Nearly Zero Energy Hotels – From European Policy to Real Life Examples: the neZEH Pilot Hotels

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ABSTRACT

The European Directive on the Energy Performance of Buildings (2010/31/EU-EPBD recast) calls the EU Member States to ensure that beginning of 2021 all new buildings are nearly zero-energy buildings (nZEBs). Moreover, it calls for policies and measures to stimulate the transformation of existing buildings into nZEBs. So far, the transposition of the EPBD has not yet been fully implemented in most Member States and examples of nZEB are scarce.

In response to this, the European initiative Nearly Zero Energy Hotels (neZEH) aims at accelerating the rate of refurbishment of existing hotels into nearly zero energy hotels, by providing technical advice to committed hoteliers and demonstrating the feasibility of nearly Zero Energy investments through pilot projects.

After an open call, 14 Hotels in 7 European countries (Croatia, Greece, France, Italy, Romania, Spain and Sweden), have joined the neZEH initiative as pilot projects. They will be supported to large scale refurbishment projects aiming to reduce their operational costs by up to 70%. Following to energy audits and feasibilty studies, best practices of energy efficiency solutions and renewable energy technologies will be applied, ranked according to the potential energy savings, the size of the financial investment and the availability of appropriate supporting instruments. A list of the most suitable technological solutions per hotel will be elaborated, as well as cost scenarios and return-of-investment calculations. In order to demonstrate a variety of solutions and to maximise the impact and replicability of the neZEH outcomes across Europe, the pilot hotels will represent different climate zones and hotel typologies.

This paper presents identified example hotels analysing their energy status and best practices applied and explains the neZEH benchmark methodology: energy flows; assumptions; data used; as well as identified solutions and obstacles addressed.

INTRODUCTION

The EU calls on radical reduction of GHG emissions by 2050 (80-95% compared to 1990 levels). Buildings consume 40% of total energy and emit 36% of GHG in Europe. The existing building stock represents the highest potential for energy savings (Dascalaki and Balaras, 2004; Karagiorgas et al, 2006). Currently, there are few successful demonstrations of nZEBs within the EU to inspire and drive replications in the private sector. Hotels in specific represent an even bigger challenge, since they are more complex building systems, and energy intensive businesses.

The European initiative Nearly Zero Energy Hotels (neZEH, *www.nezeh.com*) aims at accelerating the rate of refurbishment of existing hotels to become nZEBs. 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

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energies (Tsoutsos et al, 2013a; Tsoutsos et al, 2013b). The methodology to achieve the project's scope consists of:

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

The neZEH initiative is a response to the EPBD recast (2010/31/EU), contributing directly to the EU 2020 targets and supporting the EU MS in their national plans for increasing the number of nZEBs. It runs for three years (2013-2016) and is co-funded by the Intelligent Energy Europe Programme (IEE) of the European Commission (neZEH, 2013a). The major outputs of neZEH will be:

- An integrated set of decision support tools to assist hoteliers in identifying appropriate solutions and designing feasible and sustainable nZEB projects.
- An EU neZEH network to facilitate knowledge exchanging and cooperation between the demand (hotel owners) and supply side (building professionals).
- Demonstration pilot projects in 7 countries to act as "living" examples.
- Practical training and capacity building activities to support the implementation and uptake of nZEB projects.
- Integrated communication tools to promote front runners and to foster replication; challenging much more SMEs to invest in refurbishment projects in order to achieve nZE levels.

In the long term neZEH will support the EU hospitality sector to reduce operational costs, to improve their image and services and so to enhance their competiveness, contributing in parallel to the EU efforts for the reduction of GHGs.

LEGISLATIVE FRAMEWORK

European policy

In the EPBD recast (European Commission, 2010), Article 2, an nZEB is defined as "a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby"; article 9 of the EPBD recast requires from MS to ensure that:

(a) By 31 December 2020, all new buildings are nZEBs and

(b) After 31 December 2018, new buildings occupied and owned by public authorities are nZEBs.

Even though the EPBD recast provides the framework for defining what an nZEB is, it is up to the MS to give numerical definitions that reflect their national, regional or local conditions. Annex I of the EPBD recast provides a common general framework for the calculation of the energy performance of buildings, in order to determine nZEB levels.

