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Towards a nearly zero-emissions dwelling in Mallorca

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Abstract

Concern about climate change and its impact on the environment has become a problem of vital importance nowadays. New regulations have been approved and nearly zero-energy buildings have been defined as a target for the State Members in the European Union (EU). In this study the assessment of a nearly zero-emissions dwelling was shown in the Balearic Islands. The use of a system composed by different renewable energies in the building allowed getting a negative indicator both for primary energy consumption as well as for the CO_2 emissions per year.

Keywords: *Nearly zero-energy buildings, nearly zero-emissions buildings, dwelling, energy consumption, renewable energy.*

1. Introduction

More than 40% of European Union (EU) energy consumption and about 36% of CO_2 emissions comes from the construction sector and services, mainly composed of buildings (Nuij, 2013). New regulations have been approved in order to achieve the Kyoto Protocol compliance. The Energy Performance of Buildings Directive (EPBD) had as final objective the increase of the energy efficiency of buildings in the EU as well as the establishment by Member States of minimum requirements for energy efficiency, periodical inspection of energy systems and the creation of a methodology for the energy certification (The European Parliament and the Council of the European Union, 2002). The EPBD recast included the concept of a nearly zero-energy building (NZEB) as a building with a very high energy performance, in which the low amount of energy required should be covered mainly by energy from renewable sources with a very high level of energy efficiency (The European Parliament and the Council of the European Union, 2010). The Directive established all new buildings to be nearly zero-energy buildings before 2021, and two years earlier in the case of public buildings.

Ferrante and Cascella (2011) presented a study based on the design of a prototype dwelling in Italy. The authors highlighted the fact that zero balance both for energy and CO_2 emissions could be easily obtained in the Mediterranean area. Attia et al. (2012) presented a simulation tool as a support in the design phase of a NZEB in the residential sector in warmer climates. Zeiler and Boxem (2013) assessed the first school designed according to the principles of NZEB in the Netherlands and compared the results obtained with traditional schools. The present study arises from the current need to obtain effective reduction of CO_2 emissions and lower energy consumption patterns. The main objective is to assess the conversion of a conventional dwelling to a nearly zero-emissions dwelling in the Balearic Islands.

2. Methodology

In this study, an assessment to convert a single-family detached house to a nearly zero-emissions dwelling was proposed. For the energy demand assessment the “Unified Tool LIDER-CALENER” (Ministry of Development, 2013) was used. It is one of the official energy certification tools in Spain, and it comes from the unification of the tools LIDER and CALENER (already used in Spain previously) in the same platform. This tool includes a graphical interface for a 3D representation of the building and performs an hourly simulation

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considering a transitional regime, taking into account thermal coupling between adjacent zones and thermal inertia (Instituto para la Diversificación y Ahorro de la Energía (IDAE) y Asociación de Investigación y Cooperación Industrial de Andalucía (AICIA), 2009). The validation of LIDER tool was made through Building Energy Simulation Tests (BESTEST) by the International Energy Agency (IEA) (Instituto para la Diversificación y Ahorro de la Energía (IDAE) y Asociación de Investigación y Cooperación Industrial de Andalucía (AICIA), 2009), where a great number of cases were evaluated under specific conditions and the results were compared with those obtained by other internationally known tools, such as TRNSYS or DOE2. Results were presented in per kWh/m^{2}year (1 kWh=3,6 MJ).

2.1. Case study building

In this study a single-family detached house located in Mallorca with two floors and sloping roofs was used for the assessment. Facades composition is shown in Tab. 1. An image of the building represented in the HU-tool is shown in Fig. 1. The system in the original building was composed by a heat pump air to water (10 kW) for hot water, a heat pump air to water (16 kW) for a multizone water heating system and a direct expansion air conditioning (3 kW) for cooling the living room. As it will be seen in the Results section a new system composed by renewable energies was proposed and evaluated in the building.

