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neZEH NEARLY ZERO ENERGY HOTELS

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A future nearly Zero Energy Hotel in Italy



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The paper presents the refurbishment project of one of the Italian pilot cases of the European neZEH project, the Residence L'Orologio in Turin. The provided information resulted from the energy audit and the feasibility study, currently in progress, aiming to guide the hotel owners in their choices.

Keywords: neZEH, nZEB, hotel, refurbishment project, energy efficiency measures.

Introduction

The case study proposed in this paper aims at demonstrating the feasibility and sustainability of a refurbishment project of a small-medium hotel. This is also one of the main goals of the IEE funded project neZEH[1] and, indeed, the presented hotel, the Italian Residence L'Orologio, is included in the long list of the thirteen

1 Nearly Zero Energy Hotels (neZEH) is a three years long project supported by the Intelligent Energy Europe (IEE) program started in April 2013, involving a consortium of seven European Countries (Croatia, France, Greece, Italy, Romania, Spain, Sweden) and ten partners. The project aims at accelerating the refurbishment rate of existing buildings into nZEB in the hospitality sector and promoting the front-runners. Focusing particularly on the SME hotels. www.nezeh.eu

European pilot projects that will run for the nearly Zero Energy goal in their businesses across seven countries.

The information derived from the energy audit of the Residence L'Orologio were used to structure this paper. Based on the current building features, the building model was implemented in an energy simulation software and retrofit interventions were simulated and evaluated by applying the cost-optimal methodology.

The Hotel and its context

The Residence L'Orologio is an urban hotel located in a central area of Turin, in Piedmont Region. The geographical location is representative of the Italian Middle Climatic Zone (HDD=2617), such as classified by Tabula project [1]. The specific location of the building, a densely built and historical part of the city, exemplifies the challenges of renovating the building stock in Italy.

This apartment building built at the beginning of 20th century was refurbished and converted into a hotel about ten years ago; the renovation process was started in 2003 by Talaia family, current owners and managers of the Residence. It is worth noting that, because of its historical features, the building is subjected to some constraints, to be considered during the renovation process. Particularly, the main façade cannot be insulated neither from the outside, because of aesthetical reasons, nor from the inside, because of standard minimum guestroom dimension to be maintained.

The building has a rectangular plan, developing in six floors above ground and in a half-basement area (**Figure 1**). Not the whole building area is occupied by the hotel: the top-floor hosts two private apartments, independent from it. Residence L'Orologio offers twenty guestrooms, each of them fully supplied with appliances such as fridge, dishwasher, electric oven, microwave, electric stove, washing machine and TV. Indeed, this business mainly relies on guests' long-term stays, which requires the guestrooms to be very similar to small apartments in terms of internal layout and equipment. The extra facilities offered by the Residence are a small gym, a kitchen for the staff and a children playroom, all located at the half-basement. The main data about the hotel are displayed in **Table 1**.

Figure 1. Typical floor.

Table 1. Hotel's main information.

Name	Residence L'Orologio
Location	Corso Alcide De Gasperi 41, Turin
Type of hotel	Urban
Owner	Talaia family
Manager	Stefania Talaia
Floor area	1 138 m² *(heated area)*
Floors	6 (one half-basement area)
Guest rooms area	874m²
Guest rooms	20
Guest beds	78
Offered facilities	Gym, kitchen for the staff, (children playroom)

Original building envelope and energy system

Residence L'Orologio presents a very traditional structure with load bearing masonry walls. During the first refurbishment of the building, ten years ago, no further insulation was added because their thermal properties were good enough according to the national minimum requirements in effect at that time [2]. Nonetheless, the walls transmittance ($U_{wall,hotel}$ = 1.12 W/m²K) is far below the limit U-value currently in force in Piedmont ($U_{wall,standard}$ = 0.33 W/m²K [3]). On the contrary, all the windows were substituted with the most up-to-date solution in 2005: windows with double-pane and wooden frame ($U_{window,hotel}$ = 2.5 W/m²K). Again, the thermal performance of windows are below the current standards expectations ($U_{window,standard}$ = 2.00 W/m²K [3]).

Dealing with plants, the building is now heated by two condensing boilers powered by natural gas (rated output 84 kW), also used for Domestic Hot Water (DHW) production. The DHW loop also includes an accumulation tank of 300 litres, where water is maintained at the temperature of 46°C. A chiller (cooling capacity 97 kW) is installed for the cooling system. Two-pipes fan coil units, placed in the false ceiling, are the terminals of the heating and cooling system. At present, the building does not have a mechanical ventilation system (except for exhaust air systems in bathrooms and kitchens) and it does not use any on-site renewable energy source.

In terms of energy use management, a number of energy saving measures are installed. All rooms are supplied with key-card and windows' opening sensors communicating with the cooling system.

