

A non-residential NZEB in Naples



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The feasibility of several new technologies for energy efficiency in buildings is investigated by means of a novel in-house developed Building Energy Performance Simulation (BEPS) code (called DETECt). A novel case study referred to a non-residential NZEB to be built up in Naples is presented.

Keywords: net zero energy building, passive design strategies, energy optimization procedure, building integrated solar thermal systems, phase change materials.

Buildings energy efficiency targets have led the research interest toward new energy saving strategies to be integrated into the design, construction, and operation of new and retrofitted existing buildings. Particularly for sizing and optimising purposes (especially for NZEBs), advanced energy analysis tools should be adopted to analyse the potential effects of crucial design and operating variables on the building energy performances. Aim of this work is to present the results of a comprehensive energy analysis, carried out through an in-house validated dynamic simulation code written in MatLab (called DETECt 2.2 [1]), and referred to a non-residential multi-zone NZEB to be located in Naples, Southern Italy [2]. In such building, electricity is produced through a BIPV/T system, while heat is obtained by innovative integrated solar collec-

tors (also driving a double stage absorption chiller for solar cooling). Different novel building integrated energy saving techniques are taken into account: PCM, sunspace, smart daylighting, etc. A suitable parametric analysis is carried out in order to identify the optimal set of design and operating parameters that minimizes the building heating and cooling energy consumptions. Details about the simulation results and the economic feasibility of all the considered energy efficiency techniques are provided. According to the authors' knowledge the presented non-residential NZEB is the first one conceived for Mediterranean climates.

Site and climate

The building will be built up in Naples (Southern Italy, 40°20'N – 14°15'E), which features a Mediterranean temperate climate with rather hot and humid summers (CDD = 185 Kd, design temperature and humidity: 32°C and 60%) and quite mild winters (HDD = 1 163 Kd, design and average temperature: 2 and 10°C).

Building envelope

The project initiative stems from the action ED6 of the Sustainable Energy Action Plan (SEAP, Covenant of Majors of the European Community, August 3rd 2012) and from an explicit Resolution (n. 517 on April 21st 2011) of the Municipality of Naples. The NZEB will be built up on three floors, two of them above the ground level (**Figure 1**). It will host offices (at the ground floor) and conference and exposition spaces (at the first floor). Equipment rooms and stories will be located at the basement.

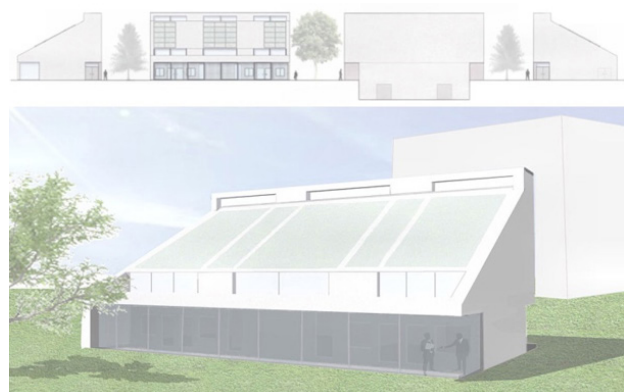


Figure 1. Non-residential NZEB to be built up in Naples, southern view.

In order to fulfil the criteria for passive heating and cooling techniques, the building is subdivided in ten thermal zones and it is conceived with a rectangular shape (15.0 × 24.5 m, East-West oriented longitudinal axis) with a S/V ratio equal to 0.38. In order to minimize the primary energy demand, several design parameters have been optimized through a validated simulation code, DETECt 2.2, which easily enables the automatic comparison of multiple building scenarios by a single simulation run [1, 3]. Several obtained building features are reported in **Table 1**.

For optimizing the winter heat loss and the yearly solar heat gains and radiation loads, windows are designed only on the southern façades (**Figure 1**). Thus, the low building window to wall surface area ratio (about 15%) reaches 70% if referred to the southern façade only. Here, first floor terrace windows are equipped by external variable tilt solar shadings. At the southern side of the ground floor, a sunspace is designed to maximize the winter passive heating. Such space becomes (by opening the external sliding windows) a shaded open porch during summer. The porch ceiling width and height are optimised to prevent indoor space superheating (**Figure 2**). More details are reported in [2].