Tab. 1: Facades composition in the case study building

Facades composition	U-value (W/(m^{2}K))	Thickness (m)
Cement mortar (1.5 cm)/polyurethane panels (PUR panels) (12 cm)/concrete blocks (24 cm)/plaster(1.5 cm)	0.19	0.39

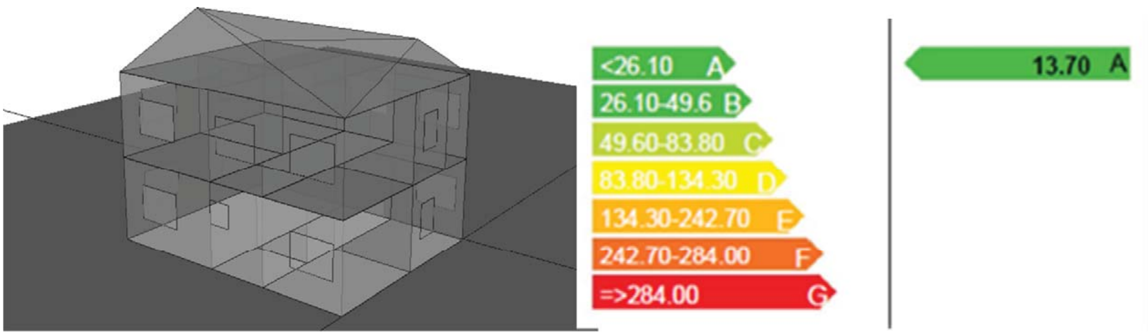

Fig. 1: Case study building represented in the HU-tool

3. Results

In this study a single-family detached house insulated with 12 cm of polyurethane panels and sloping roofs was used as a base case. Final thermal energy demand values obtained for the building were -12,97 kWh/m^{2}year for heating and 14,31 kWh/m^{2}year for cooling, under the limit established by the Spanish Building Technical Code for the Balearic Islands (15 kWh/m^{2}year). Heating and cooling energy demands per month are shown in Fig. 2. Heat losses and gains were evaluated per building component and results are shown in Fig. 3 and Fig. 4.

