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Benefits from energy related building renovation beyond costs, energy and emissions

Marco Ferreira[a]*, Manuela Almeida[a]

[a]University of Minho, Civil Engineering Department, Campus de Azurém,Guimarães 4800-058, Portugal

Abstract

The relevance of the building sector in the global energy use as well as in the global carbon emissions, both in the developed and developing countries, makes the improvement of the overall energy performance of existing buildings an important part of the actions to mitigate climate changes. Regardless of this potential for energy and emissions saving, large scale building renovation has been found hard to trigger, mainly because present standards are mainly focused on new buildings, not responding effectively to the numerous technical, functional and economic constraints of the existing ones.

One of the common problems in the assessment of building renovation scenarios is that only energy savings and costs are normally considered, despite the fact that it has been long recognized that investment on energy efficiency and low carbon technologies yield several benefits beyond the value of saved energy which can be as important as the energy cost savings process.

Based on the analysis of significant literature and several case studies, the relevance of co-benefits achieved in the renovation process is highlighted. These benefits can be felt at the building level by the owner or user (like increased user comfort, fewer problems with building physics, improved aesthetics) and should therefore be considered in the definition of the renovation measures, but also at the level of the society as a whole (like health effects, job creation, energy security, impact on climate change), and from this perspective, policy makers must be aware of the possible crossed impacts among different areas of the society for the development of public policies.

Keywords: Building renovation; Energy efficiency; Carbon emissions reductions; Life cycle costs; Optimization; Co-benefits

* Corresponding author. Tel.: +351 912 354 865
E-mail address: marcoferreira@civil.uminho.pt

1. Introduction

In the existing building stock relays a huge potential for actions to the mitigation of climate change through the reduction of non-renewable energy use and consequently the reduction of carbon emissions. However, this potential has not yet been fully explored, partly due to social and economic barriers [1].

Normally, energy related building renovation is evaluated considering the trade-offs between savings resulting from the reduction of energy use and costs of implementing the energy saving measures [2]. This traditional approach disregards other relevant benefits resulting from the interventions and thus, underestimates the full added value resulting from the energy related improvement of the buildings [3].

In fact, building renovation measures improving the energy performance of buildings usually trigger benefits to the residents such as increased comfort, reduced problems related to the building physics, improved air quality or reduced exposure to energy price fluctuations. These benefits improve the building quality and the residents' well-being and presents economic benefits beyond the reductions of the energy bill. The added value of energy related renovation measures for a certain building refers to the difference in the market value of this building before and after the improvement of its energy performance and results from the valuation from the market of the future energy related costs and of the other resulting benefits (co-benefits). From this, the inclusion of the co-benefits results crucial for decision makers involved in these projects.

Besides these decision makers, also policy makers have to consider the impacts of policies and actions promoting the renovation of the existing building stock in several areas of the policy action such as health, employment, energy security or climate change [4], [5].

Figure 1 illustrates the multiple benefits and co-benefits resulting from the intervention in existing buildings with measures to improve the energy performance and reduce carbon emissions.

