Paper No 1643

Towards Nearly Zero Energy Hotels Technical Analysis and Recommendations

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KEYWORDS - nearly zero energy buildings, nZEB, sustainable energy, EPBD, large scale renovations, high energy efficient hotels, sustainable tourism

ABSTRACT

Buildings account for 40% of energy consumption and 36% of CO_2 emissions in the EU, therefore demonstrate a high potential for energy savings. To reach the 2050 targets, large scale renovations towards nearly Zero Energy (nZE) are at the forefront of the EU policies. The European Directive on the Energy Performance of Buildings (2010/31/EU, EPBD recast) mandates that all new buildings should be nearly Zero Energy Buildings (nZEB) after the end of 2020, while for new public buildings this applies sooner, from the 1st of January 2019. At the same time, Member States should develop policies and take measures such as the setting of numeric targets and supporting mechanisms in order to stimulate the transformation of buildings into nZEB.

Accommodation represents about 21% of total tourism sector CO_2 emissions. In this light, the neZEH - "nearly Zero Energy Hotels" initiative, co-funded by the Intelligent Energy Europe Programme of the European Commission, aims at accelerating the rate of the refurbishment of existing hotels - representing 90% of the EU hospitality industry - into nZEB. This is achieved by providing technical advice to committed hoteliers, demonstrating the feasibility of investments towards nZE, undertaking training and capacity building activities and promoting front-runner hotels at national, regional and EU level, to increase their market visibility and to inspire a second wave of neZEH projects.

This paper presents the results from 16 pilot hotel projects in 7 European countries (Croatia, France, Greece, Italy, Romania, Spain and Sweden) that are working towards transforming into nZEB. The process consists of four steps: i) an energy audit, assessing the current energy status and suggesting appropriate energy efficiency and renewable energy measures ii) a feasibility study and rollout plan, iii) tendering, contracting and financing the renovation project and iv) training of management and staff. A ranking tool has been developed that prioritize potential measures for hotels with the input of country, region and hotel type. The overall average primary energy reduction for the 16 pilot hotels reaches to 56% whereas RES share reaches to 41%. The preliminary estimation of the positive impacts from nZEB investments in the accommodation sector by the end of 2020, triggered by the neZEH activities, assumes cumulative primary energy savings of 47,000 toe/y, renewable energy production of 7,000 toe/y, 93,000 tCO_2eq/y GHG emissions avoided, while the cumulative investment is estimated to 160 M€.

1 INTRODUCTION

Buildings account for 40% of total energy consumption and 36% of CO_2 emissions in the EU [1], having a large potential for energy saving. Hotels and other accommodation buildings are responsible for 21% of total GHG emissions of the tourism sector [2]. In order for the EU to reach its 2050 energy efficiency targets, large scale building renovations towards nZE, will be at the forefront of its energy policy. The European Directive on the Energy Performance of Buildings (2010/31/EU recast, EPBD), mandates that Member States shall ensure that: (i) by 31 December 2020, all new buildings are nZEB and (ii) after 31 December 2018, new public buildings are nZEB [3]. The Member States, following the leading example of the public sector, should develop policies and take measures, such as the setting of targets and funding tools, to stimulate the transformation of buildings into nZEB. Additionally, the Energy Efficiency Directive (2012/27/EU, EED) establishes a set of binding measures to support the EU in meeting the 20% energy efficiency target by 2020 [4].

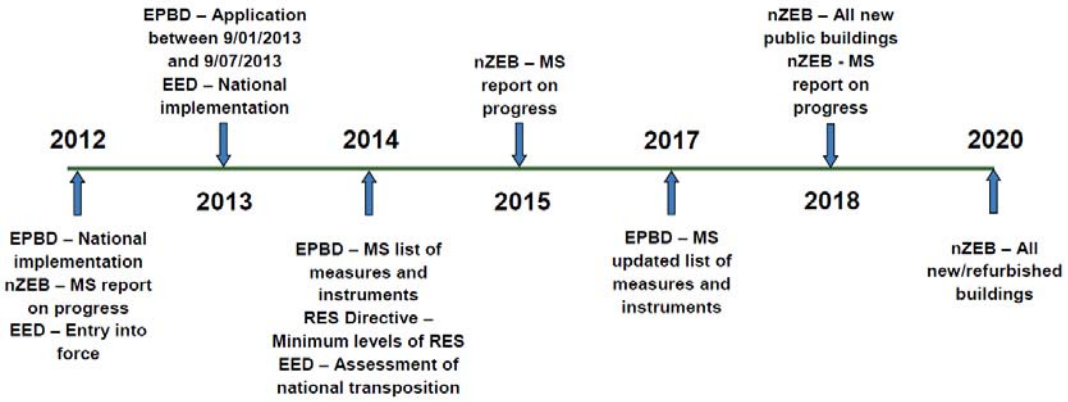

Figure 1: Timeline of nZEB policy implementation in the EU

According to the EPBD, an nZEB is a building that has a very high energy performance; the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from Renewable sources (RES), including energy from renewable sources produced on-site or nearby.