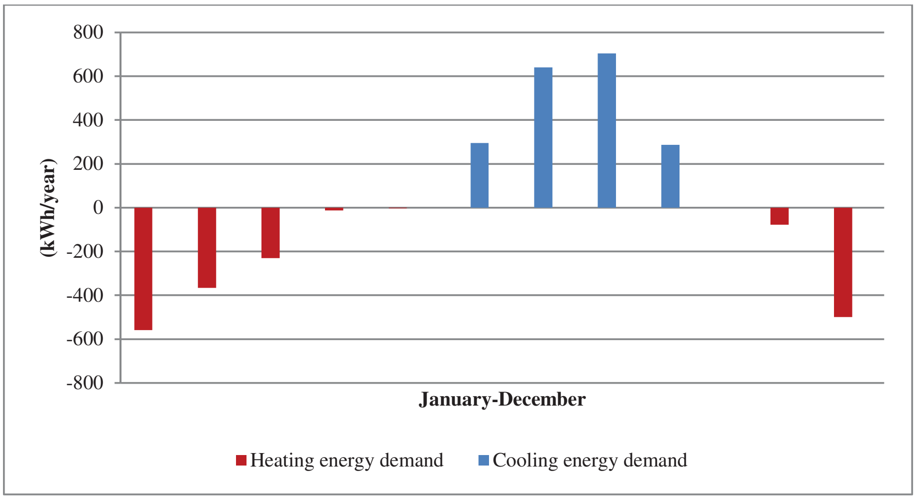

Fig. 2: Heating and cooling energy demands per month

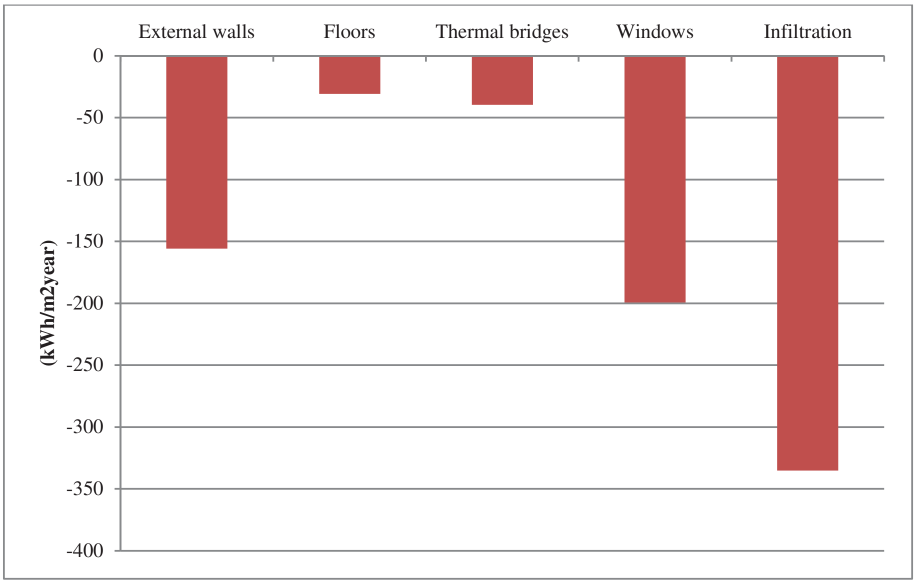

Fig. 3: Heat losses per building component

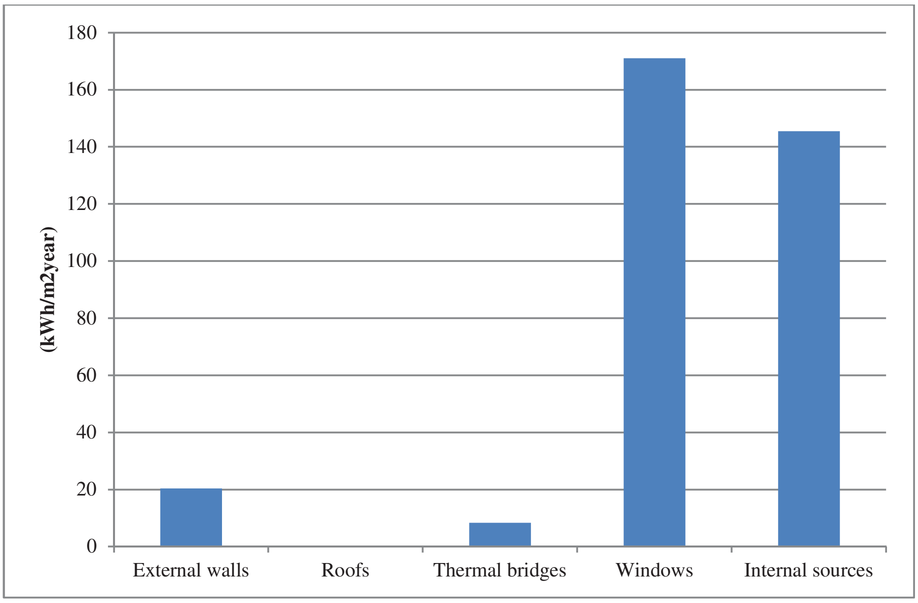

Fig. 2: Heat gains per building component

The results obtained for the base case taking into account the initial energy system of the building were 13,7 $kgCO_2/m^2$year for the CO_2 emitted and a value of 46,8 kWh/m^2year for the non-renewable primary energy consumption. Specific primary energy consumptions for heating, cooling and hot water and specific CO_2 emissions are shown in Fig. 6.

