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Sigmund, Zvonko

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Barriers and Incentives for Extensive Implementation of Combined Seismic and Energy Efficiency Retrofits

Z Sigmund

University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia

zsigmund@grad.hr

Abstract. European cities usually consist of old building stock, which often present social, financial and tourist center points of the cities. With regards to sustainability and in accordance with the aim of the European Union to limit soil use, to keep usefulness of existing building stock and to ensure sustainability, the EU invests a lot of effort in promoting energy efficiency and low-carbon emissions. On the other hand, even though large parts of the EU are seismically active regions with questionable seismic resistance of older built environment preventive seismic disaster risk reduction measures are attracting less investments. Additionally, private investors are reluctant to invest in seismic safety of their buildings for a number of reasons. As seismic and energy efficiency retrofits should be implemented together to prevent damage, life and financial losses as well as to reduce costs of works that would otherwise be duplicated, the aim of this paper is to review and discuss barriers which limit the possibility to extensively undertake combined seismic safety and energy efficiency retrofits. Moreover, several incentives used in different countries are presented in the paper that might reduce or eliminate barriers and increase interest of private investors in investing into sustainable development.

1. Introduction

The resilience of the society against all kinds of hazards has become a major concern generally and just as the Energy efficiency hype disaster risk resilient buildings might be the next big issue in the civil engineering industry. World Bank Group [1] reports that when it comes to preventive protection measures for protecting people and the built environment, a trend to increase resilience of the critical infrastructure or even the entire built environment (if an excessive vulnerability is expected) should be observed. This is also the case of Switzerland [2], or Nepal [3]. Nevertheless, “green investments” in the area of energy efficiency still seem to attract investments more easily than the projects aiming at reducing the impacts of possible hazards.

According to the United Nations World Summit, sustainability needs to be based on three main pillars: environment, society and economy. However, in order to cover all these three pillars, disaster risk reduction has to be a part of the sustainable development, as natural hazards could have major impact on both the society and the economy.

Recently, European Union has invested large efforts in increasing sustainability level of the built environment. Majority of these resources has been directed at energy efficiency and low-carbon emissions to enable achievable development and reduce hazards related to climate change. Special care has been dedicated to existing buildings which are responsible for 40% of current energy demand [4–5]. In some cases, renovation and retrofitting activities have been prioritized over new building construction to limit carbon emissions, urban expansion and soil use, which is in accordance with the European aim to achieve “No net land take by 2050” [6].

Even though huge parts of Europe are seismically active regions (Figure 1), less effort has been made to reduce seismic vulnerability of the existing built environment, thus it can be assumed that regions in seismic areas can achieve a lower level of sustainability as their buildings remain questionably earthquake resistant.

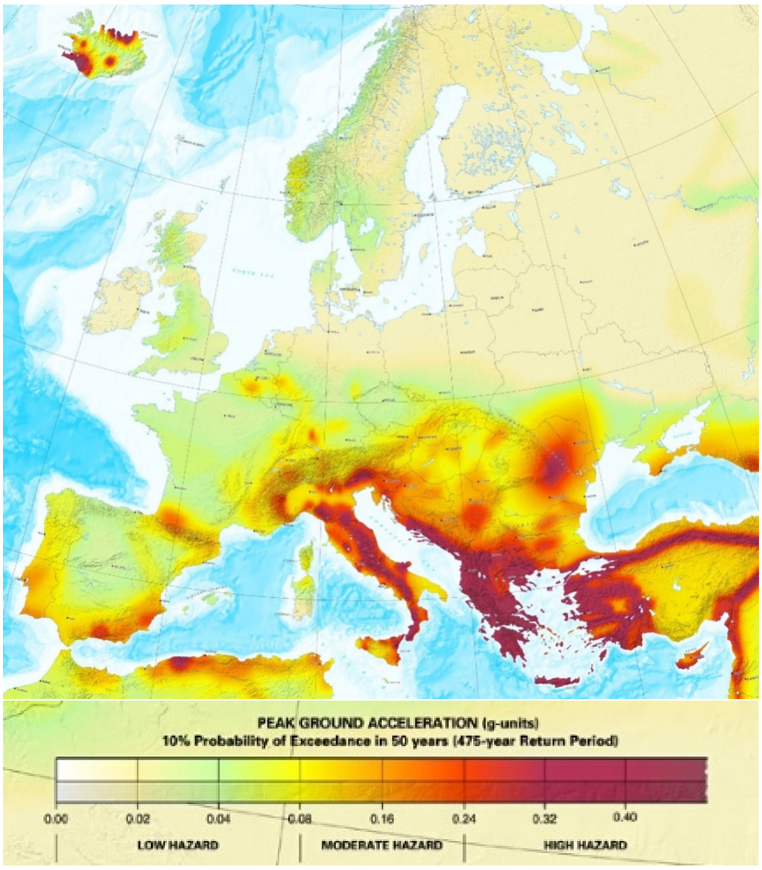

Figure 1. European-Mediterranean seismic hazard map with 475 years return period [7].

