

# Supplementary Materials: Energy Analysis at a Near Zero Energy Building. A Case-Study in Spain

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From the plans developed concerning the building, in AutoCad, by the Technical Unit of Architecture at the University of Valladolid, where knowing all the materials existing in the construction of the building, the thermal transmission, the orientation of the building with respect to the sun, its HVAC systems, renewable energies which are used and its geolocation, a greater precision is obtained in the development of the model. All this leads to a model of the LUCIA nearly Zero Energy Building which was exported to DesignBuilder V5.

Figure 1 shows the LUCIA nZEB building model to implement in DesignBuilding V5.



**Figure 1.** LUCIA nZEB building model to implement in DesignBuilding V5.

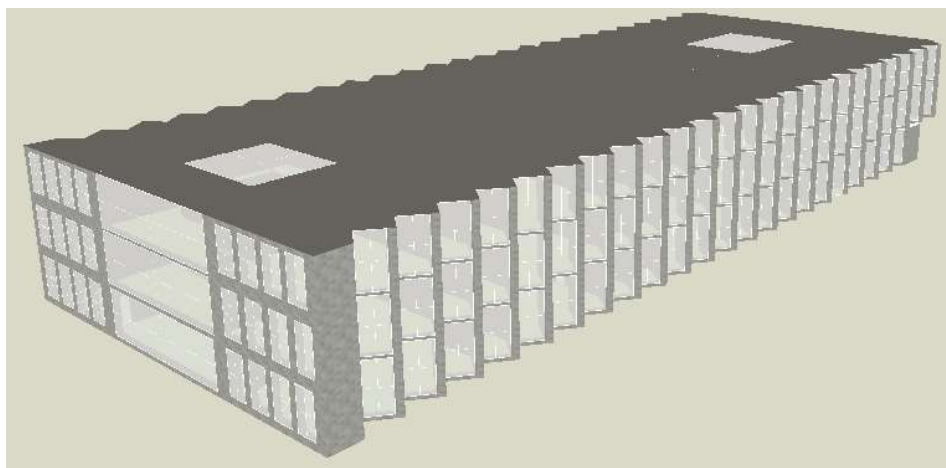
This implemented model, continuing with the previous steps, focuses on the energy use study due to the wide contribution offered by the simulation software where it is developed. They are computer programs that work on a calculation of chronologically ordered series, studying the energy performance of a virtual building, calibrated and revised, under a transitional regime. This is known as dynamic simulation, where energy parameters vary according to the weather and climatic conditions to which it is exposed. The development consists of building the 3D model and introducing all the physical parameters of the building envelope, operating mode, HVAC systems, ventilation and lighting. Due to this simulation different parameters can be obtained, in addition to building inertia, thermal heat flow, ventilation, heat recovery, solar gains and thermal losses.

DesignBuilder v. 5, is the dynamic simulation program where the implemented building model has been developed. Despite having the possibility of carrying out the model with different software, usually used in energy certifications in Spain, where some of them can obtain quite complete information on energy parameters and demand, the idea of international standardization of models based on a powerful tool in the development of energy simulations and being a tool of recognized international prestige for its stability, versatility and quality in the development of simulations, made the choice to model the building with DesignBuilder V5. Carrying out quality controls to guarantee that the model of the building and the real features of the building match both at a structural and energy level.

The simulation of the building is carried out using the EnergyPlus calculation engine, which uses all these data to simulate the thermal and energy performance of the building on an ongoing level. EnergyPlus is a globally recognized and widely used tool for the comprehensive and specific

analysis of multi-zone systems. This calculation engine is based on the development of a thermal and energy simulation of buildings and is regularly updated by the United States Department of Energy.

Figure 2 shows the LUCIA nZEB building modeled on the DesignBuilder V5 platform.