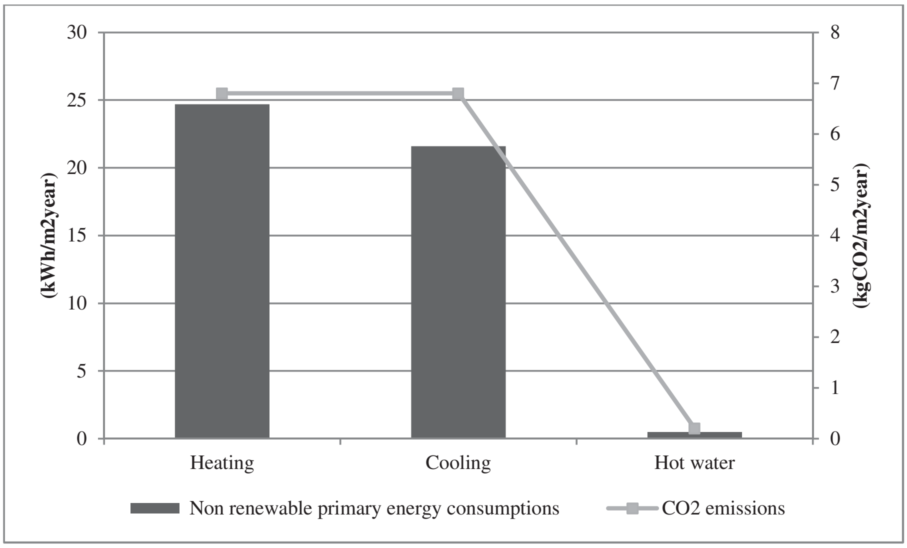

Fig. 6: Non renewable primary energy consumptions and CO_2 emissions for heating, cooling and hot water with the initial energy system

The alternative system proposed for the building was composed by a condensing biomass boiler (10 kW) and a solar water heating (SWH) covering the 95% of demand for hot water, a condensing biomass boiler (20 kW) for heating, a direct expansion air conditioning (3 kW) for cooling a single zone and a photovoltaic installation (1500 kWh/year). An indicator of -1,42 $kgCO_2/m^2$year for the CO_2 emitted and a value of -1,12 kWh/m^2year for the primary energy consumption were obtained using the Unified Tool LIDER-CALENER. Specific primary energy consumptions for heating, cooling and hot water and specific CO_2 emissions are shown in Fig. 7. Self-consumed power is deducted from the global indicator and it is not shown for specific consumptions.

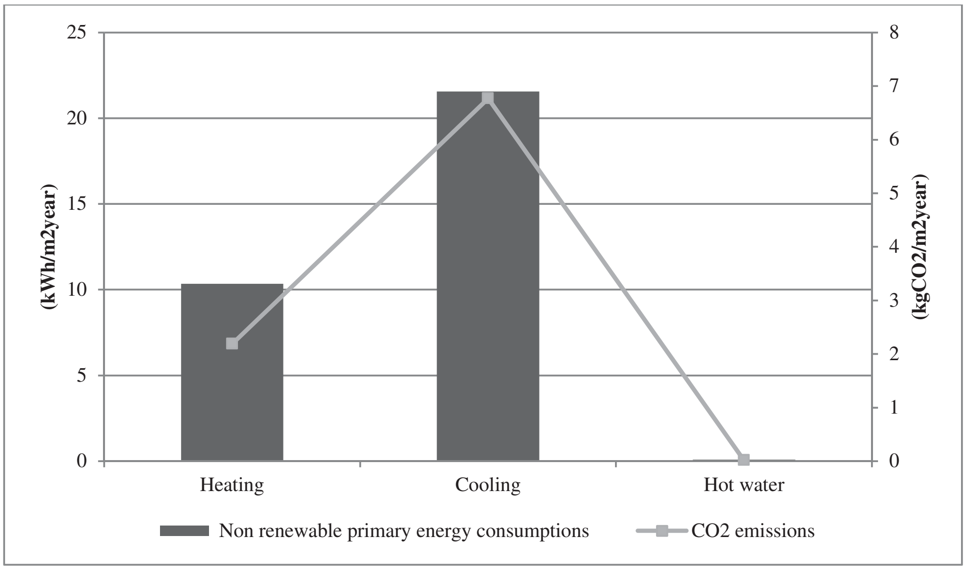

Fig. 7: Non renewable primary energy consumptions and CO_2 emissions for heating, cooling and hot water with the proposed alternative energy system

The label of the house will be A, with a few over cost of the solar thermal system and the PV system, only adding 2 m^2 more to the house and 1 kWp we can have almost zero energy buildings. In Spain the new buildings will be almost zero emissions in 2020, according to the EU law.