Seismically prone areas energy retrofits need to be combined with seismic retrofitting for two reasons: to prevent life losses, damages and financial losses due to earthquakes and to reduce costs for works that are otherwise duplicated.

As the seismic retrofit usually tends to be major investment with no instantly obvious results and due to the general belief that the relevant earthquake will not occur during the lifetime of the investor, the interest of private investors for investments in seismic safety is rather low, moreover for energy efficient retrofitting there are no subsidies. Therefore, this paper aims at reviewing and discussing the barriers which limit the possibility to extensively undertake combined seismic safety and energy efficiency retrofits. Furthermore, several incentives are analyzed in the paper that might help to reduce or eliminate barriers and increase the interest of private investors.

The idea behind this research came out after attempting to professionally implement the freshly developed and tested methodology for seismic disaster risk analysis which should provide means to get a full overview of the building’s current state, the existing risks to loss due to seismic exposures, and provide the owners with the overview of potential costs of reducing the risk and disastrous effects of earthquakes on analyzed buildings.

2. Seismic retrofit and energy efficiency renovation

2.1. Seismic vulnerability of the Croatian region

Together with Greece, Turkey, Bulgaria, Romania, Iceland, Italy, and most of Balkan states, Croatia is earthquake-prone as well. The seismicity of Croatia is characterized by earthquakes of medium-large magnitude spread all over the country. According to the Croatian seismic hazard map (Figure 2) [8], the reference peak ground acceleration varies between 0.08-0.38g on bedrock for the return period of 475 years [9].

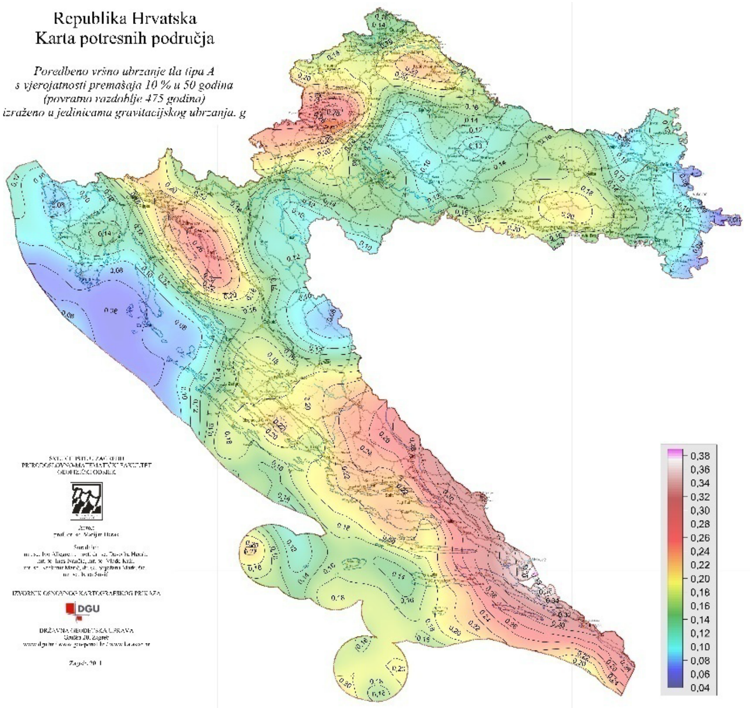

Figure 2. Croatian seismic hazard map with 475 years return period [8].

Moreover, first seismic provisions were introduced in 1964 in Croatia, after the Skopje earthquake. Additionally, approximately half of residential units built after 1964 were designed for the seismic loads that were less than 50% of the seismic load according to valid Croatian seismic standard Eurocode 8. As a result all these could be considered as potentially vulnerable.