Building plants and RES

The roof surface is 70% (135 m²) covered by mono-crystalline BIPV/T panels (16.5 kW_p). The remaining roof area (58 m²) is equipped by innovative building integrated flat-plate evacuated solar thermal collectors (37 kW_p), providing space solar heating and cooling and DHW preparation. For both such technologies, energy performance and passive effects on the thermal building behaviour were dynamically assessed through DETECt. The roof integrated PV/T system is cooled by an air stream of 0.5 kg/s, which provides free space heating during the middle seasons. For

enhancing the system energy performance, the BIPV/T system is suitably coupled to PCM panels. In summer, the hot fluid obtained by the solar thermal panels (up to 250°C) is exploited for space cooling (HVAC system supported by a 26 kW double stage absorption chiller). The passive effect of such innovative solar thermal collectors is low due to their high thermal insulation (deep vacuum up to 10⁻⁹ mbar). The HVAC system backup is obtained through a 38 kW geothermal heat pump/chiller. Heating and cooling is provided to the indoor spaces through a fan coil and primary air system (AHU of 2 500 m³/h) supported by ground-to-air and air-to-air heat exchangers (with summer evaporative cooling unit).

Energy performance analysis

The dynamic energy performance analysis is carried out through DETECt 2.2 [1-3]. Weather conditions are simulated according to the IWEC hourly data of Naples. The simulation starts on January 1st and ends at December 31st. Heating is activated from November 15th to March 31st and cooling from June 1st to September 30th (August excluded), both from 9:00 to 18:00. The winter indoor air set-point is 20°C (sensible

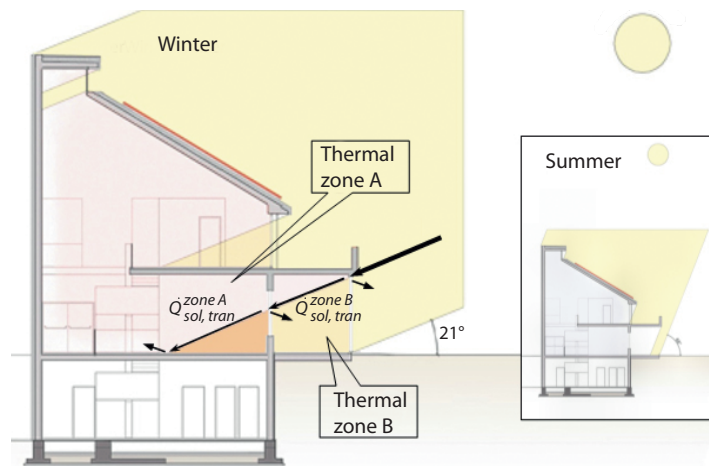


Figure 2. Winter sunspace, summer porch and solar radiation optimization.

Table 1. Building envelope features.

Building element	Density [kg/m ³]	Transmittance U [W/m ² K]	Embedded PCM layer	Note
Vertical walls	800 (brick layer)	0.23	Yes (3 cm)	
Tilted roof	1 050 (concrete slab)	0.23	Yes (3 cm)	
Sunspace (exterior), East office, conference room windows	—	1.6	No	Emissivity = 0.10. 6/13/6 glazing filled by Argon. SHGC = 0.58
Other windows	—	0.9	No	Emissivity = 0.10. 6/8/6/8/6 glazing filled by Krypton. SHGC = 0.46