**Figure 2.** LUCIA nZEB building modeled on the DesignBuilder V5 platform.

Through the calculation engine, an accurate and combined analysis of all these factors is carried out with the aim of studying the variation of energy parameters and energy use through time. Due to this, the possibility of performing a calibration by validating the simulated model using the DesignBuilder V5 platform comparing it with the dynamic monitoring of sensors working in the building, which are continuously obtained through the SCADA implemented in the building's system. In addition, due to this technological development, there is the possibility of immediately obtaining different specific energy parameters, such as temperature, humidity, enthalpy, energy consumption or power generation, reducing the time of acquisition and facilitating subsequent analysis.

Including in the simulation model the location of the building in Valladolid, with its longitude, latitude and altitude, plus the meteorological data recorded for a typical year, TMY weather data files, which are obtained and used by the current regulations of the Spanish Standard for Buildings CTE. In our case, there was free access to the weather data of Valladolid using the TMY database of data framed within the Spanish standard for buildings CTE 2013. The reason for using this archive is that the climate data of the model year and the climate data of the monitored year represent a variation of less than 2.7%, therefore the minimal discrepancies have been accepted. The real weather data have been used only for model calibration between DesignBuilder V5 and the values obtained from SCADA. Figure 3 shows the comparison between the actual external temperature data measured by sensors during all hours of the year and the temperature from TMY weather data in Valladolid. Temperature is analyzed due that it is one of the parameters that most influence on the management of energy systems.

These results obtained by the DesignBuilder V5 simulation software, are exported to an Excel file where they are compared with those obtained by the controllers and sensors that manage the building control through the SCADA system, and where we verify the proximity to the model, adjusting with a minimal error of no more than 3%, and therefore accepting that discrepancy.

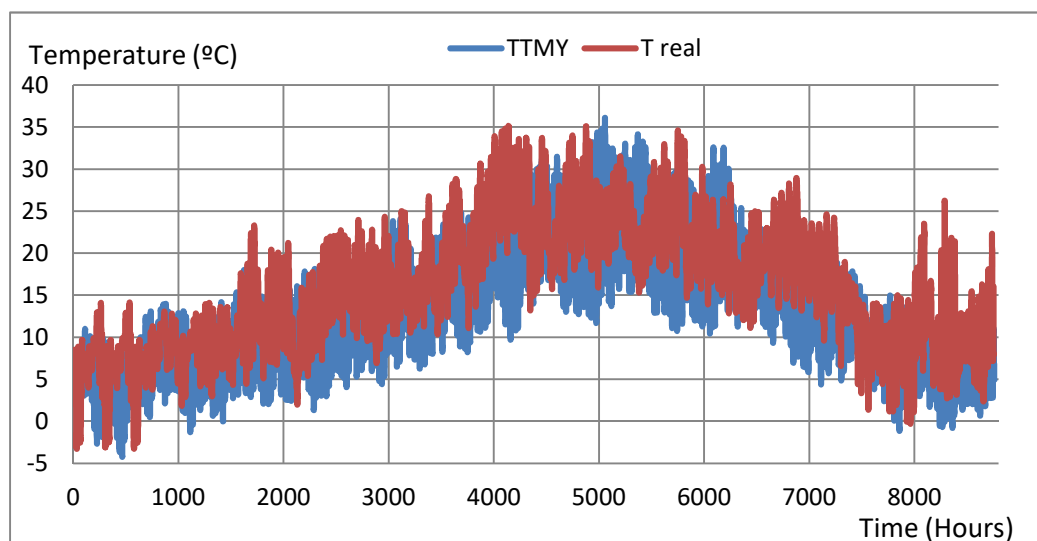


Figure 3. TMY versus Real weather data in Valladolid.

Figure 4 and 5 show an example of a validation comparison between the data obtained by Design Builder V5 and the data obtained by monitoring sensors through Siemens SCADA.