With regard to the risk estimation at global level in the framework of Global Assessment Report [10], the probabilistic seismic hazard assessment was developed and used for risk estimation. For Croatia, considering earthquake hazard, the average annual loss is estimated to be 153 million USD, while the probable maximum loss for five mean return periods (100, 250, 500, 1000 and 1500 years) is estimated at 1.7, 3.6, 5.7, 8.4 and 10.2 billion USD. At the pan-European level, the seismic risk of 28 EU countries (Croatia included) was assessed by Corbane et al [11].

Regardless how catastrophic the potential losses have been, not many investments were made to reduce the seismic vulnerability of the existing building stock [12]. Just recently the seismic risk awareness seems to have gained some importance as several items of Croatian research started to question the seismic vulnerability of local buildings stock [13].

2.2. Seismic retrofit strategies

Seismic retrofitting requires considering some peculiarities in contrast to the usual procedure followed in strengthening for static loads or energy efficiency upgrade. Three distinctive features of a structure should be considered and well-coordinated for a successful seismic upgrade: stiffness, ultimate resistance and deformation capacity. When considering seismic retrofitting, one should avoid retrofitting strategies overly focused on one single distinctive feature of a structure without considering the possible negative consequences of the other features.

For seismic retrofit of an existing building, one or a combination of the following strategies should be used [14]:

- Improving the regularity of the building
- Strengthening the structural elements
- Increasing ductility by preventing brittle failure
- Softening the structural system through reduction of its stiffness
- Building foundation damping
- Mass reduction
- Change the use of the building

All these strategies include removal, weakening, repair or addition of constructive elements to an already existing and usually inhabited building. Such interventions can be costly and invasive to the building structure as well as to the living space of the inhabitants.

Historic and listed buildings which in Europe account for around 30% of the current stock [4], need dedicated solutions due to conservation issues and the variety of building materials. These buildings in Croatia generally have unreinforced masonry bearing walls and, according to their material and cultural value, they need to be strengthened with specific interventions, such as application of anchoring and tying devices, mortar injections, overlay of RC or fibre-reinforced polymer layers, bracing (e.g., steel sections, reinforced masonry, buttresses), insertion of internal or external frames or post-tensioning of unreinforced masonry walls [15].

2.3. Energy performance of Croatian building stock

By becoming a full member of the EU and pursuant to Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, the Republic of Croatia has, together with other Member States, assumed the obligation of increasing energy efficiency in order to achieve the objective of saving 20% of primary energy consumption at EU level by 2020. Therefore, Croatian government established Environmental Protection and Energy Efficiency Fund in 2003 as a non-budgetary fund. The Fund has the objective of co-financing home energy retrofits, energy efficient construction, use of renewable energy sources, more energy efficient public lighting, fostering green transportation and energy efficiency in industry. The Environmental Protection and Energy Efficiency Fund (EPEEF) implements and co-finances a number of other programmes and projects related to energy efficiency and use of renewable energy sources [16].

To reduce the energy need of this sector in the last decade, the Directive on the Energy Performance of Buildings (EPBD) has effectively promoted increase in the energy performance especially for new buildings. However, new buildings have little influence on the overall demand on energy, since their influence on the whole building stock is very low. Nowadays, new buildings increase the existing stock by on average less than 1.5% every year, while the demolition rate is estimated at around 0.2–0.5% per year [17–18]. Therefore, nearly 85% of European building stock predicted for 2030 already exists.

This data suggests the need to improve the performance of the existing building stock to reduce energy consumptions and greenhouse gas emissions. According to the EPEEF, Croatia has about 50 mil m^2 of residential buildings. In the year 1987 first regulation concerning energy reduction applied. However, it is estimated that the majority of buildings was built prior the year of 1987with over 83% of buildings not complying even with the standard form 1987. These tend to use more than 150 – 200 kWh/m^2 of heating energy, which classifies them into the energy efficiency level E [16].

The energy efficiency retrofitting is usually financed with 60% of EPEEF co-funding of the retrofit and 40% of the investment from private funding. The co-financed retrofits are, however, limited to the exchange of the buildings outer doors and windows, outer insulation upgrade, installation of an energy efficient water heaters and finally renewable energy sources installation [16].

2.4. Current energy retrofit intervention strategies

Nowadays, there are two main solutions for enhancing the energy performances of buildings [19]:

- to reduce energy consumptions; and
- to promote the energy production on site through Renewable Energy Source (RES) systems.