Furthermore, Article 4 of the EED (European Commission, 2012) stipulates that MS shall establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. A first version of the strategy should have been published by 30 April 2014, updated every three years thereafter as part of the National Energy Efficiency Action Plans.

Figure 1 presents a timeline of the MS commitments, derived from EU Directives, until 2020. Nevertheless, most MS failed to fulfil their commitments by the designated deadlines. According to official reporting from the Commission (European Commission, 2013) at the end of November 2012, only 9 MS had reported their nZEB national plans to the Commission and from them only 5 presented a definition that contains both a numerical target and a share of RES. Intermediate targets for improving the energy performance of new buildings by 2015, were presented by 15 MS, with most focusing on strengthening the building regulations and/or the energy performance certificate level. Although most MS reported a variety of support measures to promote nZEBs, including financial incentives, strengthening their building

regulations, awareness raising activities and demonstration/pilot projects, it is not always clear that these measures are specifically targeting nZEBs. According to a more recent source (Kurnitski et al., 2014), based on data from Concerted Action EPBD (CA EPBD, 2013), 10 MS had given numerical definitions –at least for some building typologies- however these are remarkably different by content, calculation assumptions and ambition level.
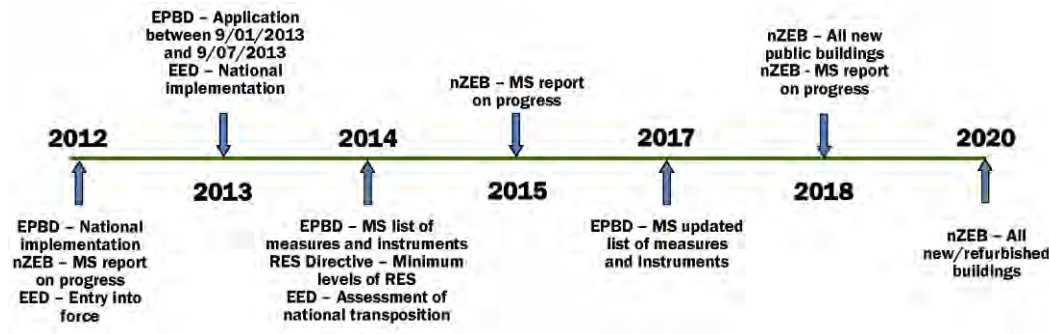

Figure 1   Timeline of nZEB policy implementation in the EU

TRANSPOSITION OF EPBD IN THE neZEH COUNTRIES' LEGISLATIONS

Within the context of the neZEH project, the national framework has been analysed for the 7 neZEH target countries (neZEH, 2013b). Two of these countries have officially introduced numerical definitions for some categories of buildings, France and Croatia **(Table 1).**

Table 1.   nZEB numerical definitions for new buildings in EU Member States

Country	Primary energy indicator (kWh/m²y)	RES share (%)	Building type
Croatia	33 - 41	20	Residential (coastal – continental)
France	50 - 70 - 110	-	Residential - Office - Office with AC

It is worth mentioning that Estonia is the only one MS that provided a numerical definition for hotel type of buildings, set at 130 kWh/m²/y of primary energy and 27% RES share, which includes heating, ventilation, cooling, hot water, lighting, auxiliary electricity, and use of appliances (Kurnitski et al., 2014). Numerical definitions for refurbished buildings have been also identified in three European countries, which suggest percentage increases from 29%-60% compared to the numerical definitions of new buildings (**Table 2**).

Table 2.   nZEB numerical definitions for refurbished buildings in EU Member States

| Country	Primary energy indicator for new building (kWh/m²y)	Primary energy indicator for refurbished building (kWh/m²y)	Percentage increase (%)	Building type
France	50	80	60	Residential
Croatia	41 - 33	51 - 52	25 - 58	Residential (continental - coastal)
Estonia	210	270	29	Hotels

neZEH BENCHMARKING METHODOLOGY

Due to the delay of national transposition of the nZEB definition and given the absence of numerical indicators in neZEH countries, there was a necessity to introduce nZEH benchmarks, which would be used for establishing the primary energy use and RES targets for the pilot hotels.

