Multiple-Benefits from Buildings' Refurbishment: Evidence from Smart City Projects in Europe

Stefano Zambotti[1], Simon Pezzutto[1] and Adriano Bisello[1]

[1] Institute for Renewable Energy, EURAC research, Bolzano 39100, Italy
stefano.zambotti@eurac.edu

Abstract. Given the necessity of strengthening the transition towards a smarter, more sustainable low-carbon future, Smart Cities are considered a powerful tool. However, Smart City projects involving the refurbishment of existing buildings carry key barriers to implementation. The most prominent ones are: i.) a wide time discrepancy between appreciable environmental and economic benefits and immediate costs of action and ii.) economic benefits that might not accrue to who bears the cost of the intervention. This research provides a clue to solving this impasse based on the concept of multiple-benefits evaluation stemming from a shift in perspective from mitigation costs to development opportunities. We considered the costs of interventions on the European building stock under the Smart City projects to assess the multiple-benefits delivered to society. Starting from the monetary aspects of single projects, we identified multipliers to assess three different types of multiple-benefits: i.) Energy savings; ii.) Health and well-being; and iii.) Employment. Our findings indicate that in a time span of 14 years (2005–2018), an amount of about 260 million Euros invested in such projects lead to: i.) an accumulated saving potential of approximately 40 kilotons of oil equivalent, corresponding to 465 GWh; ii.) a reduction in air pollution corresponding to a value of 3 million Euros in avoided costs; and iii.) the creation of around 1,000 jobs with an average duration of 5 years. Considering that most of such investments occurred during the latest economic recession, the impact of the aforementioned multi-benefits appears to be not negligible.

Keywords: Multiple-benefits, Smart City Projects, Deep Energy Retrofits, European Building Stock.

1 Introduction

The European Union (EU) is facing unprecedented challenges related to climate, energy, social and economic aspects, and has therefore set specific goals for 2020, 2030 and 2050 [1]. Cities are recognized as pivotal players for the development of a smart, sustainable, and low-carbon economy [2]. One side of the coin identifies cities as key elements of social and economic innovation, as milieus where consumers, workers, and businesses are concentrated, delivering about 67% of EU's gross domestic product (GDP) [3]. The other side points out how poverty, segregation, energy consumption, and pollutant emissions often manifest themselves there [4].

There is necessity for a rapid transition toward more efficient and sustainable urban settlements [5]. Smart Cities (SC), when properly implemented, represent the current way of creating more livable areas, which are both sustainable and energy efficient [6, 7].

Energy systems are a major domain of intervention of SC projects. The goal of SC projects is a transition towards self-sufficient, sustainable, and resilient energy systems. Moreover, these interventions aim at the optimization of the integration of energy conservation, energy efficiency, and local energy sources. Integration is mainly achieved exploiting information and communication technologies [6, 8].

A major area of intervention of SC projects concerns the refurbishment of existing buildings [9]. Unfortunately, there exist two main key barriers to the refurbishment of buildings, they are i.) the wide time discrepancy between the environmental and economic benefits resulting from the refurbishment and the immediate cost of actions [10]; and also ii.) the split incentive, which is the situation where the owner of the building pays for the refurbishment but the tenant is the person that accrues the benefits [11].

Trying to solve this impasse, we analyze the concept of multiple-benefits, to shift the perspective from mitigation costs to development opportunities [12] and to highlight other socio-economic advantages [13]. Multiple-benefits indicate the broad range of positive spillovers, energy as well as non-energy related, without prioritizing them. Moreover, multiple-benefits express a holistic balance among the various aims addressed by a project [14, 15].

2 Materials and methods

In this research, we considered the costs of the interventions carried out for refurbishments of the European building stock under SC projects. To roughly estimate the share of SC projects' total investments concerning interventions on buildings we had to consider the different sectors that each project addressed. What we found is that SC projects have three main sectors of interest. These are mobility, energy networks and infrastructure, and buildings. Once we identified the number of sectors that each project addressed (1, 2 or 3), we divided the total amount allocated for that specific project by that number. This way, we were able to roughly estimate the share of the total amount of euros spent on buildings.

Our attention focused on projects started in 2005 or afterwards, projects that have already been concluded or whose year of completion starts in 2018. We tried to assess a set of multiple-benefits that these interventions deliver to society at large. In the present work we analyzed available documentation, provided especially by the European Commission (EC), on SC projects financed within the Sixth and Seventh Framework Programme (FP6 - 2002 until 2006 and FP7 - 2007 until 2013) "CONCERTO initiative" [16] as well as the FP7 "Smart Cities & Communities" activities [17].

Starting from the share of funds spent for refurbishment activities on existing buildings, multipliers (e.g. number of jobs created by million Euros invested) estimated using the ratios provided by scientific sources (in particular [18] and [19]) were applied

to generate assumptions for three different types of multiple-benefits assessed: i.) Energy savings, ii.) Health and well-being, and iii.) Employment.