The first solution is generally addressed by increasing the thermal resistance of the building envelope (e.g., application of insulating layers on walls and roofs, and replacement the existing windows with high-performing ones), by providing sun shading devices, by improving the air-sealing (in particular for cold climates), by exploiting bioclimatic resources (solar radiation, night ventilation, etc.), by improving the efficiency of Heating, Ventilating and Air Conditioning (HVAC) equipment, and by changing operational schedules.

The second strategy, which is often combined with the previous one, is mainly accomplished by installing solar panels (photovoltaic, PV, and/or solar thermal, ST), which nowadays represent one of the most cost-effective solutions for energy production on site, especially in southern and central Europe, where sun-based RES systems turn out to be quite efficient [20–22].

Both strategies may also be optimized and interconnected by a Building Energy Management System (BEMS), i.e. a computer-based control device that supervises and monitors the mechanical and electrical equipment of the building (e.g., HVAC, RES, lighting and power systems), according to the comfort requirements and occupancy regimes. BEMS are currently used mostly for commercial and industrial buildings, but they may be effectively installed also in residential ones.

In addition, in this case, specific solutions should be considered for historic or listed edifices, which present valuable facades not suitable for external insulation application or conventional RES system installation [23]. These buildings generally need non-invasive retrofit techniques, such as insulating and/or phase-change-material plasters, internal wall insulation [24], specific solutions for PV or ST integration, etc.

3. Barriers to seismic and energy retrofit integration

Authors Sigmund and Radujković [25] have identified that critical barriers for construction projects on existing buildings are:

- Ownership risks
- Laws, regulations and standards risks
- Government shifts and elections risks
- Historic design documentation risks
- Past problems register risks
- Expert estimations and Structural condition risks
- Investor and Owner risks
- User–heritage protection risks
- Project feasibility

These risk sources have been identified as risk sources for the whole retrofitting process, however, in the case of multi-family building with shared ownership, the risk sources identified as critical suddenly get another dimension. Based on the literature review and on the authors experience in the case of a project on a shared ownership building, the decision making criteria shift from a decision making procedure based on research results and experience of the project management team, as in a case of an infrastructural construction investment or in a case of a private investment with a single investor, to a simple decision making based on the crowd psychology. In this case the vague understanding of the problem addressed is simply overruled by the question of “why the investment and what is my immediate benefit? “. Other than the simple quarrel of misunderstanding, this following section considers and discusses the known barriers that might affect combining seismic and energy efficiency retrofitting strategies.

3.1. Technical Feasibility of Retrofitting Interventions
The principle of sustainability generally leads to preferring renovation activities to demolition and reconstruction practices [26–27], since renovation may keep and reuse building structural components resulting in savings in resources and reductions in waste.

However, seismic retrofit can sometimes be technically unfeasible or not recommendable. When discussing retrofitting on shared ownership buildings, the economic feasibility is usually not set as the first priority or not considered at all, as the possible cost of interventions usually scares the owners more than possible consequences of an earthquake, thus the economic feasibility is not even considered. Technical feasibility of the interventions where the usual seismic strengthening interventions would have low or no positive influence on the seismic resistance of the building, are discussed here. This applies especially at the buildings in a very poor state of conservation, with weak and carbonated materials and/or affected by significant design or construction errors. For such buildings, any retrofitting measure may turn out to be ineffective, both from the technical and the economic point of view. In this case, the most sensible solution would be to change the retrofitting strategy.

3.2. Cost of Seismic and Energy Efficiency Retrofit
Costs have usually a key role in undertaking renovation actions. Retrofitting expenditures strongly depend on many variables, such as state of conservation, type of selected intervention, number of stories, total floor area, plan irregularities, presence of adjacent buildings, local seismicity, soil type, local prices for materials and labour cost, etc.

Recent studies have calculated the costs for the combined energy and seismic retrofit of blocks of flats which represent one of the most frequent building types constructed in urban areas. This cost currently ranges from 100 to 230 €/m3 [28].

The main contribution to these renovation costs are attributed to the seismic strengthening component that ranges from about 50 to 150 €/m3. High expenditures, along with a difficult access to capital and an unwillingness to incur debt, often discourage building owners from supporting seismic renovation practices, especially considering that earthquakes are uncertain regarding the time and place of their occurrence. Therefore, owners tend to believe that earthquakes will spare their families and properties and consequently repress eventual preventive activities.

3.3. Temporary Alternative Accommodation for Occupants
Retrofit activities imply heavy works with partial or complete blockage of building accessibility which implies the necessity of emptying and leaving the house during retrofitting works, which, on the other hand, may last for several months. This entails a relevant disruption to the occupants, additional rental costs for an alternate accommodation, a stressful interruption of everyday routines as well as psychological concerns about the real and timely conclusion of the refurbishment works.