Furthermore, hotels cannot be considered as typical non residential buildings; their business model includes a number of energy intensive operations associated to their customers' comfort and expectations, therefore closely linked with their competiveness and viability. Data from Spanish hotels suggest that energy use associated with the non-hosting function of the hotel (such as kitchen, spa, swimming pool etc.) reaches an average percentage 35% of the total energy use (Balantia-Creara, 2013). Probably this case will not be addressed in the first nZEB definitions given by the MS. At first, neZEH focused on defining benchmarks taking into account only the typical use of the building, as suggested by the EPBD. Future work shall consider a "modular" benchmarking that will include non-hosting functions, in order to be used in providing recommendations to policy makers for dealing with nZEH complexities.

According to EPBD recast, Annex I, the energy performance of a building shall be determined on the basis of the calculated or actual annual consumed energy to meet the different needs associated with its typical use and shall reflect the heating and cooling energy needs to maintain the envisaged temperature conditions of the building, and domestic hot water needs. The standard use (heating, cooling, ventilation, hot water and lighting) must refer to the standard indoor environmental conditions, which in a hotel are the comfort conditions required for guests and workers, as recommended in EN15251:2007 standard. With these premises, the standard zones of a hotel considered among the –so called- hosting functions were the zones in which the standard indoor environmental conditions are required: guests' rooms; reception hall; offices; bar and restaurant; meeting rooms. **Figure 2** presents the energy flows included in the calculation.

The additional energy uses of non-hosting functions, such as spas, swimming pools, saunas, gym, kitchens, laundry, technical rooms etc., for the implementation of the pilot projects shall be dealt case-by-case.and will be considered at the second phase "modular" benchmarking.
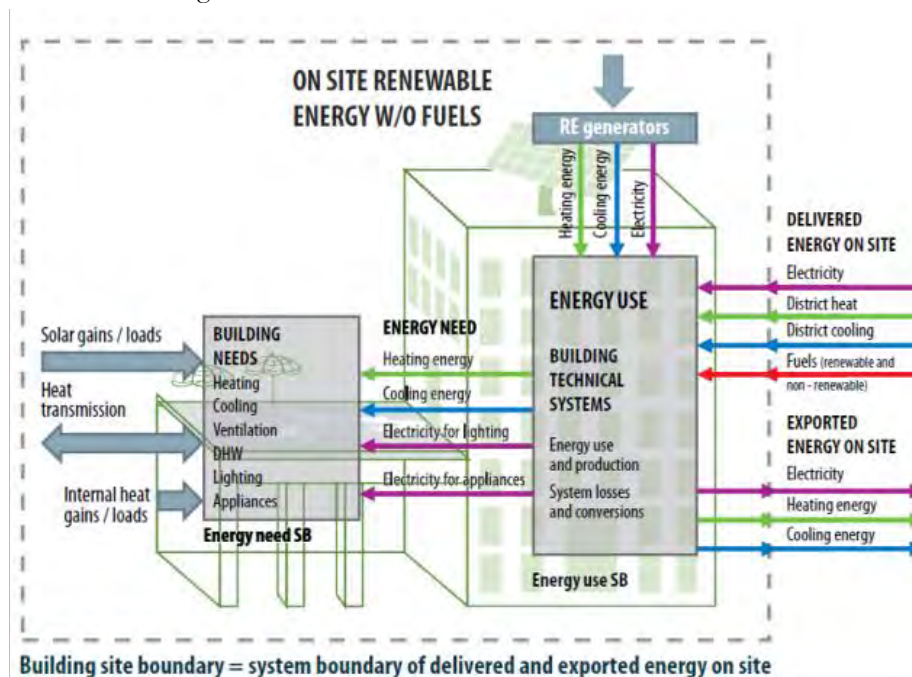

Figure 2   Energy flows in a hotel building (hosting functions and appliances)

Five European climatic zones were assumed (Ecofys, 2013), as illustrated in **Figure 3**. The nZEH requirements by climate zone were analysed, taking into account existing databases (ENTRANZE, 2013; COHERENO, 2013; BPIE, 2013) on the consumption of buildings in the 7 target countries, to calculate country-specific benchmarks.

As an assumption each of the 5 European climate zones is represented by a reference country depending on existing nZEB definition or relevant values allowing the calculation of nZEH requirements (neZEH, 2013c).

