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Methodology of energy efficient building refurbishment: Application on two university campus-building case studies in Italy with engineering students

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ABSTRACT

Politecnico di Milano (POLIMI) has launched since 2011 the project "Città Studi Sustainable Campus" to improve the university's sustainability performances within three main principles: building refurbishment, sustainable campus development and integration of facilities, research and education. The paper aims to discuss these issues, focusing on the energy efficient refurbishment on two university campuses in Milan, Italy. A Methodology for Energy Efficient Building Refurbishment (MEEBR) has been identified and tested on two case studies with students of the Integrated Design Refurbishment Laboratory of Building Engineering Faculty at POLIMI. In particular, the performance energy analyses were conducted on two university building case: the first at POLIMI campus, and the second located in the Università degli Studi di Milano (UNIMI) campus. These analyses were carried out using numerical simulations, considering the increasing important role which software are playing in refurbishment building design process also in early design phase. This preliminary experience with students on MEEBR application, with also the overview on building refurbishment methodologies, show that case study examples can help to: increase consideration of the integrated research approach and improve sustainability performance in historical buildings taking into account also the user's participation of a university campus. The comparison of the energy assessment methodology, of the two software used for the analyses (CENED+ and Sefaira), leads to the statement that it is essential from the beginning, selecting a program in function of the particular job and the outputs that you want to reach with the tool.

1. Introduction

Universities can nowadays be regarded as 'small cities' due to their large size, population, and the various complex activities taking place in campuses, which have some serious direct and indirect impacts on the environment. Campus sustainability has become an issue of global concern for university policy makers and planners as result of the realization of the impacts the activities and operations of universities have on the environment. There is a common understanding in the literature that a sustainable university campus implies a better balance between economic, social and environmental goals in policy formulation as well as a long-term perspective about the consequences of today's campus activities [36].

Velazquez defined a sustainable university as "a higher educational institution that addresses and promotes the minimization of negative environmental, economic, societal and health effects generated in the use of their resources in order to fulfill its function of teaching, research, outreach and partnership to help society make the transition to sustainable lifestyles" [53].

Some universities have also voluntarily signed some declarations to indicate their commitments to sustainability and the number of those universities is increasing [57]. In 1972 the Stockholm Declaration was the first that made reference to sustainability in higher education and they identified many strategies to achieve environmental sustainability [49]. They follow many others important declarations [48,50–52] which focuses their attention on addressing and incorporating sustainability and environmental literacy in teaching, research, operations and in the buildings themselves of the university campus. The need for environmental sustainability in university campuses has been stressed in many articles [10,13,14,55,9]. The higher educational sector has discovered that its activities and physical structures can have significant impacts on the environment and have started devising ways to organize the activities and to recognize and

Abbreviations: POLIMI, Politecnico di Milano; MEEBR, Methodology for Energy Efficient Building Refurbishment; UNIMI, Università degli Studi di Milano; ISCN, International Sustainable Campus Network; WBETs, Whole Building Energy Tools; EPDB, Energy Performance of Buildings Directive

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reduce their adverse effects on the environment. These include workshops and laboratory use, buildings and grounds maintenance as well as energy and materials use [25].

1.1. "Città Studi Campus Sostenibile" project

To transform an institution into a sustainable university and contribute to a sustainable world, various efforts have been made by universities around the world. One of the best examples is the International Sustainable Campus Network (ISCN), which provides a platform for leading universities and educational institutions around the world to exchange ideas and information for realizing a sustainable campus. To date, its signatories include the world's top ranked universities, such as Yale and Harvard in the United States, National University of Singapore, University of Gothenburg in Sweden and many other renowned educational institutions [47].

In June 2011 "Politecnico di Milano" (POLIMI) participates at the ISCN in Gothenburg and then joins the network. The establishment and participation evidences the urgency and the strength of POLIMI to establish a sustainable campus, ISCN provides a global forum to support leading colleges, universities, and corporate campuses in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching.

POLIMI has taken a more responsible approach to managing its environmental performances and improvements with a well-organized green agenda and different initiatives. In particular, POLIMI together with "Università degli Studi di Milano" (UNIMI) promoted the "Città Studi Campus Sostenibile" project [12] with the aim to transform the whole campus neighborhood into an urban area which can serve as an urban model in Milan with respect to life quality and environmental sustainability.