3.4. Insufficient Awareness and Skills
Building owners are often unaware of the real seismic vulnerability and energy performance of their dwellings.

With specific reference to the seismic vulnerability they tend to assume that earthquakes are unlikely events. Therefore, unless they are driven by the emotional push of a recent devastating seismic event, they are often inclined to neglect the relevant efforts necessary for a seismic renovation. In addition, energy performance issues are also usually ignored by building owners, who often do not monitor their energy consumption and costs, do not fully comprehend the effectiveness of specific retrofitting technologies, and might not be keen on learning about renovation options.

Even if seismic and energy retrofitting works and related financial or fiscal incentives were available in Croatia, they would require a specific knowledge and expertise, while there is a lack of consulting agencies, skilled professionals (architects, engineers, auditors) and qualified constructors.

There is also a strong need for a simple and reliable decision-making tools to compare different seismic and energy retrofitting scenarios, select the best option in terms of costs, available incentives and financial aids, improved seismic and energy performance, thermal comfort, increased property value, and reduced disruption to the residents.

3.5. Consensus to Retrofit Expenditure by Condominium Ownership

This barrier may represent the most relevant one, particularly in cases where the property of multifamily buildings is largely fractioned. In this case, it is usually difficult to find a consensus for expensive and demanding renovation initiatives among all the owners, especially for incentives as seismic retrofit, where the immediate benefit is not immediately visible. In addition, personal dislikes related to past disputes may further complicate decision making.

Moreover, in the case of a short decision time-frame, owners might neglect the best choice for the building performance and instead opt for solutions that suit their personal interest. For instance, elderly people are often not willing to engage in renovations, and the same may occur to tenants or owners who expect to move soon elsewhere.

Even if the approval of renovation works is legally insured by the absolute majority of owners, substantial practical difficulties arise every time that one or more owners disagree with the undertaking, especially if they do not have sufficient financial resources. Dissenters may severely delay decision making or even jeopardize technically necessary retrofitting activities.

3.6. Bureaucratic Obstacles

Building owners and professionals also have to face bureaucratic obstacles. More than several months can pass before obtaining a building permit, especially for renovating protected or listed buildings. This is mostly due to confusing regulations, which often overcomplicate the procedure, to the fragmentation of competences among many different agencies (responsible for architectural design, structures, listed buildings, etc.), and to the inertia of the offices in charge of releasing permits.

Moreover, the access to fiscal incentives is complicated due to some aspects. For instance, it is now necessary to follow two distinct and parallel procedures for seismic and energy renovation, increasing the likelihood of making mistakes and consequently of missing the incentives.

4. Possible incentives

As a combined seismic and energy efficiency retrofit is a relevant financial undertaking that turns out to be unaffordable for most people, the retrofit costs often represent the most relevant barrier. In this paragraph, financial and regulatory incentives used in some countries are listed and commented with the aim to uncover the views on how previously listed obstacles could be reduced, if not eliminated completely.

Practice has shown that fiscal incentives are an effective measure to encourage private investment seismic and energy efficiency retrofit. A positive example comes from Italy where the government has been offering tax credits, allowing subtracting 36–65% of refurbishment costs from the tax due, with deductions equally distributed over 5 or 10 years. In 2017 these shares for apartment blocks are: 75–85% for seismic upgrades (according to the reached seismic vulnerability), with deductions distributed over five years, and 70–75% for energy upgrades (according to the reached energy performance), with deductions distributed over 10 years. For all these costs, the current regulation also allows reducing VAT from 22% to 10% [15].

Providing specific tax incentives, different retrofitting on existing buildings in addition to more general urban renewal tax provisions seem to be a superior way of ensuring quality care existing buildings. Specific funding mechanisms, as used in the USA, which utilize tax incentives, including relief from income tax, property tax, value-added tax (VAT), transfer tax, inheritance tax and capital gains tax, may apply only to the particular taxpaying parties [29]. However, the proposed mechanism forces the low-income owners to either sell their property (which is now lower priced due to badshape) or to live in bad conditions. Potential unwanted effects of this nature can be resolved by allowing tax-exempt entities and low-income owners to receive a higher level of grant assistance, as is the case of Netherlands.

