



Design of a multipurpose “zero energy consumption” building according to European Directive 2010/31/EU: Architectural and technical plants solutions



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ABSTRACT

Considering the significant impact that the residential sector has on energy consumption, it is particularly important to implement policies aimed at improving energy efficiency in buildings. Highly energy efficient buildings can either save primary energy or disseminate the use of the most suitable technologies to be used in new constructions.

Due to those reasons, the Municipality of Città della Pieve promoted the creation of a “Renewable Energy Park” in a deprived area of its territory, where some green technologies could be installed and tested. This site has also been considered as an optimal location for an educational/demonstrative “zero energy consumption” building for multifunctional activities and realized with the most innovative techniques to save energy.

The building may be considered as an example to study and optimize the benefits of higher energy efficiency together with the use of renewable energy systems.

In this paper the technical solutions adopted both in the building envelope and the technical plants are described and discussed. A simulation of the behaviour of the building in summer and winter was carried out in order to assess the benefits that can be obtained both in energetic and economic terms.

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1. Introduction and regulatory background

The unhealthy state of our planet and the awareness of the current reserves of non-renewable energy sources, are causing a deep change in the development of human activities, which must now be consistent with a policy of energy saving and a more and more widespread use of alternative energy sources [1]. Data from ENEA MSE (Italian National Agency for new technologies, energy and sustainable economic development) show that the residential sector in Italy consumed in 2008 about 45 MToe of energy out of a total of 192 MToe, showing an increase from about 42 MToe requested in 2005. Those data show that residential and commercial/office use of energy has continued to grow despite the economic crisis, that struck developed countries in the last few years, and affected other economic sectors [2,3].

Considering the impact of the residential sector on the emissions of greenhouse gases and on the use of primary energy, it is of main importance to implement policies aimed at improving the energy efficiency of buildings [4,5]. It is also important to disseminate the concept of sustainable development by using the appropriate technologies and design criteria for new constructions and for the renovation of existing ones [6].

In recent years, several agreements were signed at international level, starting from the Geneva Convention of 1979, to the 1997 Kyoto Protocol and to the following related COPs (Conferences of parties). Those documents define the timing and extent of the reduction of greenhouse gases emissions by 2012, and explicitly identify the policies and actions to be undertaken. In the EU, this is a new reference framework for the development of standards related to energy conservation, to combat climate change and to the management of environmental resources and energy [7,8]. Under this perspective, the Energy Certification of buildings defined by the European Directive 2002/91/EC has a particular importance [9]. The creation of an energy label associated to buildings, allows classifying them according to their energy

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performance. The recently published Directive 2010/31/EU [10] integrates the 2002/91/EC and promotes the improvement of buildings' energy performance in the EU. As already foreseen by Directive 2002/91, Directive 2010/31 defines the energy performance level with reference to the costs (Art. 4). The obligation to build near-zero energy buildings will be enforced from December 31, 2020, for private homes, and from Dec. 31, 2018, for public buildings (Art. 9).

The measures to be undertaken vary depending on the type of building. For new buildings it is necessary to submit, before work, an assessment of technical, economic and environmental feasibility for the use of alternative energy production systems. It is fundamental to take into consideration: the decentralized energy supply systems based on renewable energy sources; cogeneration; urban or collective district heating or cooling, particularly if it is based wholly or partly on renewable energy and heat pumps [11–13]. The preliminary study, which must be documented and made available for inspection, can be made for individual buildings, groups of similar buildings or for common types of buildings, which lie in the same area.

The Energy Performance Certificate allows evaluating and comparing the energy performance of different buildings/housing units with the same method. The novelty is that, in case of sale or lease, the energy performance indicator contained in the certificate of the building or building unit, must be shown in all advertisements of commercial media in Italy [14]. The directive is enforced from July 8, 2010, but the States of the EU could postpone the adoption until July 9, 2012.

This paper describes the study of technical plants and architectural solutions for a multipurpose building with near-zero energy consumption [15]. In particular, the project is focused on the implementation of the aforementioned European Directive (2010/31/EU). For this purpose, five different solutions have been developed. For each one of them, the energy performance has been evaluated in relation to the costs in order to identify the most efficient scenario. The project will also promote, on a broader scale, the use of technologies aimed at energy savings while providing the same level of service and to stimulate the energy production from renewable sources; for this purpose, different energy conversion systems from renewable energy sources, such as solar and wind power plants, will be designed, constructed, managed and monitored.

2. Case study

2.1. General framework

The building will be located in the territory of Città della Pieve, in Umbria (central Italy) on a hill at 508 m a.s.l. dominating the Valdichiana and Trasimeno Lake. The town has about 7800 inhabitants and a territorial extension of 111 square kilometers, at the border between Umbria and Tuscany. The hill is like a plateau (Fig. 1), characterized by ridges alternating with deep ditches with layers of sands and conglomerates and large amounts of fossil fuels. This is the area where the delta of the Tiber River was located, several geological ages ago.

The area identified by the city Administration for the implementation of the Technology Park for Energy and Environmental Sustainability, is on the northern side of the village of Ponticelli, and covers an area of approximately 9 ha. The Park is located in a degraded industrial area bounded on the west side by the Chiana and Astrone canals and on the east side by two Rome–Florence railway lines. The location of the whole area is therefore particularly suited for the creation of a Technology Park for Energy and Environmental Sustainability.

In detail, the functional project for the entire area (Fig. 2) foresees the construction of:

- No. 1 stationary PV (photovoltaic) solar field, with a peak power of 900 kW;
- No. 3 “Sunflowers”, made up of three two-axis sun tracking plates with 12 kWp each;
- No. 4 micro-wind turbines, two of which, with horizontal and two with vertical axis, with a peak power lower than 10 kWp;
- A multipurpose building, with green building and sustainable solutions, for the services of the Renewable Energy Park. It will be a passive building designed with lightweight technologies and aimed at being a good expression of contemporary architecture in compliance with European Directive 2010/31/EU. In particular, the building is intended to play an educational/demonstration role as a “zero energy consumption” building. It will also exemplify the optimization of the benefits derived from improved energy efficiency together with the renewable energy systems. Finally, it will be used as a training center for young people from Città della Pieve and neighboring towns, in



Fig. 1. Landscape of Città della Pieve.

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