Summary

In the last decades, the European Union has implemented several energy policies aimed to the decarbonisation of the building stock, the reduction of energy consumption, the reduction of energy poverty, and the restraint of global warming through the Paris Agreement. The role of architectural design, calculation models or building energy simulation for building behaviour prediction, and the availability of standard reliable data are central to the pursuit of these goals. According to the European Commission, the implementation of Nearly Zero-Energy Buildings (NZEBs) represents one of the biggest occasions to increase energy savings and reduce greenhouse gas emissions.

The design of NZEBs for different climatic and local conditions, requires a set of considerations including cost-optimal and high-performance technical solutions.

This thesis explores the theme of NZEBs focusing on those characteristics that have an influence on energy consumption.

The first section of the document analyzes the legislative development in Italy and Europe, highlighting the main differences and emphasizing how minimum design requirements and the related energy consumption can change from one country to another.

Attention is subsequently shifted to the Italian situation. The first definition of NZEB in Italy occurs in 2015, while the actual application (so far only in the public sector) was in 2019.

The national framework is therefore examined by proposing adjustments both to the technical regulations of the sector and to the legislative framework. Part of the work involves verifying the legislative requirements and updating the methodology of the notional reference building.

The energy performance of buildings can be estimated through various calculation methods. The most used approach by EU member states is the Quasi-Steady State Approach. This methodology is mainly used in the legal context of energy certification. The academic world and the scientific community instead use more sophisticated simulation tools that perform an hourly calculation of energy needs and allow to estimate more realistic energy consumption. The energy performance of some case studies has been calculated using both the quasi-stationary calculation methodology and the dynamic calculation method. The objective was to highlight the main differences between the results when some building envelope parameters change. And so for which buildings and climates the semi-stationary method can provide acceptable results.

In this part of the research, the building is not considered only as a whole. In fact, the single building unit behaviour has been investigated proving how energy needs between building units can vary a lot in the same building.

Therefore, an index that expresses the homogeneity of energy needs behaviour between building units has been also introduced.

Then, following the path of dynamic simulation, parametric analysis was carried out with a building energy simulation program (*EnergyPlus*) to evaluate the energy behaviour by varying the thermal insulation, the presence of thermal bridges and the availability of transparent area (WWR) and its thermal properties.

This analysis was carried out for various locations in different climatic zones. The analysis has allowed to highlight how the design choices can modify the energy building performance. Although it is good practice to insulate buildings, not all buildings have the same behaviour: in fact, it varies according to the climatic characteristics of the locations. The research has investigated what conditions cause a significant imbalance of the energy needs and at which extent.

The last section concerns the realization of TMY for the verification and design of NZEB using the dynamic simulation program. A new methodology that considers the realization of TMYs has been proposed to determine the sensible and latent energy needs of buildings.

This methodology was applied to five locations and verified on twelve case studies with different characteristics of the building envelope. Therefore, sixty-seven TMYs have been tested. In fact, when designing NZEB buildings, considering the low or nearly-zero energy requirements, data about the most realistic boundary conditions are needed.