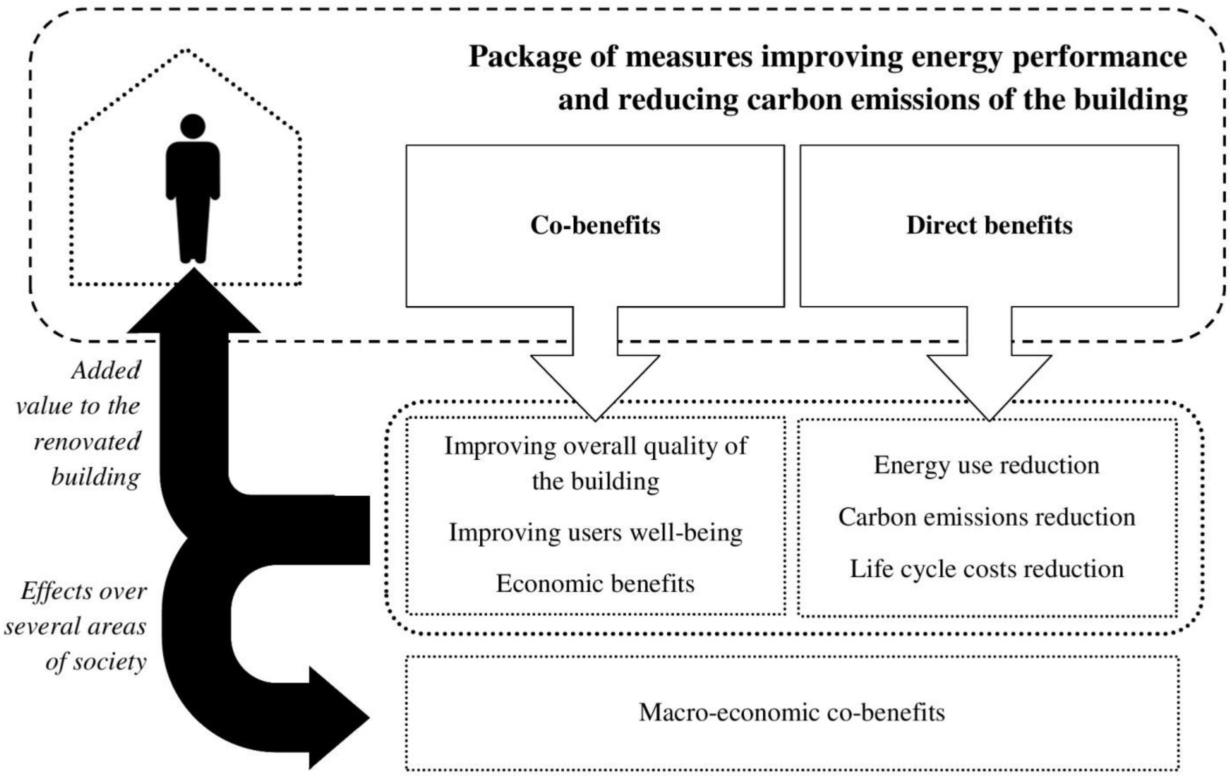

Figure 1 Direct benefits and co-benefits from cost effective energy and carbon emissions related building renovation

Considering the described background and because existing standards do not take into account these co-benefits, the methodology developed within IEA EBC Annex 56 project in search for guidance for cost-effective energy and carbon emissions related building renovation of residential buildings towards nZEB, highlights the co-benefits resulting from a building renovation process and offers guidance on how to consider them in the decision making process [6].

The main purpose is to guide the policy makers in the energy related policies and assist the owners and promoters in the choice of the best renovation measures, considering the overall added value [6].

For policy makers the societal perspective is more relevant, once it highlights the effects of the building energy renovation in areas of the political action dealing with health issues, economy, employment, energy security and climate change mitigation as examples. For the owners and promoters the private perspective is more relevant and it considers the benefits at the building level such as the increase of comfort, less problems with the buildings physics and improved aesthetics [6].

2. Co-benefits according to the perspective

Based on the analysis of relevant literature and numerous case studies, co-benefits have been identified and catalogued according to the perspective of the main target groups. The private perspective mainly refers to the building level being relevant to owners and promoters and the macroeconomic perspective is more relevant for the policy makers.

2.1 Private perspective

In private perspective, the reduction of the global costs of the renovation intervention and the maximization of the added value of the building are the main concerns. The reduction of the global costs to the minimum corresponds to the cost optimal level, which tends to be the market based solutions if co-benefits are not taken into account (Figure 2).

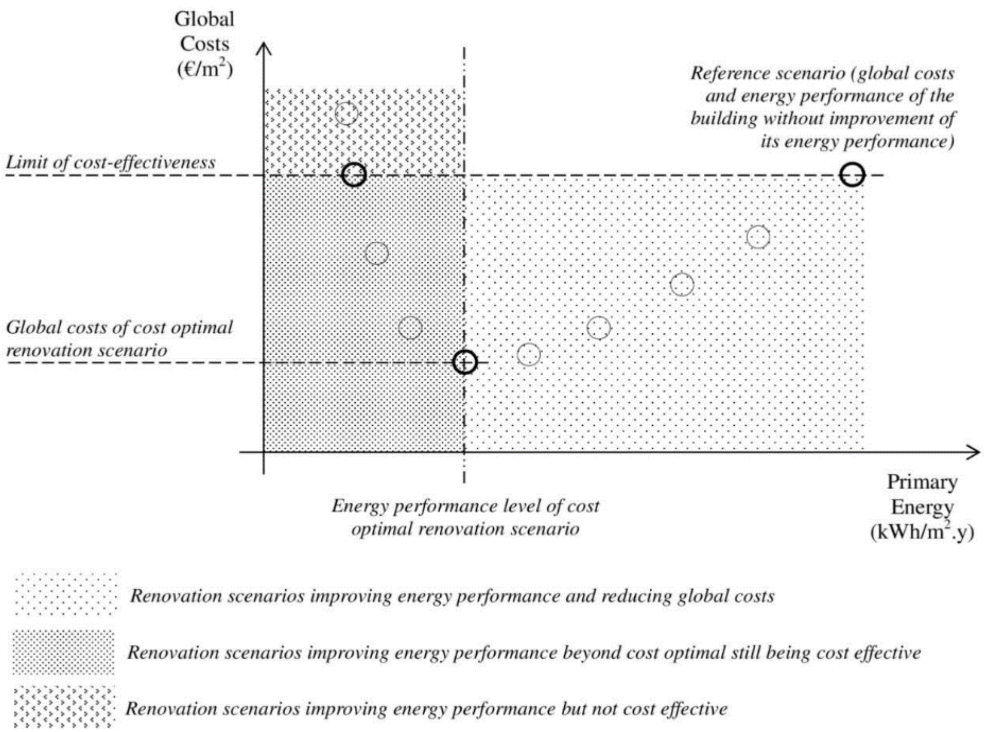

Figure 2 Cost optimal and cost effective evaluation of energy related renovation scenarios

