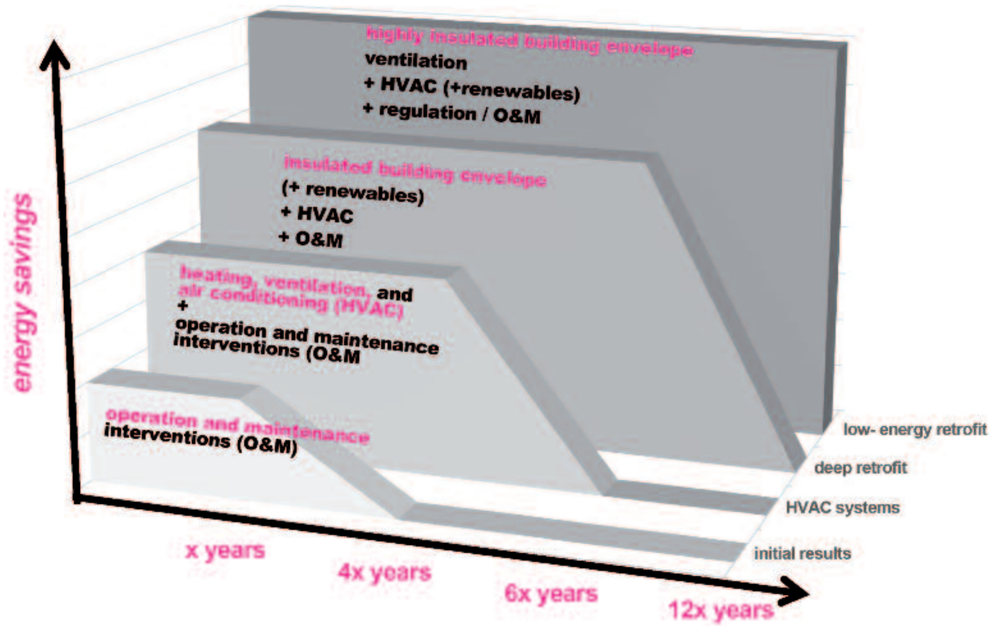

Figure 3 Time of return on investment for different types of energy renovation intervention; in order: operation and maintenance interventions, interventions on air treatment systems, interventions for an insulated envelope, interventions for a highly insulated envelope.

FIELD OF APPLICATION

The hypothesized mechanism is proposed as applicable to portions of urban fabric defined and assessed as a whole; the most appropriate scale may, in general terms, be considered that of the neighbourhood. The choice of intervening on a neighbourhood scale is motivated by the need to extend, as much as possible, the complexity and richness of the urban fabric, in both social and morphological terms, thus excluding the limiting conditions represented by the individual building, considered as an architectural object in and of itself, as well as the urban dimension proper, which clearly introduces different kinds of logic and problems of scale that are anything but straightforward. Considering the urban fabric as a whole, consisting of solids and voids, as discussed above, the possible energy efficiency interventions may be filtered, from an operative standpoint, in accordance with four main classes, in the following manner.

Type of ownership: private, condominium, public.

Type of prevalent intervention: on HVAC systems (for example, solar panels, wind micro-generators, heat pumps, water reuse systems, high-efficiency air treatment systems, and so on); on the envelope (for example: recladding, green roofs, bioclimatic façades, plugging of loggia and of piloti levels, etc.); on open spaces (for example, upgrading green areas to obtain climate mitigation, reducing traffic, eliminating surface parking, bike and car sharing, smart mobility systems, strengthening data networks, etc.).

Financial instruments used: loan for renovation, energy efficiency investment funds, Utility energy services contracts, Property Assessed Clean Energy, public ESCos for deep retrofit, third-party financing.

