CLIMA 2016 - proceedings of the 12th REHVA World Congress

volume 6

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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):

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Abstract

Energy efficiency in buildings is a top priority for energy policy at European Union level. Important legislative initiatives are in place to increase the diffusion of high energy performance buildings in European building stock. However, the cost for achieving energy efficiency, especially in the field of building construction and renovation, is still high and this acts as a barrier in individual investment decisions. This is likely to increase the division between advantaged and disadvantaged social groups, fostering vicious circles of social exclusions, fuel poverty, precariousness and uncertainty on the future. Structuring a Concept for a Design Competition is a way to build a path to achieve concrete results. The Guidelines of this Competition can serve as a concept catalyst for demonstrations, showcase projects, innovative ideas to merge societal, economic and environmental goals in the field of building design and construction.

Keywords – Energy efficiency, Positive energy buildings, Social housing, Building design, Technological innovation, Cost optimization.

1. Introduction

The possibility to live in a comfortable house, with an adequate level of comfort, at an affordable price is a citizens' basic need and should be considered a fundamental right for all EU citizens. However, this still remains an important challenge for a significant number of European countries. Definitions as "energy poverty" or "fuel poverty" are more and more used to highlight the increasing problem in the last decade. The poor or inadequate energy efficiency conditions of the majority of European homes exacerbate the problem. Strategy to prevent or solve this situation should be
put in place by many actors: governmental institution, regulators, researchers, architect, engineering stakeholders can all be involved in the improvement of the situation. Building measures and technical innovations in heating, cooling and lighting system can play a fundamental role in this process. Best practices examples can be an important trigger to involve many actors in the battle against energy poverty, social discrimination, and unhealthy way of living, social cost and increasing of CO$_2$ production. Although all the difficulties listed above, owning a house remains a primary objective for the majority of European citizens. As indicated in the latest EUROSTAT statistics on housing conditions, 7 out of every 10 (70.1%) persons in the EU-28 lived in owner-occupied dwellings, while 19.1% were tenants with a market price rent, and 10.8% were tenants in reduced-rent or free accommodation. In 2014, an 11.4% share of the EU-28 population lived in households that spent 40% or more of their disposable income on housing showing that fuel poverty is not a negligible problem and, even if current low energy prices can mitigate the issue, structural solutions are required.

2. Aim of the paper

The paper presents and discuss a concept for a EU Design Competition for affordable Positive Energy House projects for young families. The Competition is seen as a direct and concrete way to stimulate creativity for innovative solutions and build a path to achieve tangible results with direct application to vulnerable citizens. The Guidelines of this Competition can serve as a concept catalyst for demonstrations, showcase projects, innovative ideas to merge societal, economic and environmental goals in the field of building design and construction.

This concept for a Design Competition aims at challenging the perception that positive energy buildings are luxury goods and to collect innovative projects that drastically reduce the cost of building positive energy houses. The idea is to merge affordability, comfort/quality of life and energy performance, with in mind a specific family target (young family) for which all these components are important.

Therefore a holistic approach to building design is required and the guidelines of this concept aim to develop cross-fertilization between different disciplines to achieve the best result. Moreover the promotion of the widespread diffusion of positive energy buildings with a focus on very-high energy performance, if not adequately balanced by economic concerns, negatively affects young people in their investment and future life-planning decisions, recognizing the key importance of the house and housing decisions in the life of people.

For the purposes of this concept a "positive energy building" is defined as a building that is high energy performance and that produces more energy
than it consumes. Therefore, the energy goal will be achieved by using a combination of technologies which reduce energy requirements and on-site renewables energy production. An affordability criterion is fixed by the requirement of a cost minimizing approach towards maximum overall cost of 80000 Euros.

The concept developed for this Design Competition can be a useful Guideline for a future possible launching of a competition in the area of high efficiency buildings supplied by renewable energy, incentivizing the production of Best Practice examples.

3. Concept for the Design Competition

The Concept is developed in the following chapter:
• Location and Organization
• Project Description – Major Criteria
• Specific Area of Evaluation
• Final Evaluation – Award

3.1 Location of the Project

For the purpose of the competition a location for the projected building should be decided.