Next, energy use data of existing building stock from EU level sources were analysed, showing that values of residential buildings are more reliable to describe the hosting function of hotels than generic non-residential building values. The energy use of existing residential buildings by energy source (ENTRANZE, 2013) was used in conjunction with national primary energy factors in order to calculate primary energy values (neZEH, 2013e). Adjustments for additional cooling and ventilations needs were made taking into account EN15251:2007 standards, thus resulting primary energy indicators for the hosting function of hotels. The benchmarks calculated for the 5 European climatic zones, were increased by a primary energy amount corresponding to appliances, thus ending up with 7 country-specific nZEH benchmarks for new hotel buildings (**Table 3**). These benchmarks were compared with the primary energy indicator for hotels, showing that an average 75% energy reduction has to be achieved, a value which is in accordance with the COHERENO project findings (COHERENO, 2013).
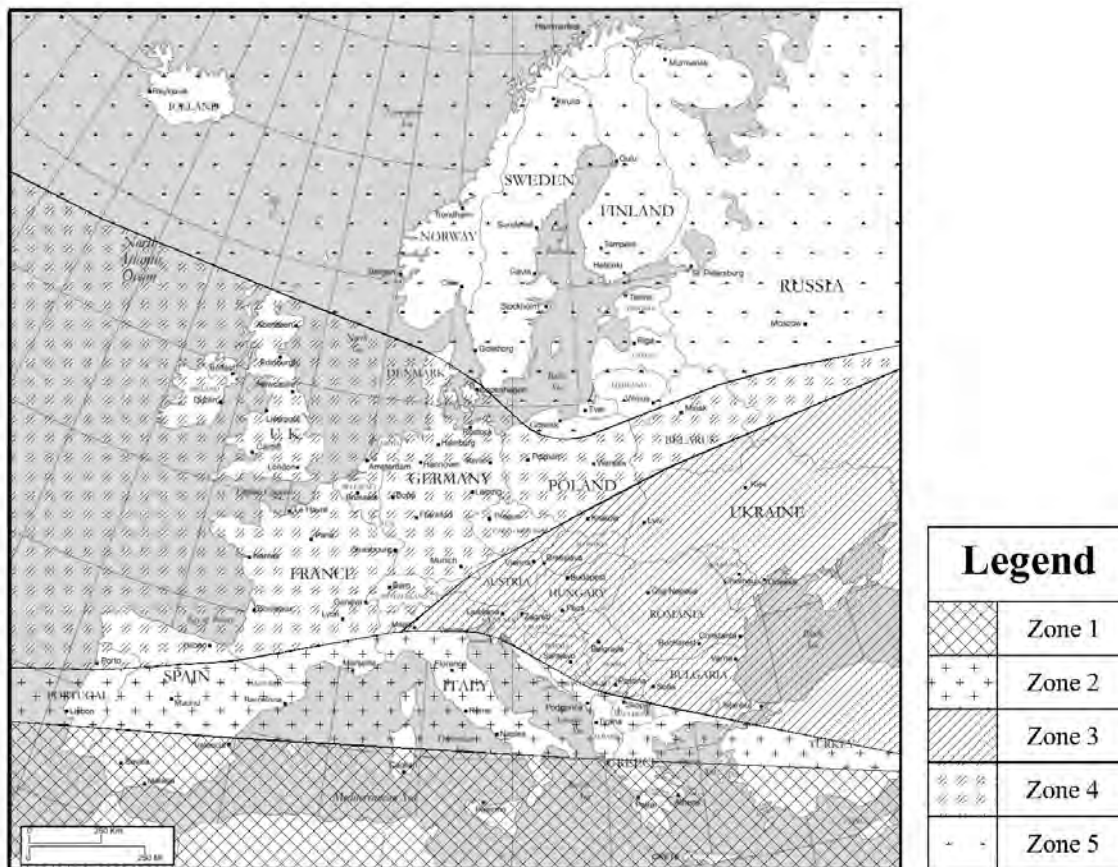
Figure 3   Indicative schematic illustration of the Ecofys EU climatic zones (neZEH, 2014)

In order to introduce nZEH benchmarks for refurbished hotels, correction factors based on **Table 2** were applied resulting in the nZEH benchmarks for refurbished hotels (**Table 3**).

