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Ali Sayigh *Editor*

Sustainable Energy for all

**Selected Papers from the
World Renewable Energy
Congress WREC 2016**



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83- Climate Change Assessment, Simulation and Adaptation for Hot-Arid Urban Settlements: The Case Study of Asmara Project, Cairo, Egypt

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(Full Paper WILL BE RECEIVED LATER)

A project for the NZERO-Foundation in the south of Italy

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Forum topic:

Sustainable architecture

Keyword:

BIM, nZEB, green building, tools, wind control, dynamic envelope, sun shading, buffer spaces, roof garden, efficient heating

Abstract:

NZero-foundation is a complex future oriented student housing.

It has been designed thinking about the characteristics of the place that surrounds it, the specific climatic properties of the Mediterranean region, and the needs and the behavior of the final users.

The model of the building has been completely created using a BIM software, which permitted to simulate the performances of the envelope, annual energy consumption, lifecycle cost, daylight and shading of the facades, and most important, it permitted to use a unique tool for the different phases of the design management.

The nZero-foundation is a green building, the energy consumptions are near to zero, maintaining reasonable realization costs. To reach the target it adopts different strategies to reduce heat losses during winter (buffer spaces, roof gardens, low transmittance glasses and walls, led lights) and during summer (brise-soleil, natural shading, natural daylighting, high-efficiency mechanical ventilation systems). The complex collects rainwater, coming from roofs and non-permeable soils, for domestic and watering uses, recover heat from geothermal and produce energy from photovoltaic on the rooftop obtaining a balanced system between energy performances and an affordable realization cost.



1. Introduction

The concept of green architecture, also known as sustainable architecture, is the philosophy, science of buildings designed and constructed in accordance with environmentally friendly principles.

The purpose of the study is to manage the entire design process through a single software, from the preliminary conceptual phase until the energy simulation phase, allowing the designer to correct in real time the strategic decisions and avoiding multiple software problems.

The use of a holistic BIM methodology, permit to create a visual high detailed model, useful to chose the shapes of the architectural object and, at the same time, to calculate the performance of the system, wich is essential for a responsible shared strategy. The difficulty of the study is to manage a very great volume in this calculation, keeping in mind that the project refers to a social housing district, and that passive strategy can't be easily computed in a conceptual energy building model.

2. Project objectives

The target is to demonstrate with a conceptual model, that even a very large scale building, mostly reserved for public use, can reach Nearly Zero Energy Building standards (NZEB). NZEB building is defined in Article 2 of the EPBD Directive 2010/31/EU as “ building that has a very high energy performance. The nearly zero amount of energy required should be covered to a very significant extent by energy from renewable sources, produced onsite or nearby². In our case the transmittance requirements, that are specific for different climatic zone in the south of Italy (south area is mostly assigned to B and C) refer to D.M. 26/06/2015, that defines the limits of the opaque ($U = 0.38 \text{ W/mq} + K$) or transparent envelope ($U = 2.40 \text{ W/mq} * K$) in addition to roof and floor transmittances ($U = 0.36 \text{ W/mq} * K$). The metric that is used to compare the energy consumption for different buildings by accounting conditioned floor area is EUI, Energy Use Intensity, that is defined as annual energy consumption divided by conditioned floor area and is expressed in the units of kBtu/sf/yr or kWh/sm/yr. Our specific objective is to reach at least $16 \text{ kBtu/sf/yr} = 52 \text{ kWh/sm/yr}$, which is a good goal for a social housing complex that can accommodate over 2600 students and contain many services for the entire community in 89.000 square meters of conditioned floor area.

In addition to the technical requirements, the very important target is the implementation of a passive strategy which contributes to maintain high level of comfort using basic knowledge of bio-climatic architecture, essential creating a healthy green design with a limited budget.