Multiple locations (characterized mainly by their meteorological conditions) with possibility for the applicants to choose among them could be foreseen, however, for sake of simplicity and most immediate comparability, a unique location for all prospective building projects has been decided. In this case, the choice was to require projects facing challenges on energy efficiency technologies for heating, cooling and ventilation.

The location for the building project is Ispra\(^1\), in northern Italy in the Varese province on the Lake Maggiore. It is located about 50 km from Milan and 20 km from Malpensa International Airport.

The meteorological conditions require solutions both for hot and humid summers as for cold and rainy winters.

Meteorological information is featured:
• Good sun exposure also in winter time
• Remarkable rainfall in autumn and spring time, with an average rainfall of 1600 mm by year and peaks of 200 mm /month in April and October;
• High degree of humidity in summer
• Occasionally strong winds with prevalent winds North-South having an average speed of 1m/s (measured at 10 m above ground level)

\(^1\) Ispra is one of the sites of the Joint Research Centre.
Month average temperature ranging from 2.3 °C (January) to 22.1 °C (July); Maximum of the month average maxima temperature: 27.5 °C (July 1999); Minimum of the month average temperature: 4.9 °C (January)

However, the building, as a forward-looking project, should take into account possible future changes to these conditions (e.g. increased frequency of warm summers and winters due to global warming).

The site determines also the market conditions (e.g. costs of the technologies, manpower, maintenance costs, etc.), which should be equal for all participants and for simplifying verification.

3.2 Organization

A technical Committee formed by a group of experts will select among the participants in the Competition a shortlist of projects based on the selection criteria. A final Jury\(^2\) composed by international experts will assess the shortlisted projects according to the evaluation criteria and they will indicate the awarded projects. Since the Competition is still in its pilot phase we decided to limit the evaluation and voting to a restricted number of technical experts however, in future, more diffused audience can be called to express their opinions on the projects, for instance through internet and social media.

4. Project Description – Major Criteria

4.1 Positive Energy Building

The project shall comply with the Positive Energy definition below, considering that the building is to be located in Ispra, Italy. The participating teams shall present the necessary calculations and documentation in order to make proof that the design complies with such requirements.

A positive energy building is a building that produces more energy from on-site or nearby renewable sources than it consumes (including appliances), balanced on an annual period, to achieve appropriate comfort levels as defined by the Italian regulation. Energy consumed must be produced on-site by renewable energy sources. On-site refers to renewable energy sources that are in, on, under, or adjacent to the building. The building energy demand shall include: heating, cooling, ventilation, dehumidification and other

\(^2\) To reflect the holistic nature of the Competition, the members of the jury might be experts in different fields (engineering, architecture, economics sociology, etc.)
auxiliaries and all needed supplies (i.e. circulation pumps are considered as auxiliary and they may be proposed for geothermal energy production), domestic hot water, integrated lighting systems, and all appliances.

4.2 Additional technical requirements

In addition, the building design shall take into account the climatic characteristics of the site and the project proposals shall comply with the following technical requirements:

Surface: The overall gross floor area\(^3\) of the building shall be of 80m\(^2\) ± 10%. An external area a maximum of 400 m\(^2\) is also available for the project.

Grid connection: The building shall be connected to the local electricity grid

4.3 Young family

The project shall ensure the comfort of a young family of one or two adults and one or two children. It shall take into consideration family life, work and telework, mobility, social life and leisure activities of all the occupants as well as possible changes in the family composition.

4.4 Total cost

The cost of building the project should have a ceiling of 80,000 Euros. The cost estimation should be presented in any form based on the most accurate market values available. As mentioned, these market values should refer to the costs at the location of the project (Ispra, Italy)\(^4\). A separate estimation for one year of maintenance and operation of the house shall also be presented. The cost estimation should also take into consideration that the

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3 Gross floor area (GFA) - The total floor area contained within the building measured to the external face of the external walls.
4 See reference of public prices for the region of Milan: https://www.comune.milano.it/portale/wps/portal/CDM?WCM_GLOBAL_CONTEXT=/wps/wcm/connect/contentlibrary/Ho%20bisogno%20di/Ho%20bisogno%20di/Listino%20prezzi%20opere%20pubblicate%202014_%20Listino%20opere%20pubblische%202014&categId=com.ibm.workplace.wcm.api.WCM_Category/IT_CAT_Bisogni_21/94c17f80446e01afbab3bbd36d110d8a/PUBLISHED&categ=IT_CAT_Bisogni_21&type=content
The project could be replicated and then benefit from economies of scale. The costs of land and appliances shall not be included in the cost estimation.