Activation of public/private partnerships. In particular, this mode of intervention relies on financial instruments developed in collaboration with EU financial institutions in order to give small owners and small businesses the possibility of contributing with their own abilities, actions, and resources towards renovation interventions, which may in turn have impacts on a bigger scale. Loans aimed at efficiency and at energy requalification may then be defined as innovative ways to indirectly finance the regeneration of a vast array of spaces, whether private, condominium, or public.
Here, the combined commitment of the public and private sectors can yield good results for the citizen's expectations: in fact, by combining the strength of both players, partnerships allow effective measures to be put into play in order to attack the aforementioned financial obstacles on a number of fronts, thus amplifying the effects on the market.
A fundamental point is at any rate the fact that, to be fully operational, more generalized efficiency interventions for private buildings would require creating full-blown dedicated markets; as things currently stand, these markets are more the exception than the rule: these dynamics can be stabilized only where there is actual demand with characteristics of continuity. In this context, public/private partnership agreements can help guide the process, particularly by harmonizing the individual financing demands within a more general framework of regeneration interventions. For example, specific financial support might be dedicated to interventions regarding activities with social value, and in particular those capable of impacting the social fabric of the area being considered. As regards the interventions as a whole, it is to be considered that not all types – even if in some cases they are closely interrelated – are possible (or reasonable, or affordable) for all types of space, as charted in Table 1.

		Type of space		
		Private	Condominium	public
Type of intervention	on systems	x	x	
	on envelope	x	x	
	on open spaces	x	x	x

Table 1 Types of intervention depending on the type of space.

As regards types of interventions, some further specifications should be remarked upon, in order to define what their relevance may be from the standpoints taken into consideration – that is to say the possibilities for economic return and, consequently, the impact on the urban environment as a whole, of interventions triggered at their origin by the lever of financing for energy efficiency.

Interventions on HVAC systems
This type of intervention apparently presents a lesser impact on the quality of the urban fabric as directly perceived: as already discussed, in most cases these interventions are characterized by predominant technical aspects, and are not directly visible; this is the case, for example, with actions on heating systems. In some cases, a contribution to urban quality may simply be provided by proper integration between technical installations and the building (as in the very clear case of the installation of solar panels). Another clear contribution is the reduced emission of pollutants in the urban environment. However, one aspect often not taken into consideration in all its potential is the lower costs (that is, the lower energy bill) for the party carrying out the intervention. Consequently, the savings thus obtained may be used to finance more efficiency measures, or simply to improve individual life.

Interventions on envelopes

When considering a typical case of an energy renovation intervention, such as recladding (Figure 4), it is clear right away that the operation, aimed above all at improving the individual building's energy characteristics, has immediate morphological impacts, first of all on the façade of the building itself, on the relationship between the building and the external environment, and consequently on the perception of the quality of the surrounding urban environment. Therefore, this type of intervention – if not considered exclusively from a merely technical standpoint – may present the opportunity to redesign the façade itself, in order to introduce increases or decreases of volume, and so on.

For example, if we consider the typical case of a residential building in a non-central area of the city, placed on pilotis, or with a non-inhabitable ground floor (typically occupied by car garages), the usual technical approach, after intervening on the façade, might typically be that of insulating the intrados of the first-floor slab. Conversely, following a more systemic approach to the problem and considering the condition on the micro-urban scale as well, it might be more interesting or affordable to insert new partitions, so as to enclose, in whole or in part, the volume corresponding to the ground floor. This increase in volume might accommodate new functions, such as for example commercial and/or handicraft activities to increase the functional mix, or new types or sizes of flats to increase the social mix, or, lastly, public or collective activities to improve the quality of the services and introduce gathering places. Instances of this kind produce a change for the positive in the relationship between the building (private) and open space (public, private, condominium), thereby improving the social control of the space itself.

In certain cases, the improvement of the building's energy characteristics may be more massive and follow more radical paths. For example, the addition of bioclimatic façades helps increase the building's volume and floor area (Figure 5). The overall increase in the building's volume can be used to trigger processes of re-articulating how flats are subdivided, thus introducing new typologies (Figure 6). This kind of intervention can be particularly attractive in the case of buildings from the 1950s and 1960s, whose flats were designed for larger households than present-day ones; in these cases, the flats are often underused nowadays, and could be subdivided into smaller units. The final outcome might be an increase in the social mix, due to a new availability of flats, with sizes and characteristics that may be quite different from the pre-existing ones.