A rendered view created with internal program engine

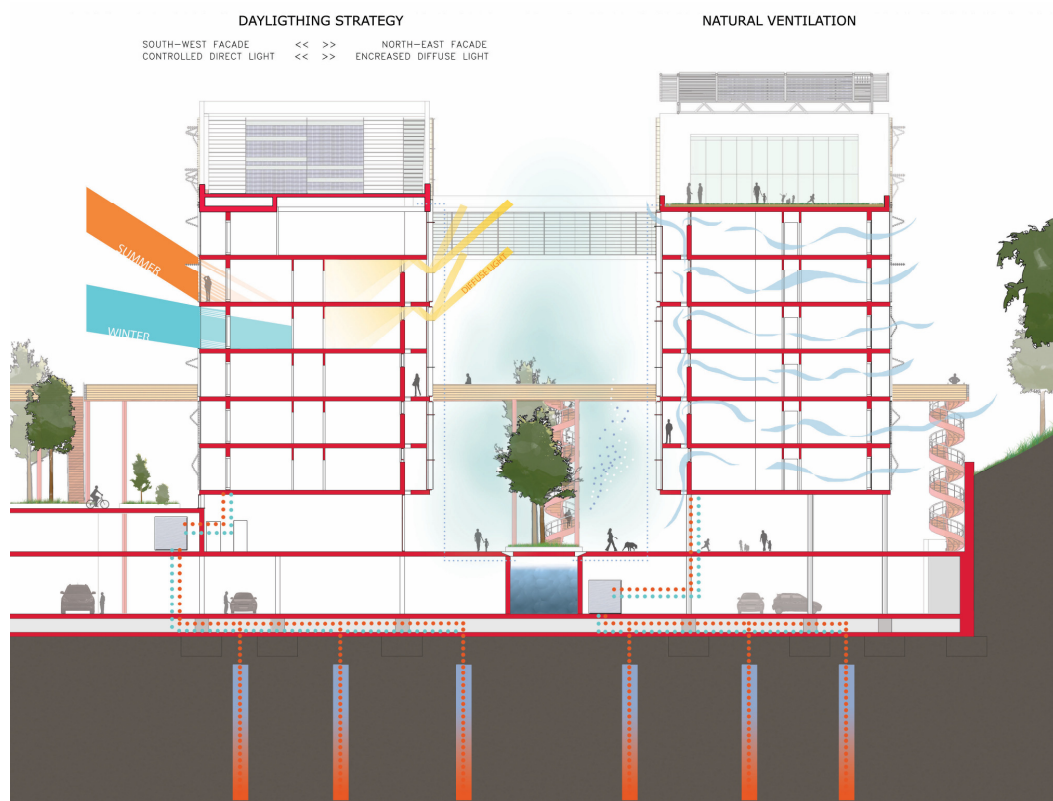
3. Methodology

In order to achieve the stipulated aim, the study presented in this paper traces the following steps:

1. Describing the benefits of applying adopted passive strategies that depend from site climatic considerations;
2. Exposing the technical properties of the building;
3. Defining the criteria assumptions for the creation of a simplified conceptual model;
4. Describing the results of the simulation in order to validate the strategic assumptions.

3.1. Passive strategies:

The passive bioclimatic strategies are the following, and allow to reduce the Energy requirements of the entire system without requiring additional costs:



Illustrated south-west section

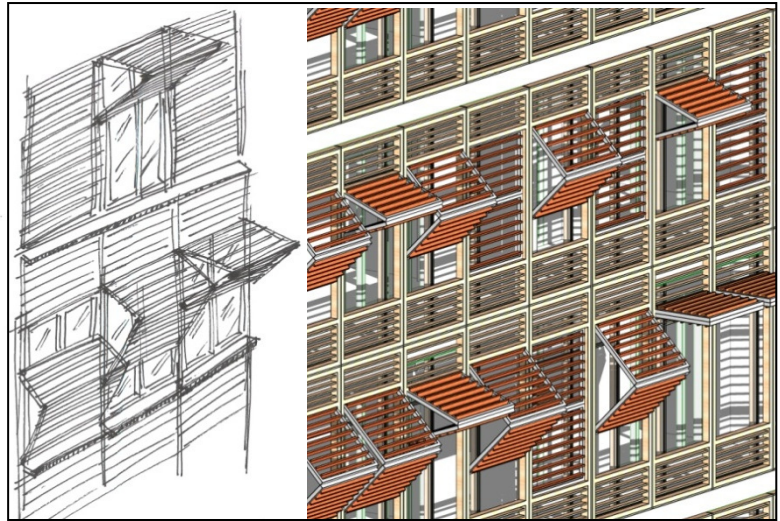
- *Wind control:*
Take advantage of fresh winds during late hours of summer to increase cross ventilation and reduce mechanical intervention as much as possible;
- *Environment:*
Benefit from existing vegetation buffers to reduce noise and cold winds;
create gardens at different levels to multiply green socialization spaces and increase healthy places;

recover rainwater for domestic use;

- *Sun shading:*

A double skinned wall surrounds the building, reduces sun penetration during summer months and lets the light and heat in during winter months.

In particular, a “parametric family” has been expressly created to speed up the creation process of the shading facade, which allows to regulate the right angle of the brise-soleil fixture according to the final user needs.



From the sketch to the “parametric family”

- *Buffer spaces:*

Passive solar design pre-heat air entering from adjacent rooms and help maintain thermal comfort indoor;

Adjustable windows permit the users to control natural ventilation according to their own needs;

Intermediate space permits a flexible use, ideal for drain clothing, summer lecture room or outdoor dog house.

- *Distribution balcony:*

Facing the internal court makes it possible to create two-sided overlooking apartments, and generates vertical stack effect through ventilation grids;

- *Roof garden:*

Create high insulated rooftops;

Generate exclusive shared spaces ideal for socialization and with high solar exposition.

