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How Net Zero Energy Buildings and cities might look like? New challenges for passive design and renewables design.

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Abstract

This paper deals with new considerations about the design of Net Zero Energy Buildings and Net Zero Energy Neighbourhoods in the future. The perspectives presented here are the results from an international work named Task40/Annex52 "Towards Net Zero Energy Solar Buildings" conducted within the framework of the International Energy Agency (SHC-EBC) and in particular from the sub-group working on Solution Sets and case studies. We will see through case studies in different climates that the design scale to reach the Zero Energy goal is not the building anymore. The design of renewables as well as passive strategies must be extended to the whole neighbourhood.

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Keywords: Nearly Net Zero Energy Buildings; Passive design; Renewables design; Photovoltaics

1. Introduction and main contents

To comply with the European Union Directive, from 2020 all new buildings within member countries will be Nearly Zero Energy Buildings (Nearly ZEBs) [1]. This means that in the near future buildings will have to be designed to need very little energy without significant changes to occupant behaviors (comfort). As a consequence passive design strategies will be adopted (reducing the energy needs), and renewables will be used within the building's footprint or nearby to power the building's energy consumption. From a design point of view the buildings can be understood as an integrator of technologies, aimed at the Zero Energy balance: a very radical shift from the conventional idea of how to design a building. What will be the visible consequences on our buildings and cities, and what will be the new challenges that passive design and renewables design have to face? The paper deals with these issues, based on the experience carried out within the International Energy Agency (IEA) SHC-EBC Task 40-Annex 52 Towards Net Zero Energy Solar Buildings (2008-2013), and in particular, in the research group working on Solution sets and case studies [2].

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2. What is the appropriate design scale to design a Nearly (Net) Zero Energy balance?

The use of passive strategies and renewables is not really new in the practice of design. Nevertheless the need to achieve a Zero Energy balance opens a new perspective on the design process and aims, because such an approach is no longer voluntary, but mandatory. This implies a very strong formal relationship between the way the building is designed and its energy performance. To investigate how this relationship works from a formal point of view, we will refer to the use of PV, considering that PV was used in all the case studies investigated within the IEA SHC-EBC Task 40 [3] [4]. To propose some considerations, we will give an example of the use of Photovoltaics in a "green building": the Eternity Tower, a residential tower designed by DOS Architects for the Dubai Marina in 2005. The passive design greatly influenced the visual appearance of the envelope, conceived to work as a powerful solar shading element resembling natural elements like the dunes of the desert. PV was used on West and East facades, and the modules were conceived as precious stones embedded into the envelope (Fig. 1).

Fig. 1. Dubai Eternity Tower, design: DOS Architects, 2006. The use of PV is conceived as if the modules were precious stones embedded in the building's envelope. The PV area has not been calculated on a Zero Energy balance objective. (Images from www.dosarchitects.com)

Now, the question that arises is: how a building might look like, if conceived so as to work as a Nearly Zero Energy Building? To answer this question, we will consider again the Eternity Tower. If one looks at the PV surfaces, it is evident is would be too small to power such a kind of tall building.

The analysis carried out on the case studies in the framework of the IEA SHC-EBC Task 40 shows that when a ZEB is taller than 2 floors, its envelope surfaces are not sufficient to install all the needed PV, and that the most used part of the envelope for installing PV is the roof (optimal solar potential and ease of installation). So as, to simplify, we assume that a 2 floors building can be a ZEB when it is designed according to passive strategies approach, and its roof is completely covered by PV.

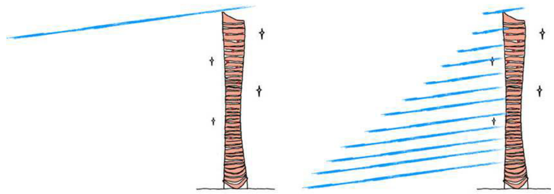

Fig. 2. Possible formal results for a PV generator shown in blue able to transform the Dubai Eternity Tower into a Zero Energy Building. (Image: Alessandra Scognamiglio)

According to this approach the Eternity Tower (93 floors) might have a ZE balance if it had a PV generator placed on the roof, which should be big at least 46 times the building's physical footprint. How might this (big) surface look like? The nice PV jewels embedded in the façade, might look like a kind of big "hat" that occupies the area around the building; or may be, they would be shaped as a sun-shading device, made out of surfaces designed to catch the sun (Fig. 2, left and right). For sure, it is possible to say that the architectural scale is not enough for designing such a building, and that an enlargement of scale to the urban one is necessary when thinking of Net Zero Energy Buildings.