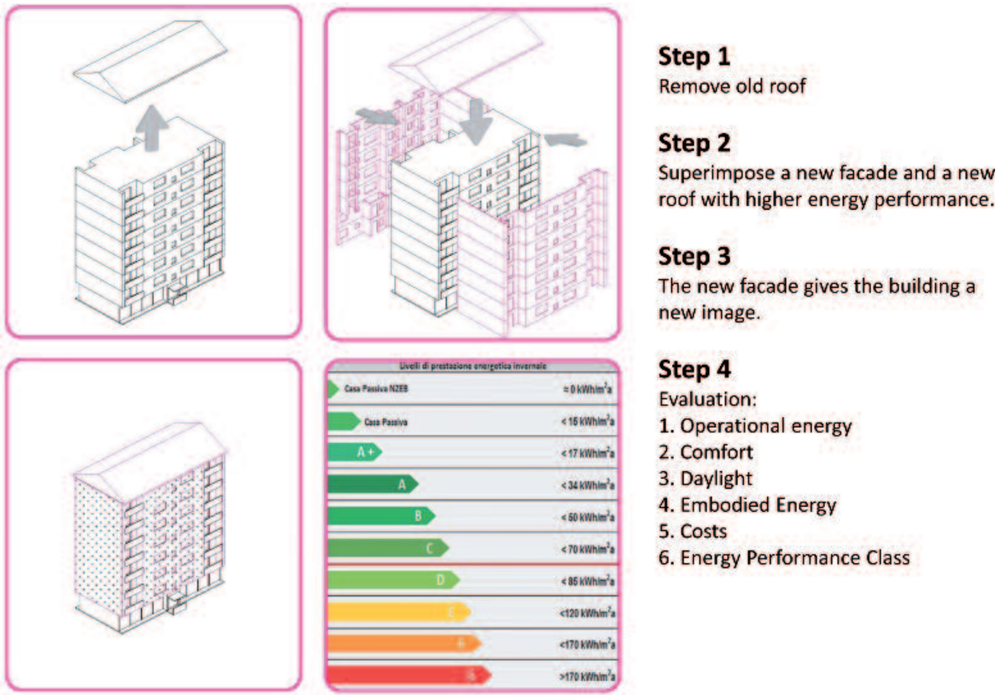

Figure 4 Typical energy renovation intervention:
recladding of the façade and insulation of the roof, with unchanged volume.

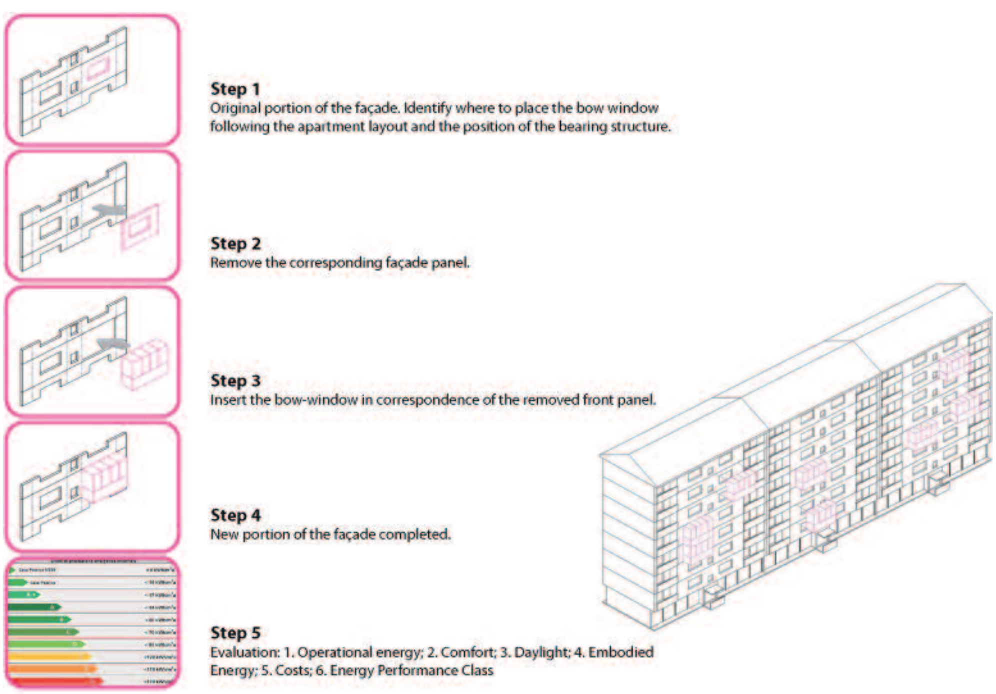

Figura 5 Adding bioclimatic sunspaces helps increase the building's volume and floor area.