National legislation should answer to questions such as "what is the nearly zero amount of energy" or "how much should be the RES share", as well as other technical issues and include numerical indicators. According to recent reports [5], 16 Member States have already legally set nZEB numerical definitions for some building types, out of which 9 have also numerical definitions for refurbished buildings.

Table 1 nZEB numerical definitions for refurbished buildings in the Member States

Country	Primary energy use indicator for new buildings (kWh/m^2/y)		Primary energy use indicator for refurbished buildings (kWh/m^2/y)	
	Residential	Non-residential	Residential	Non-residential
Austria	160	170	200	250
Belgium-Brussels	45	~90 [a]	54	~108 [a]
Cyprus	100	125	As for new buildings	
Czech Republic	75-80% [a,c]	90% [c]	As for new buildings	
Denmark	20	25	As for new buildings	
France	40-65 [a,b]	70-110 [a,b]	80 [b]	60% PE [a]
Latvia	95	95	As for new buildings	
Lithuania	comply with class A++		As for new buildings	

[a] Depending on the reference building; [b] Depending on the location; [c] Maximum primary energy consumption defined as a percentage of the primary energy consumption (PE) of a reference building. In the Czech Republic, the non-renewable primary energy is considered instead of the primary energy.

The energy performance of a building is determined on the basis of the calculated or actual annual energy that is consumed in order to meet the different needs associated with its typical use and reflects the heating and cooling energy needs to maintain the envisaged temperature conditions of the building, and domestic hot water (DHW) needs.

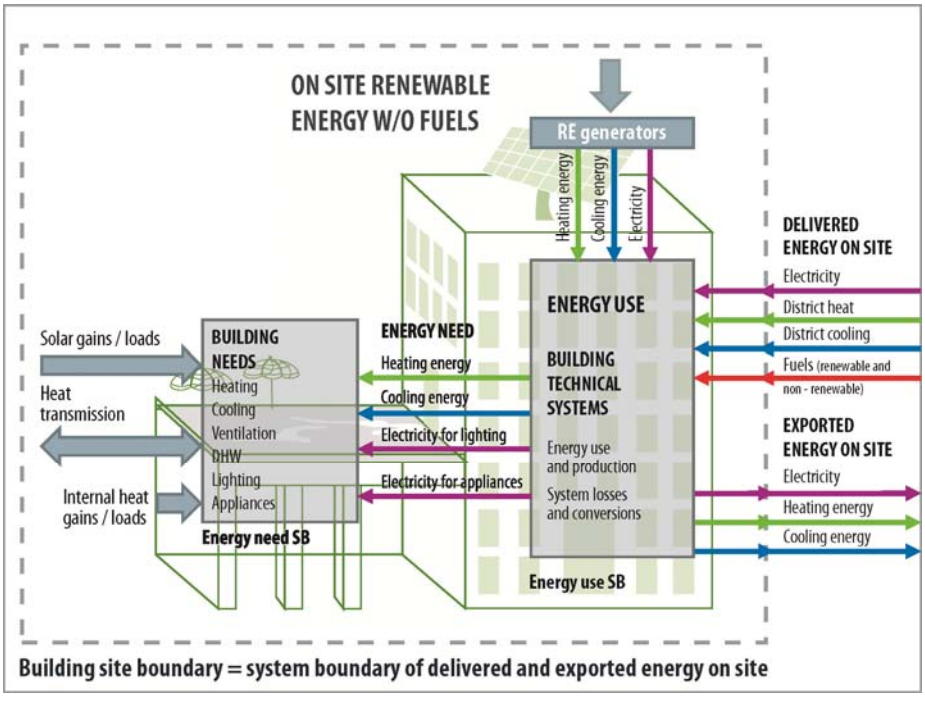

Figure 2: Energy flows in a hotel building

Hotel buildings, however, feature some special characteristics that inevitably are taken account when planning an energy renovation:

a) Seasonal operation on many occasions. Many hotels, especially coastal, operate only during spring/summer months whereas the hotels that stay open all year round have high and low seasons, causing a fluctuation in their energy demand.

b) A large share of their energy demand is consumed for functions that are not associated with the building's typical use, but have to do with additional services provided to their guests, such as spa, pools, gym, etc. These functions are tightly connected with their guests' comfort and expectations, thus critical for their business competitiveness and sustainability. Data from Spanish hotels indicate that energy consumption for additional services can reach up to 35% of the total consumed energy[1].