The rebound effect, that is the potential cancelling out of benefits stemming from increased efficiency due to changings in people's behavior, was not taken in consideration in this study.

i.) Energy savings

Energy savings through reduced energy consumption is a direct consequence stemming from increased energy efficiency. In the following, energy savings have been quantified by units of kilotons of oil equivalent (ktoe) [19]. Energy savings are the source of three primary benefits, namely cost savings, climate change mitigation and energy security. It is generally shown that interventions aimed at reducing energy consumption have significant cost-effective potential, even without including climate change mitigation or energy security improvements in the calculation [20]. The calculation method and the proportions used to estimate the energy savings were retrieved from a Fraunhofer's report [21]. For this estimation Fraunhofer considered the specific building stock of all EU Member States considering age, climatic zones, buildings' energetic standards and countries' energy demands. Information on material cost, labor cost, costs for different sorts of refurbishment was also considered. Energy savings have important consequences in terms of CO_2 emissions reduction, contributing significantly to the fight against global warming [22]. Furthermore, energy savings have the potential to improve energy security at national and EU level [19, 23].

ii.) Health and well-being

A more indirect benefit occurs through health benefits. Most energy renovation measures will improve the indoor climate, and by doing so health benefits can be obtained through fewer diseases, reduced mortality, improved worker productivity, and improved overall quality of life. While most of these benefits accrue to society in general, public budgets may also be improved through fewer hospital expenses and fewer sick days. Health benefits also occur as power and heat production from power plants, district heating (DH) plants and local heating is reduced. Power and heat generated in these facilities give rise to air pollution and particularly to dangerous chemical compounds such as nitrogen oxide (NOx), sulphur dioxide (SO_2), small particle matters and carbon dioxide (CO_2). By reducing energy consumption, air pollution can be reduced. The health impact of air pollution from different inputs is well defined [24]. In the following, we therefore calculate the economic value of reduced air pollution stemming from the refurbishment of buildings under the considered SC projects using the ratios provided by the Copenhagen Economics [19].

iii.) Employment

The construction sector is considered a significant source of low- and high-skilled jobs [25]. Given the current slow recovery from the global economic downturn, investments concerning buildings' refurbishment can increase economic activity, and improve public budgets by reducing unemployment costs and increasing tax revenue from the raised economic activity. The direct impact on the local labor market is mainly related to the implementation phase, and it widely varies due to some characteristics. One is the size of the intervention: how many buildings are refurbished or how large is the demonstration site. The second concerns the different approaches of physical intervention on buildings [18]. In the following, we calculate the number of jobs stemming from the refurbishment of buildings under the considered SC projects using the ratios provided by The Energy Efficiency Industrial Forum [26].

3 Results

Nearly one-third of the identified SC projects result to have carried out buildings' refurbishment activities. Considering only the interventions on buildings, the CONCERTO projects account for approximately 65% of the investments while the remaining 35% concerns the FP7 Smart Cities & Communities projects. These activities of energy renovations of buildings are performed in nearly one-hundred locations (i.e. cities, provinces, regions). Specific areas have been home to several SC projects - e.g. Amsterdam for nearly 30 times. Figure 1 shows these locations across Europe. The 51% of the capital invested in these projects has been provided by the EU and the remaining part by private investors.

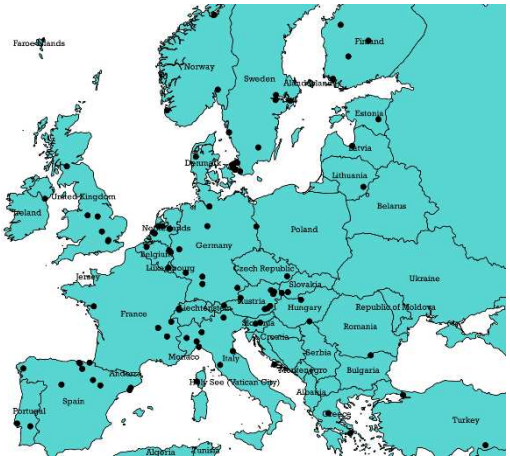

Fig. 1. SC Projects locations in Europe in which building's refurbishment took place (indicated by dots on Europe's map) [16, 17].

Figure 2 shows an estimation of the amount of euros investested per year in Europe to carry out refurbishment interventions on builidngs under SC projects from 2005 until 2018 (2018 corresponds to the last year FP7 spendigs are provided for SC activities on buildings' refurbishment).

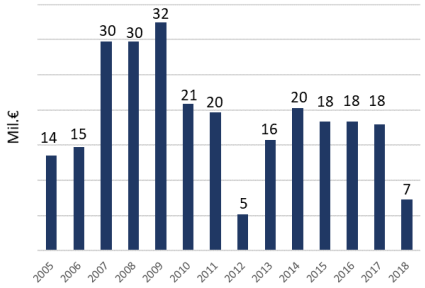

Fig. 2. Amount of mil. € invested per year (2005-2018) to carry out SC projects in Europe (values indicated in this figure and next figures 3, 4 and 5 have been rounded) [16, 17].