Investments made in improving the energy performance of a building may not be proportional to the building added value. Two renovation packages with similar life-cycle costs and energy performance may add different value to buildings according to the specificity of the intervention. This happens because the value of the renovated building relays on the willingness to pay for the full scope of benefits and so it varies according to the market conditions.

In this context, co-benefits may be difficult to quantify, hampering their inclusion in the traditional cost/benefit analysis. Figure 2 shows the graphic results of a cost-benefit analysis. In the figure, each point results from global costs of each renovation package and corresponding primary energy. This representation shows that every point below the reference scenario is cost-effective and the lower point represents the cost optimal solution.

The solutions below the reference scenario and placed between the cost optimal and the vertical axis, are still cost-effective. These solutions beyond cost optimal present higher global costs, but may bring additional added value to buildings. As an example, changing the windows for more efficient ones may have as co-benefit the increase of comfort conditions, the reduction of external noise and the increase of security, although may lead to increased global costs beyond cost optimal level.

It is important that decision makers are fully aware of expected co-benefits associated to each possible renovation measure during the decision-making process. This awareness might lead to decisions beyond the cost optimal level or might trigger investments which otherwise would have been substituted by economically more profitable investments.

In this perspective, Table 1 summarises the co-benefits in the private perspective, catalogued in three categories, namely building quality, economic benefits and user's wellbeing. The co-benefits may have a positive or negative impact and different relevance depending on the building and owner/promoter's context.

Table 1 Typology of private benefits of cost effective energy related renovation measures

Category	Co-benefit	Description
Building quality	Building physics	Less condensation, humidity and mould problems
	Ease of use and control by user	Ease of use and control of the renovated building by the users (automatic thermostat controls, easier filter changes, faster hot water delivery, etc.)
	Aesthetics and architectural integration	Aesthetic improvement of the renovated building (often depending on the building identity) as one of the main reasons for building renovation
	Useful building areas	Increase of the useful area (taking advantage of the balconies by glazing or enlarging the existing ones) or decrease of useful area (like the case of applying interior insulation or new BITS)
	Safety (intrusion and accidents)	Replacement of building elements with new elements at the latest standards, providing fewer risks such as accidents, fire or intrusion.
Economic	Reduced exposure to energy price fluctuations	Reduced exposure to energy price fluctuations gives the user a feeling of control and increased certainty to be able to keep the needed level of comfort.
User wellbeing	Thermal comfort	Higher thermal comfort due to better room temperatures, higher radiant temperature, lesser temperature differences, air drafts and air humidity.
	Natural lighting and contact with the outside	More day lighting, involving visual contact with the outside living environment (improved mood, morale, lower fatigue, reduced eyestrain).
	Indoor Air quality	Better indoor air quality (less gases, particulates, microbial contaminants that can induce adverse health conditions) better health and higher comfort
	Internal and external noise	Higher noise insulation but increased risk of higher annoyance due to internal noise after the reduction of external noise level
	Pride, prestige, reputation	Enhanced pride and prestige, an improved sense of environmental responsibility or enhanced peace of mind due to energy related measures
	Ease of installation and reduced annoyance	Ease of installation can be used as a parameter to find the package of measures that aggregates the maximum of benefits

2.2 Macroeconomic perspective

In the macroeconomic perspective, the co-benefits are intended to help policy makers in the development of energy related policies and understanding how these policies may impact on other areas of the policy action. Most of the energy programmes and policies are mainly based on energy savings, not considering the full impact of energy renovation in buildings. The inclusion of the co-benefits may affect different sectors of economy and society, mobilizing more intervenient in the efforts of achieving the 2050 targets for energy and carbon emissions reduction. In this sense it can be said that co-benefits may act as drivers in the promotion of the other policy goals [7], [8].

A literature review has allowed to separate the co-benefits in three different categories, where the co-benefits may have impact. In this context, Table 2 summarises the co-benefits in the macroeconomic perspective, presenting a short description of each one of them.