5. Specific areas of evaluation

If the projects comply with the 4 major criteria, they should be then evaluated in the following contests. Technical Committee shall evaluate the proposals and assign scores in each of the following 5 areas:

- Architecture
- Engineering
- Cost optimization
- Environmental Sustainability
- Smartness and connectivity

As guidelines for the evaluation, for each of the areas, eight key questions have been specified. The solutions that the project offers to answer each of the questions have the same weight in terms of the overall evaluation of the area.

In turn, each area is equally weighted and it can be scored from 8 to 40 points, thus the projects can be assigned up to a maximum of 200 points. A shortlist with the 10 projects with the best scores will be submitted to the final Jury.

5.1 Architecture concept

The score will be assigned for the design concept by reviewing hand sketches, technical drawings, construction specifications, the audio-visual presentation and the architecture narrative.

The committee shall consider the following sub-categories in order to score the proposal.

- How well does the team explain its understanding of the Competition's intent and objectives and its approach to achieving these objectives?
- How well is the overall concept developed through the drawings and descriptions?
- How well is the coherence among architectural, structural and technical equipment demonstrated?
- How well the concept is developed in terms of modularity and replicability of the construction elements?
• How well does the project offer the occupants a safe, functional, comfortable and enjoyable place to live?
• How effectively does the team consider a holistic and integrated design, inclusive of spaces, structure and equipment?
• To what extent does the project develop an innovative approach in addressing positive energy building concept in the field of residential architecture?
• How effectively do the sketches, drawings, construction specifications, audio-visual presentation and architecture narrative enable Jury to conduct a complete architectural evaluation?

5.2. Engineering and energy concept

The score will be assigned for the engineering concept and the implementation by reviewing technical drawings, construction specifications, energy calculation, audio-visual presentation and engineering narrative.

Particular attention will be given to the energy system, as well as to the integration and optimization of all the technological systems (water and sewage, telecommunication, heat and cooling, etc.).

The committee shall consider the following sub-categories in order to score the proposal.

• To what extent were new approaches used to solve the engineering challenges, and in particular the positive energy challenge?
• To what extent can the proposed innovations have a market potential for the positive energy residential housing?
• How effective is the energy concept (envelope, plant and technical equipment) in minimizing energy consumption while ensuring thermal quality, occupant comfort, including indoor air quality?
• How well is the use of renewable energy sources implemented in the project?
• How well is the lighting concept defined (daylight integration, zoning, power installed, type of lighting, levels of lighting)
• How well do the house systems allow the inhabitants to monitor and control their resource consumption, and in particular their energy consumption?
• How effectively will the house controls facilitate a reduction in energy consumption during an entire year of operation?
• How effectively do the technical drawings, construction specifications, audio-visual presentation and narrative enable Jury to conduct a complete engineering evaluation?

5.3 Cost of the concept
The score will be assigned for the cost effectiveness of the design concept and implementation by reviewing drawings, construction specifications, construction details, cost estimation, audio-visual presentation and narrative.

- How successfully does the project demonstrate the cost minimization of its positive energy concept design?
- How successfully does the design meet the affordability focus (80000 euro) of the Competition?
- How much would cost change when it is replicated in the European market?
- How well does the project minimise maintenance and operations costs for the house?
- How effectively do the drawings, the construction specifications and the cost estimation enable, through sufficient quality and detail, a contractor to generate an accurate and detailed construction executive project?
- How does the project minimize labour cost?
- How does the project optimise material costs?
- Is the cost calculation robust and well explained?

### 5.4 Environmental sustainability

The Committee will assign score from 1 to 5 for the sustainability of the concept and its implementation by reviewing drawings, construction specifications, construction details, audio-visual presentation and life-cycle process narrative.