Low-interest loans have been lately getting more attention and are available in a number of countries. An owner may combine a grant in addition to tax relief and the remainder in the form of a low-interest loan to cover repair costs. To alleviate cash flow problems, grant awards may also be provided in the form of a short-term loan pending satisfactory completion of works and payment of the award. As in the USA, the low-interest and the guaranteed loans, in addition to grant aid and fiscal incentives, can be used to encourage conservation activity [29].

In some cases, as in Belgium, Germany, Netherlands, and the UK [30], some architectural heritage buildings may be entitled to a property tax exemption, deduction or freeze. These are usually raised at the municipal government level. This principle is usually used in cases of an unoccupied heritage buildings to claim an exemption. Taking advantage of these incentives, in particular the tax credit, as well as the reduced energy bill after renovation, the investment for combined seismic and energy retrofitting may be repaid within 10–11 years, as highlighted by previous studies [31].

An effective way of promoting building renovation is the imposition of a seismic label to rate the seismic safety of a building. This label has been recently adopted in Italy [15] and works likewise the energy one, which has been already imposed by the EPBD to rate the energy performance. However, thus far, the energy performance certificate for the sale or rent of buildings has still had little effect on the market price of the real estate [15]. To increase the value of the renovated stock, the seismic and energy label should also be supported by a new taxation for real estate transactions, which should be indexed according to the reached performance.

Moreover, governments could promote mandatory insurances to cover damage from natural hazards as in Turkey or New Zealand [32], with premiums based on the same label. The risks faced by the insurance company in case of earthquakes or other natural hazards can be opportunely alleviated through new security tools, like the catastrophe bonds (namely “cat bonds”), which allow transferring some of these risks from the insurance company to the investors [15].

Countries such as Croatia, with low level of state subsidies, must rely heavily on direct regulation to conserve heritage assets. This strategy is neither popular nor efficient as owners of protected heritage structures must bear the burden of repair and maintenance costs, with little or no compensation from the government. Sanctions, however, for non-compliance with regulatory policies, in most cases, are limited to the use of the architectural heritage buildings, and in reality, authorities are reluctant to use force against private owners without economic compensation and only take action in the most severe cases. In the worst cases, the owner may be expropriated and the building is assigned to a caretaker. Where deliberate neglect of a protected structure (listed building) can be proved in the UK, legislative provision exists for minimum compensation. Following expropriation, buildings may be sold to a Building Preservation Trust for repair [33].

5. Conclusion

Sustainability needs to be based on three main pillars: environment, society and economy. For these three pillars to be achieved, disaster risk reduction has to be a part of the sustainable development. Just as energy efficiency is currently the biggest imperative in Europe, the disaster risk resilience has been gaining importance.

In seismically prone areas, energy retrofits need to be combined with seismic retrofitting for two reasons: to prevent life losses and damages and financial losses due to earthquakes; and to reduce costs for works that are otherwise duplicated.

In this paper, barriers limiting the possibility to extensive implementation of seismic and energy efficiency retrofits were identified and reviewed:

- technical feasibility of retrofitting interventions
- cost of seismic and energy efficiency retrofit
- temporary alternative accommodation for occupants
- insufficient awareness and skills
- consensus to retrofit expenditure by condominium ownership
- bureaucratic obstacles

For an incentive to be implemented to achieve, sustainable development, it requires a political commitment at a national level through statutory regulations combined with financial support mechanisms at a local level. Therefore, prior to adopting proactive and financially demanding incentives, removing bureaucratic obstacles and creating a good and healthy investment environment is a priority.

Possible incentives, used to simulate retrofitting activities, can be divided into two groups:

- Financial incentives
- Regulatory based tools and measures

As financial incentives to promote any type of retrofitting works on existing buildings, financial subsidies, tax exemptions and low interest loans can be highlighted. Each of those has its own positives and negatives. For instance, tax exemptions are great if the aimed end-user of the incentive is a high-income owner of an old building, but a low-income owner will not have a great use of this type of an incentive. On the other hand low-interest loans could attract more low-income owners, however such incentives are usually accompanied with a lot of administrative work.

Regulatory based tools and measures are also used to promote retrofitting works. For the government, the simplest way to promote an incentive would be to order the measure as obligatory, however, this method is usually unpopular and ineffective. A good measure on the other hand, would be a mandatory, governmentally subsidized insurance fund, but the best regulatory measure would be the one that combines also some type of a financial incentive as for instance obligatory seismic safety rating combined with tax deductions in accordance with the seismic safety and energy efficiency rating.

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