Table 2 Typology of macroeconomic benefits of cost effective energy related renovation measures

Category	**Subcategory**	**Description**
Environmental	Reduction of air pollution	Outdoor air pollution is reduced through reduced fossil fuel burning and the minimization of the heat island effect in warm periods. Less air pollution has positive impacts on environment, health impacts and building damages.
	Construction and demolition waste reduction	Building renovation leads to reduction, reuse and recycling of waste compared to the replacement of existing buildings by new ones.
Economic	Lower energy prices	Decrease in energy prices due to reduced energy demand
	New business opportunities	New market niches for new companies (like ESCOs) resulting in higher GDP growth.
	Employment creation	Reduced unemployment by labour intensive energy efficiency measures
	Rate subsidies avoided	Decrease of the amount of subsidized energy sold (in many countries energy for the population is heavily subsidized).
	Improved productivity	GDP/income/profit generated as a consequence of new business opportunities and employment creation
Social	Improved social welfare, less fuel poverty	Reduced expenditures on fuel and electricity; less affected persons by low energy service level, less exposure to energy price fluctuations
	Increased comfort	Normalizing humidity and temperature indicators; less air drafts, more air purity; reduced heat stress through reduced heat islands.
	Reduced mortality and morbidity	Reduced mortality due to less indoor and outdoor air pollution and reduced thermal stress in buildings. Reduced morbidity due to better lighting and mould abatement.
	Reduced physiological effects	Learning and productivity benefits due to better concentration, savings/higher productivity due to avoided "sick building syndrome".
	Energy security	Reduced dependence on imported energy.

3. Recommendations for policy makers and promoters of energy related building renovation

Multiple benefits can arise from the improvement of buildings energy performance towards both the nearly-zero emissions and the nearly-zero energy targets, with benefits involving different stakeholders and affecting more than one activity sector.

Policy makers must be aware of how energy policies not only lead to energy savings or carbon emissions reductions but also create impacts on a broad range of areas of the political action, from environmental aspects, such as those related to pollution or climate change, to economic aspects, as employment or economic growth, and social aspects, as health or fuel poverty.

Actions to gather data, quantify benefits and apply study results to address policy challenges are needed and several methodologies and tools already exist and can be used to implement such an approach within a national policy process.

Policy makers should create interdisciplinary teams to deal with the mechanisms by which the broader range of benefits can be measured and monetised, and propose how they can be integrated into policy development and evaluation, to support their efforts on the optimisation of the potential value of energy efficiency and renewable energy sources.

For private owners, investors and promoters, the value of a building renovation depends on the willingness to pay from the customer whether in a sale process or in a rental one. In the case of energy related building renovation, this willingness to pay depends on the expectation of future reduced costs on energy bills and building operation, but also on other benefits not related with energy costs that result from energy related building renovation measures.

The maximization of the added value associated to energy related renovation measures depends on:

- Exploring the existing close relation between specific building renovation measures and co-benefits and the relevance of those co-benefits within each building renovation process. The relevance of the co-benefits should be assessed in each renovation project, once it may vary according to several aspects: - physical or technical condition of the building prior to the renovation; - climate condition of the building site; - urban context of the building site; - information and knowledge about the renovation measures by the residents; - age, gender and health condition of the residents; - financial condition of the residents; - occupation profile of the residents; cultural habits of the residents related with the use of the dwelling and comfort patterns;

- Quality on design and execution once, independently of the renovation measures, a wrong design or a bad execution can compromise the achieved added value of the building renovation, potentially eliminating the co-benefits associated to the related renovation measures;

- Going beyond cost optimality. Cost optimal packages of renovation measures only considering investment and operational costs are many times often not sufficiently ambitious regarding the building energy performance. The maximization of the added value from energy related renovation measures (considering co-benefits besides costs) requires that all main elements of the building envelope are improved to a minimum energy performance;

- Use of energy efficiency measures, which, when compared with measures for the use of renewable energy sources, are the main source of co-benefits at building level. Pride and prestige related with the use of renewable energy sources may be a relevant benefit encouraging their use, but their visibility is important for this specific co-benefit.

References

[1] BPIE. Energy Buildings Under the Microscope – A country-by-country review of the energy performance of buildings; 2011.

[2] Ferreira et al. Comparing cost-optimal and net-zero energy targets in building retrofit, Building Research & Information; 2014

[3] Urge-Vorsatz D, Novikova A, Sharmina M. Counting good: quantifying the co-benefits of improved efficiency in buildings; 2009.

[4] OCDE. The forgotten Benefits of Climate Change Mitigation: Innovation, Technological Leapfrogging, Employment, and Sustainable Development; 2003.

[5] OCDE/ IEA. Capturing the Multiple Benefits of Energy Efficiency; 2014.

[6] IEA EBC Annex 56 "Cost effective energy and carbon emissions optimization in building renovation"; http://www.iea-annex56.org/.

[7] IEA. Spreading the net - The Multiple Benefits of Energy Efficiency Improvements; 2012.

[8] Goodacre, C, Sharples S. & Smith P. Integrating energy efficiency with the social agenda in sustainability; UK. Elsevier 2001.