Current energy consumptions

The energy audit performed within the neZEH project allowed to obtain and compare real and simulated energy uses for Residence L'Orologio. On one side, the actual energy use of the hotel, derived from energy bills, were extrapolated for the past two full years (2013, 2014). On the other side, the information collected about the building physical (envelope, plants, etc.) and operational (occupancy, equipment schedules, etc.) features enabled the authors to model the building in SEAS[2] energy simulation software. In case of unknown operational details, reference was made to Italian standards (e.g. minimum ventilation rates, derived from Italian standard UNI 10339 [4]). The simulated delivered energy uses are in line with the actual energy uses, as shown in **Table 2.** Primary energy consumption was calculated by applying to the annual delivered energy results the Italian primary energy factors for natural gas and electricity (1 kWh_{gas} = 1 kWh_{PE} [5]; 1 kWh_{el} = 2.174 kWh_{PE} [5])[3].

Considering that different hotels may offer different facilities, the neZEH Project approaches to the problenm by dealing only with the hotels' energy use for the "hosting functions" (guests' rooms, reception hall, offices, bar and restaurant, meeting rooms), as defined in [6]. Therefore, in addition to the primary energy consumptions for the whole building, energy uses for the hosting functions are displayed. They will be the focus for the next steps of the study.

Toward the energy retrofit: defining Energy Efficiency Measures

The above information was the starting point to draft building energy retrofit hypothesis for the hotel. The existing building was taken as the baseline model to which technically feasible Energy Efficiency Measures (EEMs) were applied via simulations. Bespoke options were considered by taking into account energy audit results,

2 Simulation and energy diagnosis software developed by the Department of Energy Engineering, Systems, Land and Construction (DESTEC) at the Pisa University in collaboration with ENEA.

3 The Italian primary energy factor used in this paper were modified by D.M. 26.06.2015, valid from 1st October 2015. Since the study was carried on before this date, the new factors were not used.

Table 2. Energy consumptions of the building.

		REAL		CALCULATED			
		DELIVERED ENERGY		DELIVERED ENERGY		PRIMARY ENERGY	
SOURCE		2013	2014	Whole building	Hosting functions	Whole building	Hosting functions
Natural gas	kWh_{th}	160 694	142 715	152 035	152 035	152 035	152 035
	kWh_{th}/m^2	141	125	134	134	134	134
Electricity grid	kWh_{el}	96 324	80 443	81 703	69 279	177 622	150 612
	kWh_{el}/m^2	85	71	72	61	156	132

context, building typology and, of course, owners' point of view. Blending EEMs, packages of retrofit interventions (summarized in **Table 3**) were proposed.

Energy and Economic evaluation of the retrofit options

The energy and economic convenience of the proposed retrofit interventions was evaluated by applying the EU-suggested cost-optimal analysis [7], aiming to define the amount of typical primary energy use (i.e. energy use associated with a typical use of the building) leading to the minimum life cycle cost. The cost-optimal framework methodology builds on a comparative methodology framework that is based on the global cost (C_G) method [8], therefore for the baseline model and for each model implementing EEMs all the required input were defined and the C_G was calculated. The calculation period was set as twenty years; 3% discount rate was used; investment costs were taken from Piedmont Price List 2015 or derived from market estimations; replacement and maintenance costs were derived from EN 15459:2007 Appendix A [7]; energy costs were calculated by applying to SEAS simulation results the following energy tariffs: natural gas cost = 0.063 €/kWh; electricity cost = 0.190 €/kWh.

Figure 2 shows the results of the cost-optimal analysis. Primary energy results for retrofit interventions are plotted versus the calculated global cost and vertical