- *Efficient heating:*

Mechanical air systems with heat recovery reduce heat losses;

The vertical geothermal system linked with heat pumps permits high efficient heating system.

- *Envelope:*

Low u-value (transmittance) walls and windows reduce heat losses during cold season and minimise mechanical intervention during summer.

3.2. Project assumptions

The site is characterized by high level of relative humidity, influenced by the sea breeze, and the diurnal average temperature have a range between 9°C and 25°C.

The “block” object of study, that is reduced compared to the total project area, has a floor area of 23.000 square meters, for an estimated number of 970 people. It was necessary to isolate a single block since every block is independent of each other.

The building envelope is crucial for high performance, and has very low-transmittance properties:

Wall R-Value: made in R-20 wood frame wall, equivalent to $U = 0.28 \text{ Watt/mq}^{\circ}\text{K}$

Roof R-Value: R-30 wood frame floor with overlying garden roof, equivalent to $U = 0.18 \text{ Watt/mq}^{\circ}\text{K}$

Windows U-Value: triple low emission glass, equivalent to $U = 1.45 \text{ Watt/mq}^{\circ}\text{K}$

Window to wall ratio: 28%

The heating and cooling system and the water system are based on ground source heat pumps having 4.2 COP of efficiency and the ventilation strategy is based on natural ventilation and supply fan flow. LED lighting has an average power density of 0.28 W/sf , controlled by photosensors.

Renewable consist in 90 meters depth geothermal for heat recovery, polycrystalline and thin-film photovoltaic for the production of about 600 kWatt/h/yr over a surface of 2200 square meters.



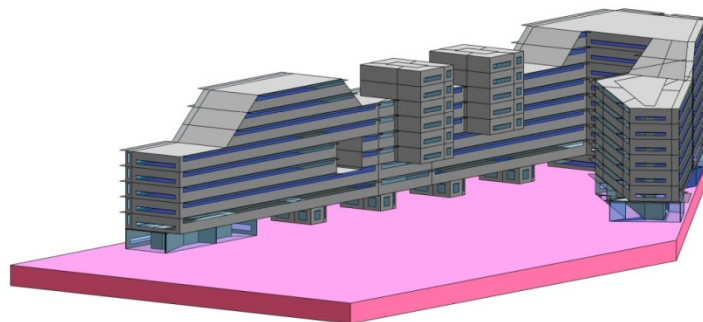
Block object of study

Photorealistic simulation

3.3. Energy model

Because of the complexity of the architectural shapes, it was necessary to create a conceptual massing elements model, easily manageable even if less accurate for the calculation.

This step, as the ideation one, has been performed with a single software, Revit Architecture, just to maintain the initial purpose of the study: manage the entire process adopting only one tool, from the design to the energy calculation.



Conceptual model created to calculate Energy performance of the block

This architectural elevation drawing illustrates the facade of a modern building. The structure features a prominent sloped roofline on the right side, which transitions into a flat roof on the left. The facade is characterized by a dense grid of windows, with some sections featuring horizontal louvers or shutters. The drawing uses a combination of solid black lines and white space to represent the building's form and window patterns. The overall design is minimalist and functional, emphasizing geometric forms and light penetration.

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3.4. Environmental Impact and results

After the modeling step, next one is to direct the information, contained inside the conceptual model, to the cloud tool GBS by Autodesk.

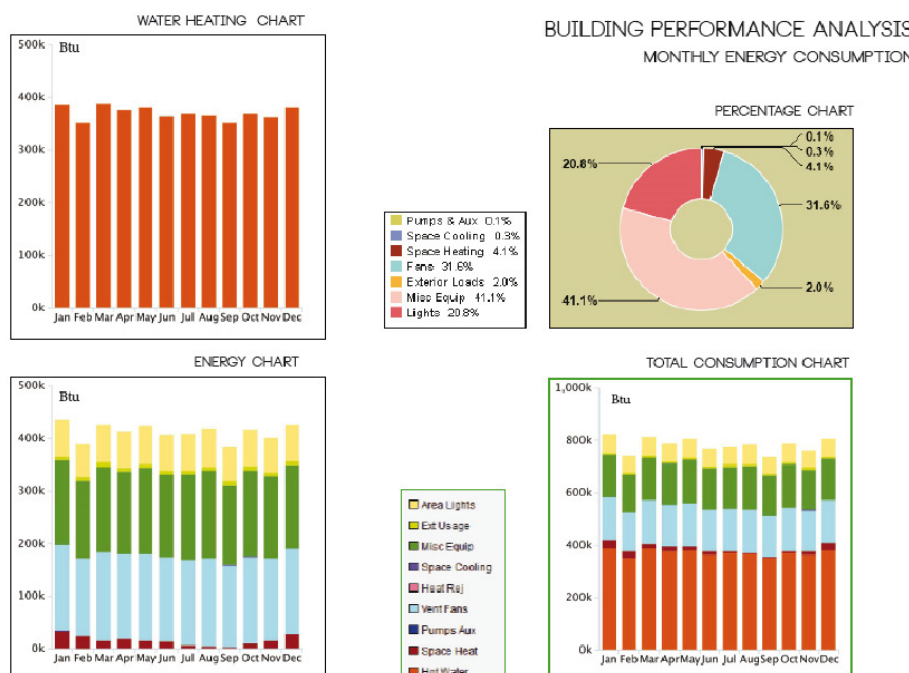
Green Building Studio is a cloud-based service that allows you to run building performance simulations to optimize energy efficiency and to work toward carbon neutrality earlier in the design process.