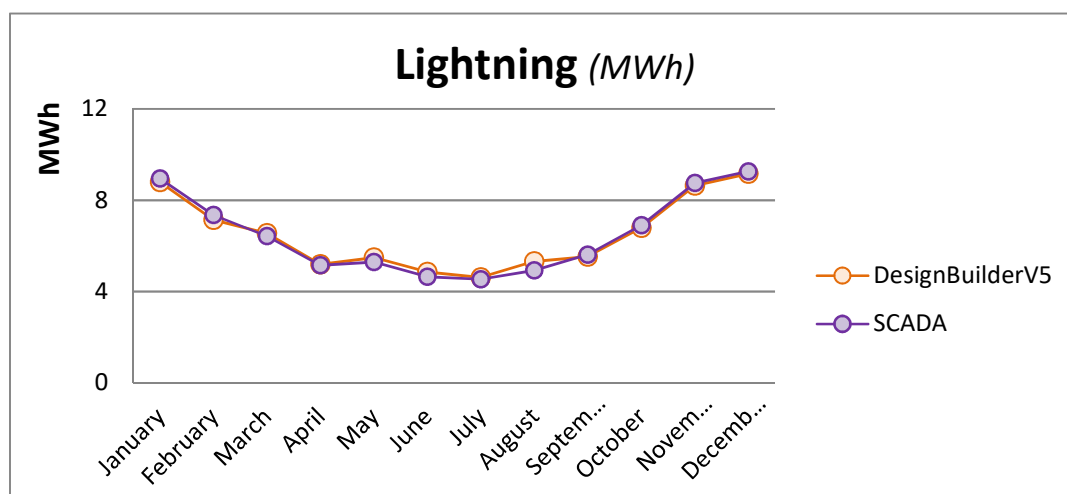


Figure 4. Example of a validation comparison between DesignBuilder v5 Versus Siemens SCADA

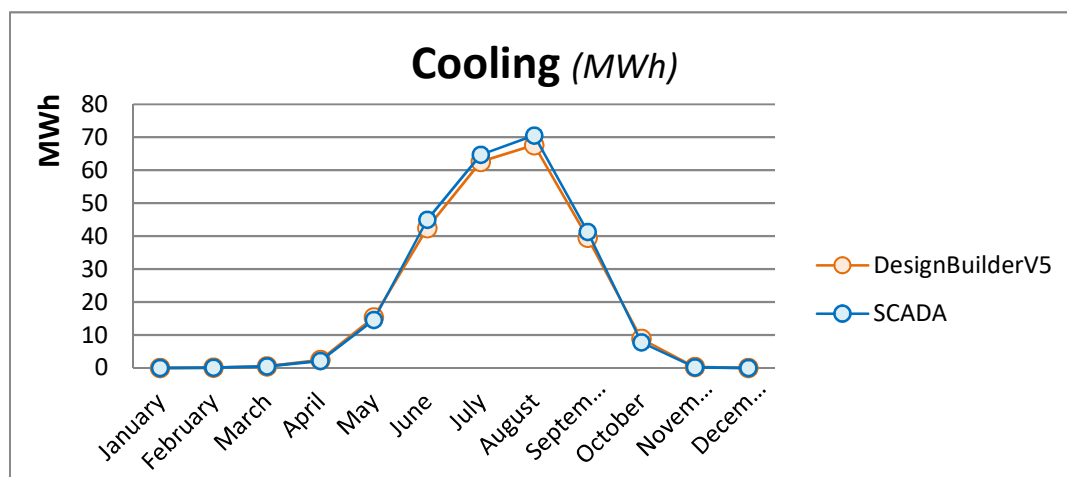


Figure 5. Example of a validation comparison between DesignBuilder v5 Versus Siemens SCADA.

After observing that the model fits quite well to the actual consumption of the building's energy systems, the building is analyzed from its simulation model and the model can be used in different studies, as well as for energy management analysis applied to new energy systems and improvement measures.

Once the model of the LUCIA building has been calibrated and validated using the DesignBuilder V5 software, different results that will be used in the study of this paper are discussed in the following sections, with the aim of achieving an annual energy balance, kWh/m<sup>2</sup>·y energy indicator, a non-renewable primary indicator and finally the renewable energy EER, which allow us to quantify the nZEB building concept and its comparison with European regulations.



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