4. Conclusions

In this study, the conversion of a single-family detached house to a nearly zero-emissions dwelling was assessed in the Balearic Islands. Final thermal energy demand values obtained for the building were -12,97 kWh/m^2year for heating and 14,31 kWh/m^2year for cooling. It was observed that the greatest heat losses per building component were due to infiltration, windows and external walls. Whereas the greatest heat gains came from windows and internal sources.

The initial energy system for the building was composed by two heat pump air to water and a direct expansion air conditioning for cooling. The results obtained were 13,7 $kgCO_2/m^2$year for the CO_2 emitted and 46,8 kWh/m^2year for the non-renewable primary energy consumption. An alternative system composed by two biomass boilers, a solar water heating, a direct expansion air conditioning for cooling and a photovoltaic installation was proposed for the building. The results obtained were -1,42 $kgCO_2/m^2$year for the CO_2 emitted and -1,12 kWh/m^2year for the primary energy consumption.

4. References

Attia, S., Gratia, E., De Herde, A., & Hensen, J. L. M. (2012). Simulation-based decision support tool for early stages of zero-energy building design. *Energy and Buildings*, *49*, 2–15. http://doi.org/10.1016/j.enbuild.2012.01.028

Ferrante, A., & Cascella, M. T. (2011). Zero energy balance and zero on-site CO2 emission housing development in the Mediterranean climate. *Energy and Buildings*, *43*(8), 2002–2010. http://doi.org/10.1016/j.enbuild.2011.04.008

Gustavsson, L., & Joelsson, A. (2010). Life cycle primary energy analysis of residential buildings. *Energy and Buildings*, *42*(2), 210–220. http://doi.org/10.1016/j.enbuild.2009.08.017

Institute of Construction Technology of Catalonia (ITeC). (2015). BEDEC Database. Retrieved from http://itec.cat/nouBedec.c/bedec.aspx

Instituto para la Diversificación y Ahorro de la Energía (IDAE) y Asociación de Investigación y Cooperación Industrial de Andalucía (AICIA). (2009). Condiciones de aceptación de procedimientos alternativos a LIDER y CALENER. Retrieved from http://www.minetur.gob.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/Documentos Reconocidos/OtrosDocumentos/Calificaci%C3%B3n energ%C3%A9tica. Viviendas/Guia-8_Condiciones_Alternativos.pdf

Ministry of Development. (2013). Unified Tool LIDER-CALENER (HU-Tool). Retrieved from http://www.codigotecnico.org/web/recursos/aplicaciones/contenido/texto_0004.html

Nuij, R. (2013). Intelligent Energy Europe. Retrieved from http://ec.europa.eu/energy/intelligent/files/events/doc/infoday13/parallel/buildings/1-nuij-energy-in-buildings-policy-overview.pdf

The European Parliament and the Council of the European Union. (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002L0091&from=EN

The European Parliament and the Council of the European Union. (2010). DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast). Retrieved from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF

Zabalza Bribián, I., Aranda Usón, A., & Scarpellini, S. (2009). Life cycle assessment in buildings: State-of-the-art and simplified LCA methodology as a complement for building certification. *Building and Environment*, *44*(12), 2510–2520. http://doi.org/10.1016/j.buildenv.2009.05.001

Zeiler, W., & Boxem, G. (2013). Net-zero energy building schools. *Renewable Energy*, *49*, 282–286. http://doi.org/10.1016/j.renene.2012.01.013