The results of the calculation, having acceptable approximation because of the simplicity of the model, are the following:

The Energy Use Intensity (EUI) is about 24 kBtu/sf/yr, from which we can subtract the photovoltaic production value of about 8.1 kBtu/sf/yr, that brings the final value to 15.9 kBtu/sf/yr, equivalent to about 51 kWh/sm/yr.

The estimated annual CO2 emissions are 494 tons for electric and 258 for onsite fuel.

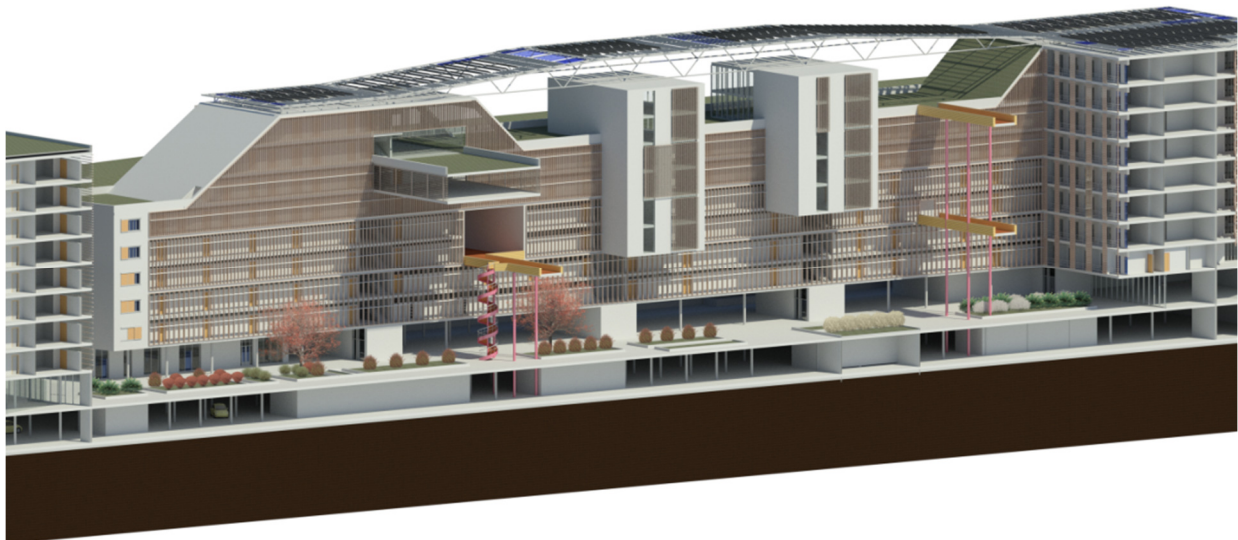
The estimated lifecycle energy demand is about 43.540.000 kW for electric and 1.335.000 therms for fuel.



4. Conclusions

Green architecture produces environmental, economic and social benefits. Environmentally, green architecture helps reduce pollution, conserve natural resources and prevent environmental degradation. Economically, it reduces the amount of money that the building's operators have to spend on water and energy and improves the productivity of those using the facility. Socially, green buildings are meant to serve the population by inserting beautiful artificial objects within the context, both natural and anthropic. To achieve this aim, the designer needs specific tools and preparation, essential to face the unforeseen and propose the solution. A holistic BIM oriented method, helps the operator make decisions in relatively short time, almost in real time, which allows generating a better architecture without neglecting aesthetics neither functionality.

[4] Tools for the energy analysis are used by architects and engineers to design energy-efficient buildings. Energy was chosen. The energy consumption analysis should be defined at the conceptual design stage, this very could be very helpful for designers when makes decisions related to the selection of the most suitable design alternative that will lead to an energy-efficient building. Building Information Modeling (BIM) has the capability to help users assess different design alternatives and select vital energy strategies and systems at the conceptual design stage of proposed projects. Furthermore, by using BIM tools, designers are able to select the right type of materials early during the design stage and to make energy-related decisions that have a great impact on the whole building life cycle.



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