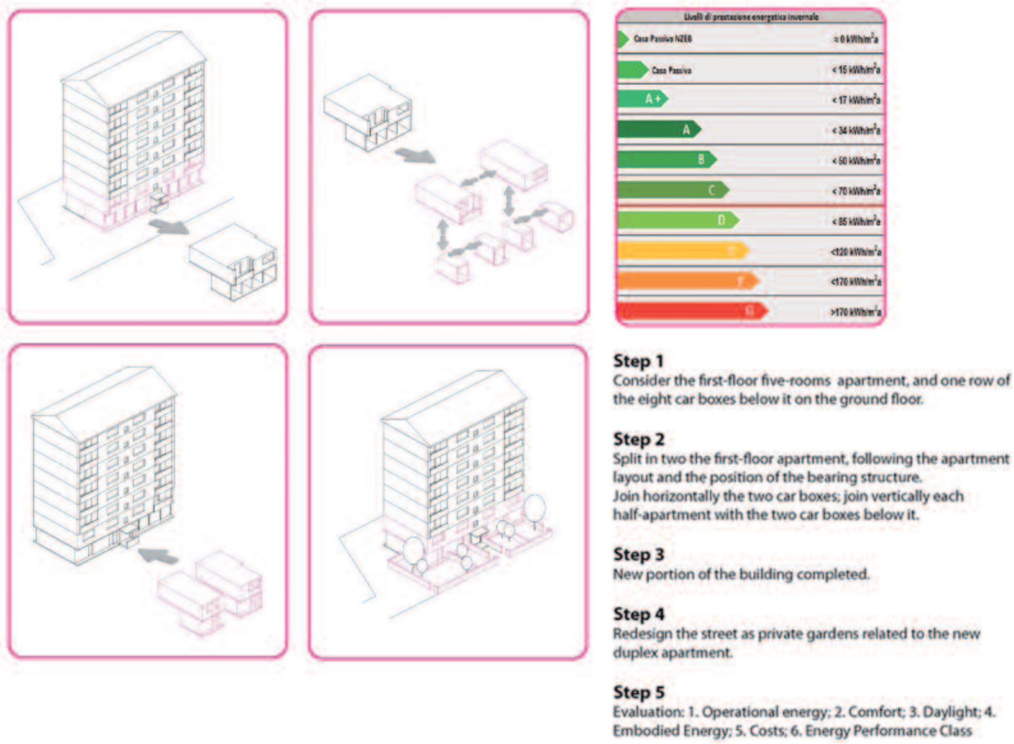

Figure 6 The overall increase in the building's volume can be used to trigger processes of re-articulating how flats are subdivided, thus introducing new typologies.

Interventions on open space, between public and private

The interventions on open space, whether private, condominium in various ways, or public, generally have the purpose of improving urban quality. Given the above-considered tight budgets allocated to this aspect, energy efficiency measures may be able to offer the financial means to operate, as well as presenting a qualification of sustainability through which they are politically acceptable. The range of possible energy efficiency interventions is large, and can involve vegetation, use of materials and of water, and the building shape itself.

The green component.

Jean Nouvel (2012) stresses that vegetation has, in urban design, earned consideration as a construction material in its own right. In open spaces, green plays a role of cooling the environment, both directly through the processes of transpiration and evaporation, and passively, by casting shade on surfaces that otherwise would directly capture the solar radiation, thus giving off heat. In addition to specifically providing places of well-being for the inhabitants, greenery thus has a direct impact on the microclimate.

It has been possible to assess various types of benefits at the micro level – on the level of the individual tree: intercepted rainwater, increased value of neighbouring properties, reduced energy consumption, improved air quality, reduced CO_2 (sequestered and avoided) in the atmosphere; for each parameter, an equivalent amount of money may be stated (www.treebenefits.com). For example, the Environmental Protection Agency in the United States, considering the cost/benefit ratio of planting a tree, estimates a benefit of 1.5-3 dollars for every dollar invested (Climate Protection Partnership Division in the U.S. Environmental Protection Agency's Office of Atmospheric Programs, 2008).