During the 4th UNESCO Chair Conference on Higher Education for Sustainable Development in September 2011 at Leuphana University of Lüneburg, the campus roundtable highlighted, in fact, the role of communication, the importance of engaging all university members and the value of acting as an example of sustainability for neighboring communities [35].

The project is open to the participation and support of researchers, students and all campus citizens. The main goals are: to test innovations developed by scientific research; to promote life style transformation and more livable spaces; to become a positive example for the entire city and to cope with the international network of sustainable campuses. In particular, the project focuses on the sustainability performance of buildings stock on campus to minimize environmental impacts and to optimize the integration of the built and natural environments.

This paper provides an overview on the latest energy efficiency buildings refurbishment researches, the identification of a methodology for energy efficiency building refurbishment (MEEBR) and its application on two buildings of "Città Studi Campus Sostenibile". The first one is located into the POLIMI Campus and the second one in the UNIMI Campus; the main purpose is to test and verify the methodology on different building heritage in order to validate the approach replicability.

The first analyses on the buildings were carried out by the students of Integrated Design Refurbishment Laboratory with the support of professors and researchers of this topic. This practical experience highlights the importance of the participatory design planning that is also one of the most important project tasks. The refurbishment design process followed, in the respect of the historical and architectural value of the buildings, was based on synergistic steps in order to do not concentrate the refurbishment only on the energy efficiency of the single case studies, but to convert their sites into a unique sustainable campus; making the "Città Studi" area of Milan an example of campus with low environmental impact.

2. Methodology for Energy Efficiency Building Refurbishment (MEEBR)

During the last decade, many governments and international organizations have put significant effort towards energy efficiency improvement in existing buildings. The International Energy Agency (IEA) has launched a series of Annex projects to promote energy efficiency of existing buildings [17,3–6] and at the same time a significant amount of research has been carried out to develop and investigate different opportunities for the definition of a sustainable refurbishment strategies [22,33,34,58,7,8].

The results have showed that energy use in existing buildings can be reduced significantly through proper retrofitting. Among the critical aspects of a sustainable campus are waste, such as food waste and recycling, energy consumption and transportation. Each aspect potentially contributes to lower total campus carbon emission. Hence, a set of implementation strategies targeted at the specific aspects is essential to support the whole process [47].

At educational level, as remarked by Crofton [15], the engineers must play a key role in global effort towards sustainability and moreover different experiences from a classroom case study have been already conducted [1,11,31,38,56]. Many system sustainable approaches have been investigated in the last decades on university campuses with implications to: social-economic and environmental aspect [23,43]; innovative technologies [24,26,29,45]; participation design process [19,41] tool simulation and ecological indicators [16,18,20,28,37,39,46].

The methodology adopted for the Integrated Design Refurbishment Laboratory exemplification derives from the study and

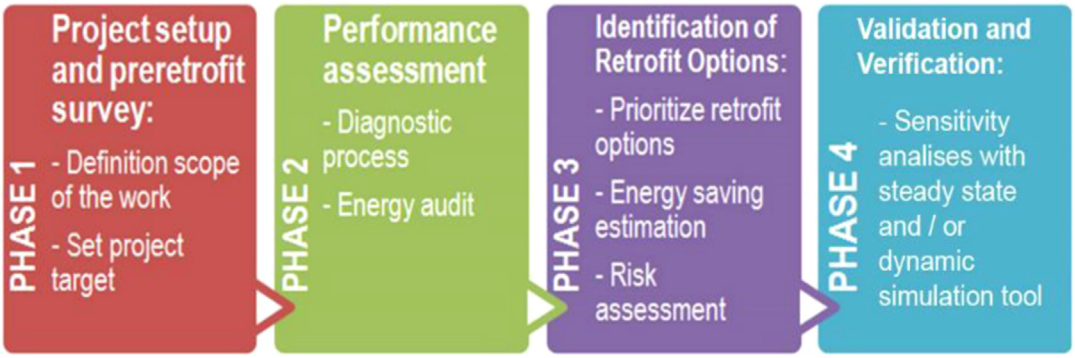

Fig. 1. Key phases of a sustainable building retrofit program.