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Life cycle energy performances of a Net Zero Energy prefabricated building in Sicily

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Abstract

The paper presents the energy performances in a life cycle perspective of a prefabricated building. The building was simulated in energy plus and validated on monitored data. To avoid the shifting of energy burdens from one life cycle stage to others, a Life Cycle Energy Assessment was performed.
The primary energy use throughout the building's life cycle is 1,242 GJ. The materials production stage consumes the highest amount of primary energy (680 GJ) followed by the use stage (484 GJ), while the construction and end-of-life require respectively 1.7 % and the 4.6 % of total primary energy.

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Keywords: Energy life-cycle approach, Embodied energy, Net Zero Energy Buildings, Modular Buildings ;

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Nomenclature

E	Electric energy fed into the grid, kWhe
EER	Energy Efficiency Ratio
E_p	Primary energy, MJ
$E_{pMaterial\ Production\ stage}$	Primary energy consumption during material production stage, MJ
$E_{pConstruction\ Stage}$	Primary energy consumption during construction stage, MJ
$E_{pUse\ stage}$	Primary energy consumption during use stage, MJ
$E_{pEnd\text{-}of\text{-}life\ stage}$	Primary energy consumption during end-of-life stage, MJ
FRP	Fiber Reinforced Material
FU	Functional Unit
GER	Global Energy requirement, MJ
$GER_{no\text{-}renewable}$	Global not renewable Energy requirement, MJ
$GER_{renewable}$	Global renewable Energy requirement, MJ
I	Imported energy from the grid, kWhe
LCEA	Life Cycle Energy Assessment
NZEB	Net Zero Energy Building
PV	Photovoltaic System
SHGC	Solar Heat Gain Coefficient
T_o	Outsite air temperature, °C
VT	Visible transmittance

1. Introduction

Energy efficiency is a key element of European policies aiming to achieve a sustainable and competitive low-carbon economy by 2020.

One of the ways to improve energy efficiency is to act on the huge potential for efficiency gains in the building sector which is the largest single energy consumer in Europe, absorbing 40% of final energy. Moreover, about 75% of buildings are energy inefficient and, depending on the Member State, only 0.4- 1.2% of the stock is renovated each year.

In this context, specific measures with the aim of creating the conditions for a significant decarbonisation of the building sector were introduced by European Union. In particular the key policy instruments towards this goal are the Energy Efficiency Directives [1], which includes provisions to increase energy efficiency at European level, and the European Directive on the Energy Performance of Buildings [2] that introduces the concept of Net Zero Energy Building (NZEB).

Since the primary energy consumption in use stage dominates the entire life cycle of conventional buildings (usually more than 80-85% of energy consumption) [3, 4], the major efforts of these Directives focus on this stage. However, due to the development of high performance buildings the other life cycle stages, such as the construction and the end-of-life, may become the most impacting ones [5].

Therefore focusing exclusively on achieving the NZEB target during the use stage can cause the shifting of the energy and environmental burdens to other life cycle stages. This means that a reliable assessment of the performances of buildings can not be separated from approaching the whole life cycle of the building [6].

In this context, the paper discusses the energy performances of a prefabricated module in Messina (Italy). Its expected main use is temporary housing for workers or for emergency housings.

The use stage performance was studied through dynamic simulation. Thermo-physical modeling was performed in Energy Plus environment [7]. To enhance the solidity of the model a validation was performed by comparing simulated and monitored data.

A Life Cycle Energy Assessment (LCEA) approach was used to assess the life cycle energy performances of the case study. The LCEA was based on the standards of the ISO 14040 series [8, 9] and on the UNI EN 15978 regulation