The European initiative Nearly Zero Energy Hotels – neZEH (www.nezeh.eu), aims at accelerating the rate of the refurbishment of existing hotels to become nZEB. The main target group is SME hotels, which represent 90% of the European hospitality market and are usually more reluctant to commit to energy saving measures and the use of renewable energies [6,7]. The pillars of the project methodology are:

- providing technical advice to committed hotel owners
- demonstrating the profitability, feasibility and sustainability of investments towards nZE
- undertaking training and capacity building activities
- promoting front runners at national, regional and EU level to increase their market visibility.

2 NEARLY ZERO ENERGY PILOT HOTELS

In the frame of the neZEH initiative, 16 pilot hotels in 7 EU countries (Croatia, France, Greece, Italy, Romania, Spain and Sweden) spread out to 5 European climate zones [8], follow a refurbishment plan to become nearly Zero Energy Hotels. Limited nZEB demonstrations in the accommodation sector at EU level make these pilot hotels frontrunners to inspire and drive replications.

A robust work plan was applied for their implementation, consisting of four steps: i) an energy audit ii) a feasibility study and rollout plan, iii) tendering, contracting and financing alternatives and iv) training of management and staff.

The energy audits assessed the current energy status of the hotels and provided recommendations for appropriate energy efficiency and RES measures in order to reach the neZEH status, while roughly estimating the financial cost and gains. An initial difficulty faced, was the lack of official nZEB numerical definitions in the target countries, in order to set primary energy use and RES targets for the pilot hotels. To counter this, benchmarks for nZE hotels were introduced, based on already existing definitions in other countries [9]. The benchmarks concerned only the hosting functions of hotels i.e. the standard zones of a hotel where standard indoor environmental conditions need to be met, including the reception hall, guests' rooms, all common areas (restaurant, bar, sitting rooms, meeting rooms) and offices. Non-hosting functions are additional facilities that may be provided by the hotel, such as kitchen, laundry, swimming pool, spa, sauna, gym. Technical rooms, garages or similar places not heated, cooled or ventilated are not included in any case. In the neZEH pilot hotels, the energy balances for both hosting and non-hosting functions were calculated separately, where possible.

Overall, for all 16 pilot hotels, the primary energy use for the whole building will be decreased from an average of 325 to an average of 142 kWh/m^2/y by applying the measures identified in the energy audits; that is an average decrease of 56%. At the same time, RES share will go up from an average of 15% to an average of 41%. For hosting functions, this number comes

[1] Balantia-Creara: Raw data from more than 50 energy audits in hotels all over Spain in the period of 2010-2013.

down from an average of 259 to an average of 99 kWh/m^2/y -a reduction of 62%- while RES share can be increased from an average of 18% to an average of 53%. The total emissions avoided are estimated to 2,444 tCO_2eq/y.

Projections for 2020 about nZEB investments in the accommodation sector, triggered the neZEH activities, assume cumulative primary energy savings to reach 47,000 toe/y, renewable energy production to 7,000 toe/y, 93,000 tCO_2eq/y GHG emissions avoided, while the cumulative investment is estimated to 165 M€.

Below, three pilot hotel case studies are further analysed; Tables 2, 3 and 4 present the measures proposed for these hotels to become neZEH.

2.1 Pilot hotel case study in Greece

This particular case study is a Mediterranean 5 star coastal resort hotel, composed of 15 buildings in total. The hotel has already made important steps towards becoming more energy efficient, operating under ISO14001:2004 and being certified with Travelife Gold. The investment to achieve the neZEH benchmarks reaches to € 1,095,000 and with savings of 65% for the hosting functions, the payback is estimated to 10 years (could be significantly reduced applying appropriate funding/supporting mechanisms).

Table 2 Energy efficiency measures for pilot hotel in Greece

Measure	Investment (€)	Savings (%)	Payback (y)
Installation of central heat pumps for cooling and DHW	300,000	36	5.4
Photovoltaic modules for electricity generation	300,000	13	6.0
Facade insulation with thermal envelope and double glazing windows	350,000	8	20.0
Solar panels expansion and indoor pool coverage	120,000	5	10.0
Outdoor redesign for better microclimate	25,000	4	4.1

2.2 Pilot hotel case study Spain

The refurbishment plan for this rural eco-resort in Vizcaya, Spain suggests a reduction of primary energy use by 47% and RES share of 85% for the hosting functions. The overall investment will be about € 306,000, while payback is estimated to 8 years.