In total, we estimated that more than 260 mil. € have been invested for buildings' refurbishments under SC projects, within the time period indicated above. A peak can be seen in 2009 with around 32 mil. € and the lowest value is reported for 2012 with 5 mil. €. The year 2012 separates the two main clusters of investments (2005-2011, 2012-2018), the one related to the "CONCERTO initiative" and the one concerning the "Smart Cities & Communities" projects. The average amount spent per year is about 19 mil. €. Starting from the expenditures per year at European level, the following three sections measure the multiple-benefits resulting from buildings' refurbishments, with regard to energy savings (3.1), health benefits (3.2), as well as employment (3.3).

3.1 Energy savings

Figure 3 displays the amount of ktoe saved by SC refurbishment activities on buildings. The peak of about 40 ktoe (equivalent to 465 GWh) saved in 2018 is the result of energy saving potentials accumulated until date. Taking advantage of the calculations carried out by Fraunhofer [21] we can assume that the monetary value of such accumulated energy saving potential resulting from refurbishment activities is about 40 mil. €. against total investments of about 264 mil. €.

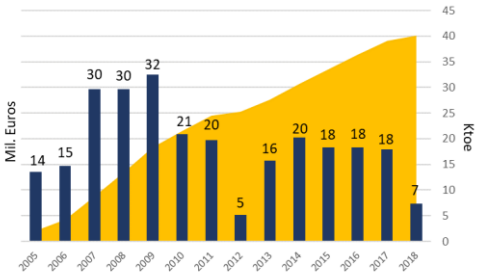

Fig. 3. Energy savings in ktoe reached from 2005 until 2018 (orange) based on SC expenditures for buildings' refurbishment in the same period (blue) [16, 17, 19].

The increase of ktoe saved per year grows rapidly from 2005 onwards with a complication in 2012 where the least amount of funding provided is shown.

3.2 Health benefits

Figure 4 visualizes the value of reduced air pollution in mil. €, generated by buildings' refurbishment performed under SC projects. A drop in energy consumption generally corresponds to a drop in air pollution since energy production from conventional power plants is reduced. Our estimation follows the approach used by the Copenhagen Economics [19] in which the reduced air pollution is considered as avoided costs from other investment measures that the EU would have otherwise needed to undertake to reach its goals of pollution reduction. The peak of more than 3 mil. € reached in 2018 is the result of the spending accumulated until date.

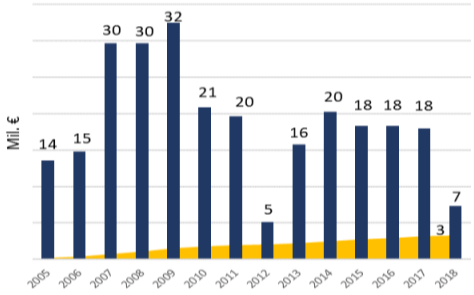

Fig. 4. Value of reduced air pollution in mil. € achieved from 2005 until 2018 (orange) based on SC expenditures for buildings' refurbishment in the same period (blue) [16, 17, 19].

As it was already the case for Figure 3, also in Figure 4 the increase for the value of reduced air pollution per year grows from 2005 onwards with a complication in 2012, were the least amount of funding provided is shown. Afterwards it rises continuously until 2018.

3.3 Employment

Using the multiplier found in the literature [18, 27], that is 19 jobs with an annual duration every million spent in energy efficient buildings' refurbishments, we estimated that the SC projects that we took in consideration generated about 33 jobs each, with a duration equal to the length of the projects that in most cases last 5 years. In total, around 1000 such jobs have been created under the CONCERTO and SSC projects that we considered, about 634 associated with the former and 367 with the latter.

4 Conclusions

Considering that these multiple-benefits occur mainly during times characterized by the deepest economic recession since the 1930s in Europe [28], the impact of refurbishments of buildings under SC projects at European level appears to be relevant. To further increase stakeholders' acceptance and political commitments towards SC projects, it is crucial to make the public, as well as policy makers more aware about the multiple benefits arising from such interventions. Moreover, linking economic values to the multiple benefits can positively change the overall economic figure of these interventions. We consider our results as a useful starting point for future research.

However, we also believe them not to be very accurate as they are the outcome of rough estimations based on large aggregate values.

The scope of our research was limited to the assessment of only few multiple-benefits that stem from the refurbishment of the European Building Stock. However, the literature on multiple-benefits [13, 29] present a vast set of positive spillovers arising from the transition towards more sustainable energy systems, such as i.) enhanced energy access and affordability; ii.) provision of ecosystem services; iii.) improved energy security; and iv.) other macroeconomic benefits that we didn't consider. We believe there is a gap to be filled within this area of research so as to shift the perspective from mitigation costs to the very attractive development opportunities stemming from the refurbishment of buildings.

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