3. Use of renewables

Renewable energy in energy efficient buildings is a key to designing a Net ZEB. There are many different renewable energy sources but not all of them have an impact on the architecture requiring them to be handled by the architect. The most used, and the most obvious, are PV (electricity) and Solar Thermal (ST) for DHW and space heating. Other renewable energy systems, like wind turbines or small-scale hydropower systems, generate electricity and the link to a building is typically made through an external electric wire connected to a technological box placed in a room in the building. Consequently, while the system within the building is hardly visible, the system itself has a character. This does not mean that the architectural influence is not present. Heat pumps have aesthetic consequences if they are coupled with solar thermal collectors or if an air-to-air system is used. Solar energy is a challenging source of energy that need to be handled by the architect, since such applications normally demand relatively large well oriented areas in the facade or on the roof to capture enough energy.

The formal results for the use of PV presented above are a very simplified version of the possible ways a Net ZEB can be shaped; the complex range of shapes that can be conceived at the building scale are of course complex and diversified, and even more when thinking at the urban shapes. Nevertheless it seems possible to summarize that very often when thinking of Net ZEBs it is necessary to conceive additional surfaces, out of the building's physical footprint, to devote to the energy generation systems (extended balance boundary). These surfaces can be shaped in different ways. For instance, they could occupy available surfaces of other buildings (Net Zero Energy Neighboring buildings); they could also be integrated into urban elements or shaped as parts of the landscape (Net Zero Energy Landscapes), when the urban pattern is not suitable for the integration of solar technologies. Whatever the formal results, a city composed of Net ZEBs is a hybrid pattern made out of buildings and energy generation systems, where the relationships between the different elements of the systems are very important [5]. The scale of the design should be extended from the building to the neighborhood or landscapes, so as to shape Net Zero Energy Neighborhoods (Net ZENs).

4. Passive strategies

The passive approach must be a key element of the design of Net ZEBs and Net ZENs. Starting from mid 2000s, when the discussion on Net ZEBs started, many papers have been published focusing on the building's design. But, as introduced above, an important outcome of the research group of the IEA SHC-EBC Task 40-Annex 52 is that the scale of the building is not enough, and the design scale should be extended to the whole neighbourhood. To clarify this approach, we will consider the design of a building in a hot climate where the main passive design strategies rely on a good solar protection and on an efficient cross natural ventilation to reduce significantly the AC consumption. A building that is naturally ventilated is an open system, which interacts with its environment. Moreover, the parking areas around the building, are made out of asphalt and generate heat islands, due to the its high absorption factor.

Fig. 1 brings elements of response by showing two recently realized neighbourhoods with a bad and a good example of design. Figure 1 (a) depicts a cluster of buildings, where envelopes are mainly made out of concrete, roller shutters are used as solar shading, central corridors; the way the buildings are design does not allow any cross ventilation. Figure 1 (b) uses the vegetation as a buffer space for thermal and acoustic purposes. The cars are parked underneath the building and in the open space around the vegetation cools down the air temperature (through evaporative effect) while providing shadow and producing oxygen. The buildings are narrow and the wooden corridor acts as solar shading elements.

Passive strategies, and natural ventilation are crucial in the case of low-medium rise buildings, and in high rise buildings too. Studies conducted on the effectiveness of the natural ventilation for high rise buildings in Hong Kong (the most dense city of the world, with about 48,571 people per km^2) to improve the effect of natural ventilation show that shape and porosity of the building have a strong impact on the natural ventilation [6].

Fig. 1. (a) Left ill. An example of a bad building cluster in the new neighborhood of “Les Hauts Vallons” in the island of Mayotte, Indian Ocean; (architects: Parallèle Architecture) (b) Right ill. An example of a good design: “L’Ilet du Centre” in the island of La Reunion, Indian Ocean (architects : Perrau and Reynaud).

In terms of design tools as well, there is an urgent need to upgrade the working habits of the HVAC design practices and their knowledge of design tools [7]. There is a gap between the Net ZE goal and the tools used by most designers. Traditionally HVAC engineers focus on the sizing of the systems (air conditioning, artificial lighting) rather than on the passive optimization of the building. This radical change into the building design process implies that new simulation tools should be used: e.g. the simulation programs must be capable of modeling the airflow transfers to take into account the effect of cross natural ventilation or the useful daylight index for daylight performances.

5. Conclusion

The main output of this paper is to point out that designing Net ZEBs is not the real challenge now and in the near future. The real challenge and the real scale of the design is at least the neighbourhood. This will affect our vision of how the cities of the future will look like in terms of passive strategies and renewables. We will have to find new solutions to manage the integration of renewables in the landscape and to take optimize the effect of the wind and the sun at the urban scale, while preserving, of course, the traditional communities values of the cities (social capital).

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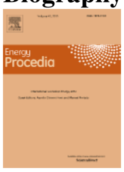
Biography



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