Table 3 Energy efficiency measures for pilot hotel in Spain

Measure	Investment (€)	Savings (%)	Payback (y)
Change inefficient lighting to LED	15,600	3.0	7.5
Install a photovoltaic system	40,500	15.0	0.5
Install a district heating system with biomass	89,000	1.0	5.1
Install flow reducers on showers	800	7.5	0.3
Other measures (building insulation, pipelines insulation, presence detectors etc.)	160,000	14.5	21

2.3 Pilot hotel case study in Romania

In Brasov, Romania, an urban 4 star business hotel needs to reduce its primary energy use for the hosting functions by 73% and increase RES share to 37%. The investment reaches to €414,389 with an estimated payback of 10.5 years. Part of the investment (LED, solar collectors) will be undertaken by an Energy Service Company (ESCO).

Table 5 shows the overall data for these three hotels. It becomes evident that the non-hosting functions are particularly energy intensive, which means that they should not be excluded when planning an energy renovation.

Table 4 Energy efficiency measures for pilot hotel in Romania

Measure	Investment (€)	Savings (%)	Payback (y)
Change inefficient lighting to LED technology	13,072	3.7	3.7
Smart sensors on Lighting circuits	2,176	0.1	7.3
Fan coils	28,704	4.5	8.6
Install and actively use BEMS	108,067	2.6	8.9
Envelope improvements and stop air leaks	81,253	35.0	9.5
Solar collectors	67,149	17.6	8.4
Install a photovoltaic system	109,120	12.0	13.7
Exchange energy source in laundry facility	4,848	-	0.8

Table 5 Refurbishment plan data for three neZEH pilot hotels

	Hotel in Greece	Hotel in Spain	Hotel in Romania
Location	Crete	Vizcaya	Brasov
Climate Zone	1	4	3
Hotel category	Coastal	Rural	Urban
Hotel type	Resort	Resort	Business
Period of operation	Apr-Oct	All year	All year
Average occupancy during months of operation (%)	78%	22%	70%
Offered facilities	pools, bars, restaurants, conference room	spa, pool, shrine room	restaurant, conference room
BEFORE			
Primary energy use, whole building (kWh/m^2/y)	281	202	470
Primary energy use, hosting functions (kWh/m^2/y)	250	181	379
Primary energy use, non-hosting functions (kWh/m^2/y)	293	226	1258
RES share, hosting functions (%)	26	0	0
AFTER PROPOSED REFURBISHMENT			
Primary energy use, whole building (kWh/m^2/y)	91	127	115
Primary energy use, hosting functions (kWh/m^2/y)	88	96	99
Primary energy use, non-hosting functions (kWh/m^2/y)	110	162	470
RES share, hosting functions (%)	60	85	37
Emissions avoided (tCO_2eq/y)	869.8	93.5	207.8

3 RANKING OF ENERGY EFFICIENCY AND RES MEASURES

Achieving nZEB targets in an existing hotel can be a long-term procedure and above all, it requires strong motivation and a clear commitment by the management and staff. The possible measures can be classified into the following categories:

- Energy management
- Reducing heating and cooling demand
- Equipment efficiency
- System efficiency
- Renewable Energy Sources

User behaviour is also a critical parameter for the success of energy efficiency interventions; not taking it into account will result in less effective measures than what was originally planned. Training of both staff and management of the hotel, as well as informing clients, must definitely be included in any plan for energy renovation.

A deep refurbishment may not be the most appropriate solution in some cases; in these cases, a step-by-step approach can be adopted. Given the current financing barriers in many EU countries, small but carefully designed renovation steps can achieve significant energy efficiency gains in the

long term. As the measures are applied gradually, the financial risk of a large investment is reduced, and the money saved by the implementation of a measure can be used to implement a next one.

In Tables 6-10, measures appropriate for hotels being refurbished into nZEBs, are ranked according to the size of investment required and the possible energy saving that can be achieved [10]. It has to be noted that the cost and savings depend highly on the type of building, its age, the energy uses, the quality of construction, the existing systems, the climatic conditions and other parameters. The real picture can only be given by a techno-economic study for a specific building and conditions, performed by professionals.