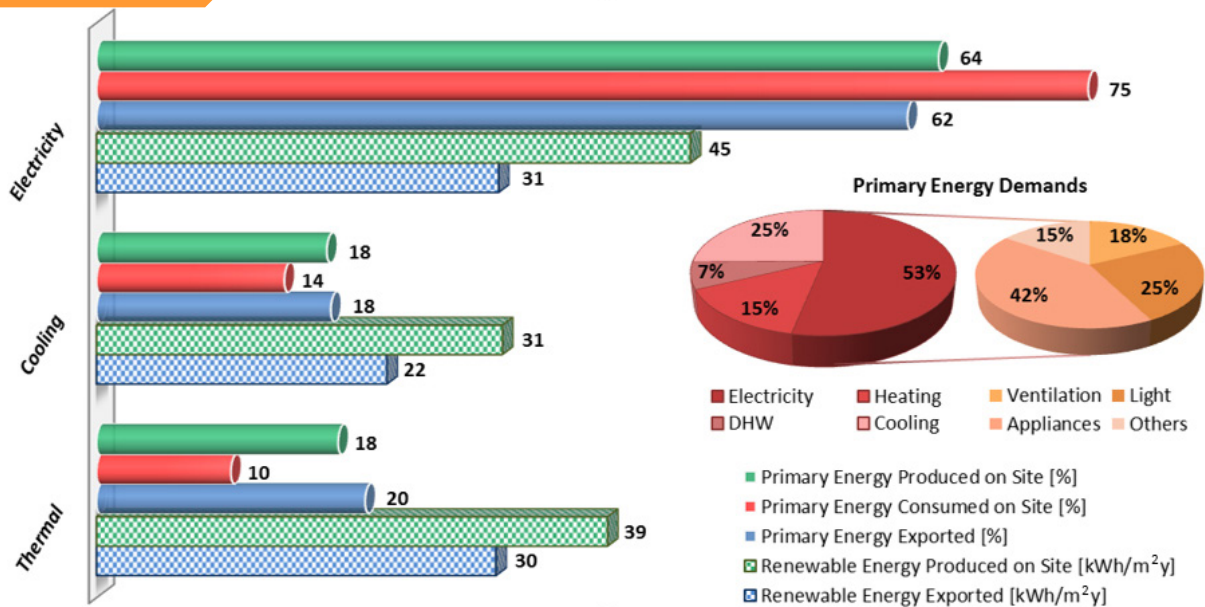


Figure 3. Annual energy analysis results.

heating only). The summer set-points for temperature and humidity are 26°C and 60% (sensible cooling and dehumidification). Occupancy rates are: offices 9 h/day, 5 d/week; expo spaces 9 h/day, 3 d/week; conference room 9 h/day, 1 d/week. Ventilation rates and internal loads are set as the standard ones for the simulated building uses.

The results of the energy analysis are shown in **Figure 3**. Here, the reported percentages are referred to the produced, consumed and exported primary energy for electricity, cooling and thermal uses, respectively. Primary energy produced and consumed on site and exported surplus are equal to 153.7, 40.9 and 108.1 kWh/m²y, respectively. The heating and cooling energy demands are very low resulting almost entirely covered by solar energy production (about 90 and 93% of the energy demands for heating and cooling are balanced by renewable energy). The electricity demand (about 53% of the overall building energy one) is mainly due to ventilation, lighting (optimized by modulating the windows shadings according to the optimal visual comfort) and appliances (rather high, about 42% of the demand, according to the considered building uses). The contribution on the overall balance of renewable energies is equal to 235% (remarkably high because of the large solar field designed to supply energy also to an adjacent public building) while the imported primary energy requirement is equal to 32.0 kWh/m²y. Note that according to the Italian rules (UNI TS 11300 - Italian release of EN 13790), the NZEB heating primary energy and cooling energy (not primary) demands result 1.92 kWh/m³y and 9.39 kWh/m²y, respectively (corresponding to the best energy efficiency classes: A+ and I).

A simplified economic analysis, referred only to the extra-costs to be considered vs. a standard NZEB configuration (fulfilling the requirements of the Italian rules for the buildings energy efficiency) was also carried out. Such overall extra-cost reaches 48.2 k€ and decreases to 1.6 k€ without PCM adoption. In this case (no PCM) the SPB period (selling the exported electricity at 0.08 €/kWh) is of about 14 years without national funding. With PCM the resulting SPB period is currently too long. ■

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