Considering more system-wide interventions on the other hand, the systemic effect of planting trees, city gardens, and parks brings immediate positive consequences on the surroundings: the denser the vegetation, the more energy is absorbed, since the plant mass acts a black body (Dessì *et al.*, 2016).

Use of materials. Investment in improving the thermal properties of the materials in open spaces plays a major role in controlling the microclimate. This effect may be achieved by making the surfaces more reflective. The albedo of materials and surfaces – defined as reflected solar radiation divided by incident solar radiation – is a critical factor. Even if the results of investments in high-albedo materials are lower than those obtained using plant masses, the low cost and relative feasibility easily permit large areas to be treated, with positive outcomes for the local environment (Ting 2001).

In this setting, one of the most important aspects related to material is permeability: the use of permeable materials in pavement increases water absorption, thus reducing runoff. Moreover, massive impermeable materials generally have the disadvantage of accumulating heat during the day. Another interesting type of paving material is photocatalytic cement, which uses titanium dioxide (TiO_2), thereby permitting the conversion of nitrogen oxides (NO_x) into nitrates (NO_3) (Demeestere, 2008).

Water. The use of water, in the form of fountains, canals, and water bodies, can play a major role in defining the shape of open urban places. A role parallel to that of using water as an element of urban design – in its various forms – is that of integrating hydraulic infrastructure in order to reuse or recycle drinking water, waste water, sewage, and rainwater. For example, rainwater management can be integrated into the design of planters, green roads, and parks, taking the form of bioretention systems, ponds, swales, and so on.

The presence of water can also have a cooling effect on the microclimate, and can improve air filtering and quality, by trapping microparticles and pollen. Water can cool through evaporation, or by trapping heat in its mass, when large, as in the case of a lake for example, or by "transporting" heat outside an urban centre, as in the case of a river. Kleerekoper *et al.* (2012) estimate that the cooling effect is between 1 and 3°C within a 30-35 metre radius from a body of water. The positive effect is affected by the area and mass of the water, or by whether it is in movement or squirted, as in the case of fountains, for example.

Hydraulic infrastructure tends to be expensive; a careful cost/benefits analysis is thus needed, to compare investments with the energy saving effects produced by the intervention, also in order to assess the degree to which the intervention may in the final analysis be reflected in savings on the bill. In general, it is considered that the installation of fountains or other elements that employ the evaporation of water has a positive cost/benefits ratio if integrated into infrastructures dedicated to reusing or recycling water: "*combination of evaporative systems may decrease the average ambient temperature between 1–2 K, while the maximum decrease varies between 1 and 7.1 K.*" (Santamouris *et al.* 2016).

Elements inserted into open spaces. The microclimate is influenced by the orientation, size, and shape of buildings and of open spaces, and their relationships: "*There is a subtle trade-off in street design which aims to maximize ventilation, dispersion of pollutants and solar access, while not compromising shelter and urban warmth*" (Santamouris, 2013, p. 11).

Since this paper considers only interventions of urban regeneration in existing fabrics, and not new settlements, the set of available interventions is from this standpoint relatively reduced; for example, rows of trees or green walls to shield buildings or open places, wind barriers, shelters, arcades, shading elements (fixed or mobile), and so on.

At maturity, the trees easily reach across streets, creating an enclosed 'roof' that improves the microclimate, especially during the summer. The same effect could be achieved along downtown streets. Sun access controls would provide direct sunlight during spring and fall, when it is needed for comfort and when trees are without foliage. [...] Buildings have to provide shelter during the winter. Along the new commercial streets on the former railyards, continuous arcades could run parallel to sidewalks, and instead of extended underground walkways, open arcades could shelter pedestrians from snow and rain. The sidewalks outside the arcades could be wide enough to provide sunny walks during the times when people prefer sunlight. During warm seasons, the arcades would be attractive places for outdoor restaurants (Bosselmann *et al.*, 1995).

CONCLUSIONS: IMPLICATIONS FOR THE CITY

This paper considers the ability to intervene in a synergistic, targeted way on public and private spaces within the urban fabric, considered as an interconnected whole, through the lever of financing with funds allocated to energy efficiency.