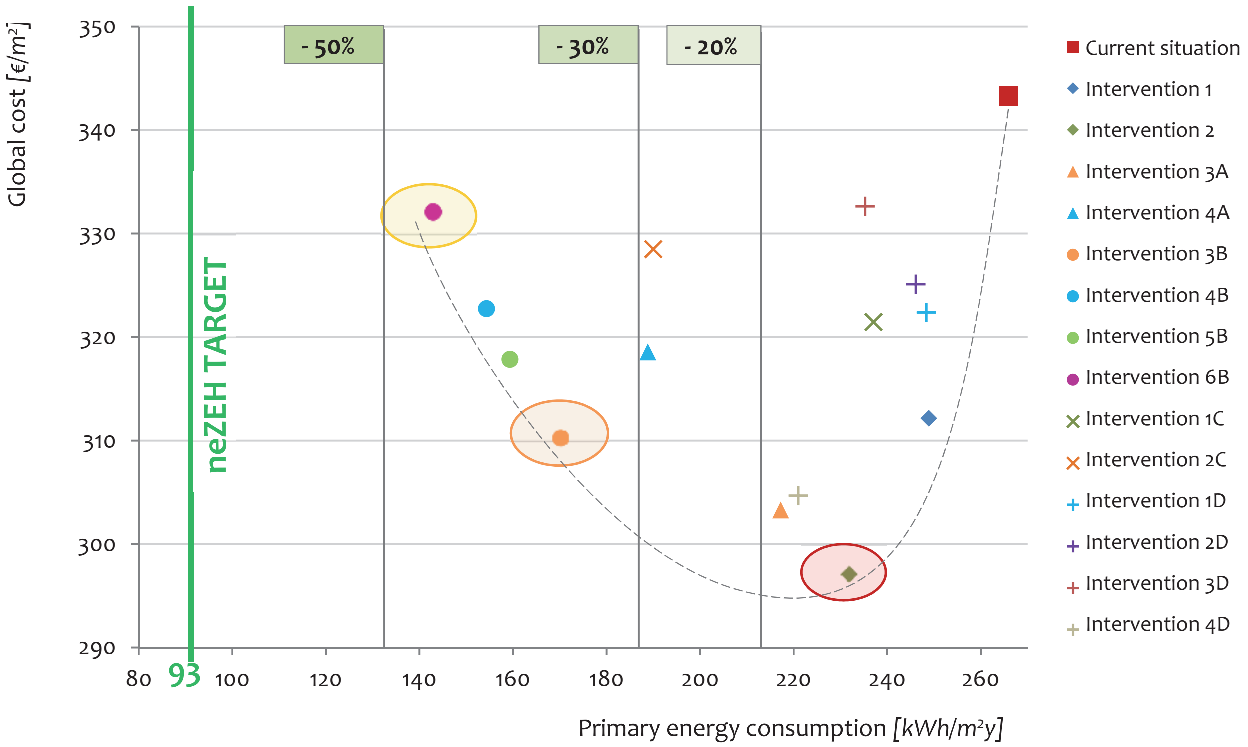

Figure 2. Cost optimal analysis.

Table 3. List and description of the packages of retrofit interventions.

EEM	Interventions													
	1	2	3A	4A	3B	4B	5B	6B	1C	2C	1D	2D	3D	4D
Water saving devices	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
District heating					✓	✓	✓	✓		✓				
Solar thermal system			✓	✓					✓					
Wall insulation - 10 cm				✓		✓								
Wall insulation - 23 cm								✓						
Windows substitution				✓		✓		✓						
Stand-by reduction	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Induction cookers		✓	✓	✓	✓	✓	✓	✓				✓	✓	✓
LED lights		✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Photovoltaic system							✓	✓					✓	✓

lines points out different reduction targets up to the most ambitious one, the Italian benchmark for nearly Zero Energy Hotels defined by neZEH project [5].

The study shows intervention 2 as the cost-optimal retrofit option. However, despite the higher global cost, intervention 3B is a valuable proposal as well, able to reach much higher primary energy savings (- 36% with respect to the baseline model).

Moreover, thinking of an on-going retrofit process, the building could implement EEMs during the years by starting from intervention 2 and going up to the intervention 6B (nearly 50% of primary energy savings). The **intervention 2** would allow the building to save more than 4 000 € per year by implementing simple EEMs. They could be the first improvements for the Residence. By connecting the hotel to the district heating system (**int. 3B**) cost savings are similar, but the higher initial cost is balanced by primary energy savings: 36% of reduction due to the high percentage of RES used to produce this thermal energy. Thus, owners could decide to proceed with the refurbishment by installing photovoltaic panels (**int. 5B**) reducing primary energy to 40%. The last intervention (**int. 6B**) was calculated with the aim to investigate on the best performances of the building by mixing all compatible EEMs.

With regard to the neZEH benchmark, none of the feasible retrofit intervention was able to reduce the primary energy use to the desired target. However, it must be noted that the high electricity consumptions of the building are mainly due to the fact each guestroom is fully supplied with appliances, which is not the case of a standard hotel. By excluding these "extra-consumptions", the best achievable primary energy index (int. 6B) decreases from 143 kWh/m^2y to 112 kWh/m^2y, getting closer to the benchmark. Major interventions, usually related to an overall building reinvestment and remodelling, would allow making the benchmark reachable.

Moreover, the peculiarities of the structure make neZEH target too ambitious. The most evident "real life" constraints for the implementation of retrofit measures are related to the building envelope. The façade insulation is not a suitable measure because of the high cost and the possibility to operate only in the south one and the windows substitution is considered just a theoretically feasible EEM (the potential energy performance improvement achieved does not justify the high investment cost).

Lessons learned

Simulation results pointed out that none of the technically feasible and admissible retrofit intervention is able to reach the target, even if they could lead to halve the current primary energy consumption. These findings are at first sight disappointing for the purpose of the project. Nonetheless on one side they might be the starting point for a review of the proposed benchmarks based on "on-field" experience. On the other side, is must be noted that all interventions were proposed based on the hotelier's needs and plans, which did not include a major renovation. In case of overall building reinvestment, more invasive interventions could have been proposed, making the neZEH target easier to meet.

The economic evaluation of the retrofit interventions, compared in terms of global cost, pointed out that the cost-optimal level of energy performance for Residence L'Orologio is very far from the higher achievable energy performance indicating that financial support by renovation grants or some other incentives would be required in order to realize the energy saving potential. Nonetheless, programming a process of implementation of retrofit measures can be a solution to reach the highest energy performance by distributing the economical efforts year by year. ■

References

See the complete list of references of the article in the html-version at www.rehva.eu -> REHVA Journal.