Table 6 Ranking of energy management measures

Measure	**Ranking by**					
	size of investment			**potential energy savings**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Energy use monitoring	✓			✓		
Building Energy Management System (BEMS)		✓				✓
Energy audit		✓				✓
ISO 50001		✓				✓
EU Ecolabel		✓				✓
Staff training	✓			✓		
Information to guests	✓			✓		

Table 7 Ranking of measures for reducing heating and cooling demands

Measure	**Ranking by**					
	size of investment			**potential energy savings**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Windows changing			✓			✓
Building insulation			✓			✓
Building envelope air tightness	✓				✓	
Installation of sun shading devices		✓			✓	
Exterior works to improve summer comfort (green roof, trees, etc.)	✓			✓		

Table 8 Ranking of equipment efficiency measures

Measure	**Ranking by**					
	size of investment			**potential energy savings**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Energy saving light bulbs		✓				✓
Electrical appliances with higher energy efficiency rating	✓			✓		
Efficient solutions for active space cooling		✓				✓
High efficiency boilers		✓				✓
Micro CHP			✓			✓
Water saving taps (to reduce DHW consumption)	✓				✓	
Low temperature heating		✓				✓

Table 9 Ranking of system efficiency measures

Measure	**Ranking by**					
	size of investment			**potential energy savings**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Key card systems	✓				✓	
Lighting controls	✓				✓	
Thermal insulation of boilers, DHW tanks and pipes	✓			✓		

Balancing of heating, cooling and air-conditioning systems	✓				✓	
Regulation of space heating and cooling	✓				✓	
Utilize waste heat of chiller				✓		
Hybrid ventilation system	✓				✓	
Utilize waste heat of chiller		✓			✓	

Table 10 Ranking of renewable energy systems measures

Measure	**Ranking by**					
	size of investment			**potential energy savings**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
Geothermal energy (heat pump)			✓			✓
Aerothermal energy (heat pump)		✓			✓	
Hydrothermal energy (heat pump)			✓			✓
Solar powered absorption chiller			✓			✓
Micro hydropower			✓			✓
Small scale wind turbines			✓			✓
Biomass boiler			✓			✓
Solar thermal		✓			✓	
Photovoltaics		✓			✓	

Further to this experts' opinion-based ranking, an online neZEH e-tool is developed, to support decision-making and motivate hoteliers wanting to refurbish their hotels to nZEB. The e-tool benchmarks the hotel's current energy performance and provides suggestions for energy efficiency measures. The tool is based on the previously developed HES e-toolkit [11] and it is being upgraded to include the neZEH project approach and findings. Indented to be used by the hoteliers themselves, it will facilitate the ranking of energy efficiency measures for different types of hotels aiming to reach nZEB status at the country level, taking into account local parameters, such as prices and climate. The ranking is based mainly on four parameters (size of the financial investment, profitability, potential energy saving, European climate zones). It includes a list of energy efficiency measures which are modelled independently and with the help of a typical energy savings database. Climatic data are incorporated (heating and cooling degree days for the 28 Member States, heating and cooling needs, etc.), as well as correction factors to incorporate potential energy savings percentage (%) depending on the climate zone where a country lies in.

4 CONCLUSION

The neZEH pilot hotels aim to demonstrate the feasibility of investments towards nZE in the accommodation sector. Today, such investments are both technically and economically feasible. There are however certain barriers, especially for SME hotels, who cannot acquire easy access to financing. Appropriate supporting measures are still needed for large scale renovation projects. There are also hotel cases where a step-by-step approach might be more appropriate and help them achieve significant energy efficiency gains in the long term.

The results from the 16 neZEH pilot hotels in 7 EU countries, indicate that an average 62% reduction in the primary energy use for the hosting functions of hotels can be achieved (from an average of 259 to an average of 99 kWh/m^2/y), while RES share can be increased from 18% to 53%. Total emissions avoided are estimated to 2,444 tCO_2eq/y.

The 16 neZEH pilot projects, in Greece, Croatia, France, Italy, Romania, Spain and Sweden, will stand out as "real life" lighthouse examples in Europe and inspire other hotel owners to invest in high energy performance refurbishments, including large share of their energy needs covered by on-site or nearby renewable energy as requested by the EPBD recast and EED European Directives.

It is projected that by the end of 2020, nZEB investments in the accommodation sector triggered by the neZEH activities, will result in cumulative primary energy savings of 47,000 toe/y,

renewable energy production of 7,000 toe/y, 93,000 tCO_2eq/y GHG emissions avoided, while the cumulative investment is estimated to 160 M€.

ACKNOWLEDGMENTS

This publication is supported by the European Commission under the Intelligent Energy Europe Programme, within the framework of the project neZEH (Nearly Energy Zero Hotels, www.nezeh.eu). The sole responsibility for the content of this paper lies with the authors. It does not necessarily reflect the opinion of the European Union. It does not necessarily reflect the opinion of the European Union. Neither the EASME nor European Commission are responsible for any use that may be made of the information contained therein.

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