Energy efficiency interventions thus comprise portions of private and public areas, built and open spaces, new interventions or retrofits, through a number of scales: from building to plot, and from block to neighbourhood. The set of these interventions may lead to results of densification and greater complexity of the urban fabric, and to an intensification and diversification of the activities that the fabric accommodates: extension and insertion of residential, commercial, and tertiary activities, enlarging buildings vertically (solar greenhouses on roofs) or horizontally (façade solarspaces), requalifying the building envelope, and retrofitting. The set of these interventions feeds urban development by enhancing the value – through micro-interventions – of the specific cultures of the community and places, through an intertwinement and cross-pollination of urbanism and natural aspects (Figure 7).

Combined interventions on the public and private space may permit smart, low-carbon urban regeneration and development. By triggering and facilitating self-organization processes, a series of targeted interventions on the built environment and on open spaces, when taken jointly, may bring the coordinated effect of modelling a green network based on the individual urban initiatives. Green networks foster interaction between urban centres and peripheral and rural areas, reintroducing and strengthening the connection between urban fabric and landscape, agriculture and nature, bringing clear benefits for the local economy, also through the urban farming in an extended city setting; lastly, green networks particularly benefit the movement of species and the integration of ecosystem services, carbon capture, and the mitigation of urban heat islands by means of corridors that give rise to effective natural ventilation, thanks to the opening of urban canyons oriented towards the cooler surrounding rural areas.

It is essential to point out that the set of interventions taken into consideration, whether brought to bear on private spaces or operating in public ones, have impacts on both.

Taken as a whole, these operations seek their own means of financing in funds in various ways oriented in their mission towards energy efficiency. The shrewd use of these instruments, which are becoming massively available in this field, to the detriment of other, traditional sectors of urban intervention, may be the key to refocusing the discourse on the issue of the quality of urban space as such.

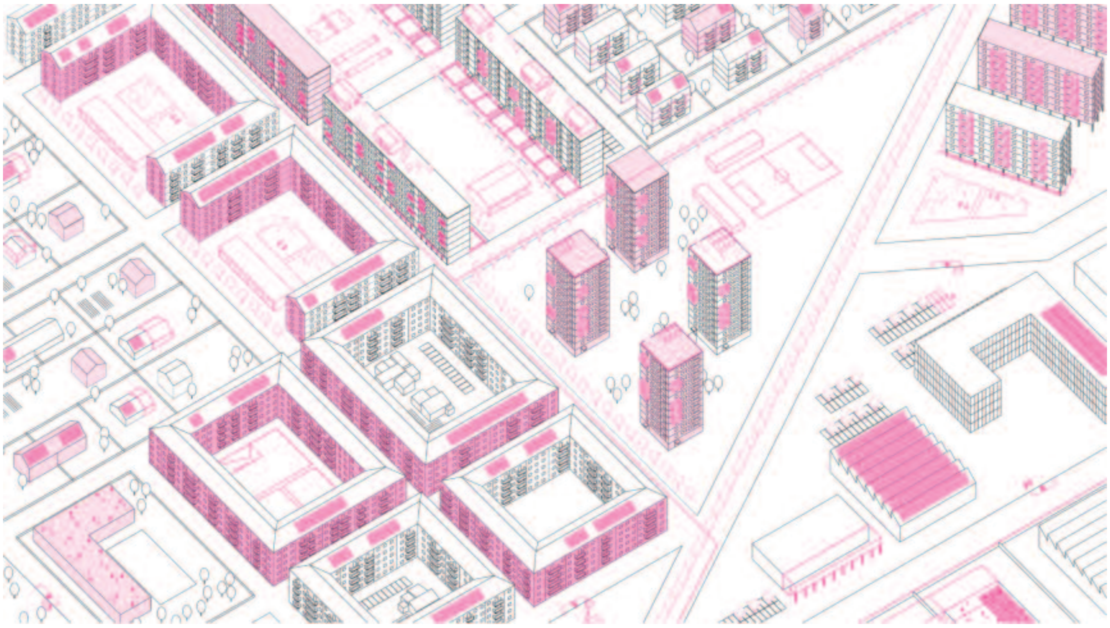

Figure 7 Arrangement of synergistic energy efficiency micro-interventions on public and private spaces, producing a coherent urban milieu.

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