- To what extent does the project use natural and/or recycled construction materials instead of materials and products that may negatively impact the environment and human health and wellbeing?
- How does the project take into consideration the origin of the materials and gives preference to indigenous resources (natural species included) in order to reduce the environmental impact resulting from transportation?
- How well is the life-cycle of materials and processes taken into account and coherently implemented, in terms of choice of materials, waste minimization, maintainability, and different phases from manufacturing to demolition?
- How well is the use of resources implemented in the project?
- How is the water footprint considered and explained, and how is it taken into account in the overall concept design?
- How well is the water footprint minimized?
• How well does the project evaluate the long-term environmental performance of the construction including materials and equipment?
• How well will the occupants be able to measure, monitor and assess the main parameters inside the house (temperature, humidity, CO2 emissions, etc.)

5. 5 Smartness and connectivity

The score will be assigned for the smartness of the design concept and implementation by reviewing drawings, construction specifications, audio-visual presentation and life-cycle process narrative.
• How well is the project able to connect, when existing, to technological networks, for energy, water and telecommunication?
• How well does the project ensure the inclusiveness of all the members of the family and support their participation to the life of the local communities?
• How well can the project fit into a community life?
• How much is the concept flexible to accommodate transformations related to possible new needs and occupants (as new children or elderly relative joining the family)?
• Does the project foresee the option of electric mobility (with charging points for electric vehicles e.g.)?
• How well will the occupants be able to measure, monitor and assess their consumptions of energy and water?
• How does the project influence the occupant's behaviour towards a more sustainable lifestyle?
• How resilient is the project in case of natural events or technical disruption?

6. Final evaluation – Award

An interdisciplinary Jury composed by international experts shall evaluate the shortlisted projects. The Jury is called to assign scores with the same evaluation criteria used by the pre-selection technical committee.

Adequate awards should be foreseen (best two or three project) and some mechanisms to incentivize also the participation of young architects and university students will be put in place (e.g. a special prize for the best project from a young professional).

In addition, at least for some selected building prototypes (e.g. the ten shortlisted projects), one or more exhibitions could be organised, as well as
communication campaigns through architecture journals and dedicated websites. This will have benefits both in terms of diffusion of best practice examples and in terms of increasing visibility for the participants.

Several constraints exist on the possibility of the real construction of the winning projects (with demo and real-life monitored energy balance); however, this should be explored as will give an important added value to the Competition and would further contribute to its goals.

7. Conclusions

The promotion of the widespread diffusion of positive energy buildings, and high energy-efficiency technologies, if not adequately balanced by economic concerns, may limit their diffusion to the most vulnerable citizens.

It is therefore important to make sure that energy improvements in construction and refurbishment do not increase the divide between advantaged and disadvantaged social groups.

To foster the development, implementation and diffusion of best practices is one effective way to address the issue.

To this end, a specifically targeted EU Design Competition has the potential to stimulate architects, engineers and construction industry professionals to adopt innovative low-cost solutions to reach high energy performance in buildings.

The article presented and discussed the concept of this Competition some of them can be summarized as follow:

- It is dedicated to projects for Positive Energy houses. The idea is to challenge professionals and stimulate innovation beyond the (already ambitious) legally binding NZEB targets.

- Five different fields are defined as evaluation criteria: architecture, engineering, economics, sustainability, smartness. All of them should be seen in a holistic approach, cross-fertilizing each other's.
- The Competition has been designed for a specific households target, young families, to put the emphasis on future generations and to take into account the social and economic changes that may occur in a near future (e.g. increased international mobility, flexibility, self-consumption, etc.). However, in future, in line with joining energy, environmental and social goals, similar competitions can be organised with in mind other specific uses and/or vulnerable target groups (elderly, social housing, etc.).

Even if still in a pilot phase, a Design Competition for affordable positive energy houses for young families has the potential to challenge the perception that positive energy houses are luxury goods and it aims at being a demonstration of how societal, environmental, and economic challenges can be successfully addressed at the same time.

A Design Competition generates a broad search for the best solution through the explorations of significant design issues. In this case an overview on best innovative practice for positive energy buildings will be possible for first time.

The Guidelines of this Competition can serve as a concept catalyst for demonstrations, showcase projects, innovative ideas to merge societal, economic and environmental goals in the field of building design and construction.

Best Cases examples as the immediate output of a this Design Competition, can be a considered vademecum for future projects of high performing building.

Acknowledgment

The authors are grateful to Heinz Ossenbrink for his continuous support during the different phases of the work. They also wish to thank Isabella Maschio, Tiago Serrenho, Luca Castellazzi, Paolo Zangheri for their contribution to the definition of the competition criteria.

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