Table 3. Country-specific nZEH benchmarks

Country	Primary energy indicator for new hotels (kWh/m²y)*	Primary energy indicator for refurbished hotels (kWh/m²y)*
Croatia	77	100
France	115	150
Greece	76	99
Italy	71	92
Romania	80	104
Spain	72	94
Sweden	134	174

*Includes hosting functions + appliances

EXISTING LIGHTHOUSE EXAMPLES

Hotel 1 is an urban 3-star hotel located in the city of Vienna, claimed to be the world's first city hotel with a zero energy-balance. The hotel comprises of a newly constructed passive building and a renovated building. Studying this case showed that the key success factor to achieving nZE status at the hotel was the owner's tenacity and complete commitment to the environment and "living and breathing green", therefore it was part of a greater vision. Thus, the owner undertook the financial risk, as due to the economic crisis no finance was forthcoming from banks. Today, the hotel reports increased occupancy rate, maintaining in parallel a higher room rate, raised customer loyalty and positive effects to employment (neZEH, 2014; Buso et al., 2014).

Hotel 2 is a coastal business and family hotel, near Split in Croatia. It is a new hotel and it is the only SME hotel that is certified as class A for energy efficiency in Croatia. The hotel owner's strong commitment to the environment was the key driver for attempting to reach an nZEB status. The process started in 2001 when the owner decided to consider all the environmental impacts of building a coastal hotel. According to the owner, the construction cost was only a 2-4% more expensive than a typical new build hotel.

Hotel 3 is one of the five interconnected buildings that comprise the Vall de Núria mountain complex (Gerona, Spain) which was build at 1935. It is located at 2.000m above the sea level and the only way to get there is through a rack railway train. After the refurbishment of the building, a new geothermal system which generates domestic hot water for radiant floor heating and for the ventilation system, provides 60% of the total consumed energy. Additional energy efficiency measures have been applied, such as, lighting control, intelligent HVAC control to match occupancy patterns and high tech isolation system with natural ventilation.

All three hotels gained important benefits from committing to their environmental and sustainability goals:

1. Reduced energy costs
2. Increased independence from energy suppliers
3. Increased publicity
4. Competitive advantage over competitors – sustainability is growing in stature as guests demand it
6. Increased customer loyalty index, showing that some guest groups value the commitment to sustainability.

Technical data of these three hotels are presented in **Table 4**.

Table 4. Technical data for the two lighthouse examples[1]

	Hotel 1: Urban, climate zone 3	Hotel 2: Coastal, climate zone 2	Hotel 3:Mountain, climate zone 2
Delivered energy[2] (kWh/m²y)	Old Building: 241 (thermal energy) + 93 (electricity) Passive Building: 54 (electricity) Whole Building: 124 (thermal energy) + 74 (electricity)	Hosting functions: 125 (electricity) Offered facilities: 29 (thermal energy) + 55 (electricity) Whole building (hosting + facilities): 13 (thermal energy) + 93 (electricity)	Hosting functions: 79 (electricity) Offered facilities: visitors centre: 48 (electricity) Whole building (hosting+facilities): 63
Primary energy[2] (kWh/m²y)	Old Building: 528 Passive Building: 124 Whole Building: 334	Hosting functions: 287 Offered facilities: 157 Whole building (hosting + facilities): 228	Hosting functions: 185 Offered facilities: visitors centre: 113 Whole building (hosting facilities): 147
RES share[2] (%)	Old Building: no data available Passive Building: 100% of thermal energy	Whole building (hosting + facilities): 28%	Whole building (hosting+facilities): 60%
HVAC systems	Heating (passive building): geothermal heating through concrete core activation, (existing building) district heating. Cooling (only passive building): geothermal cooling through concrete core activation. VAC (only passive building): Active ventilation system with heat exchanger. Hot Water: (passive building) geothermal heating, (existing building) district heating, solar thermal panels	HVAC: 8 VRF systems powered by aero-thermal heat pumps Hot Water: 1 VRF Inverter system powered by aero thermal heat pump, 1 electric heater, solar thermal panels	HVAC & DHW: 4 geothermal heat pumps with heat exchanger and water accumulator.
RES Systems	Solar Thermal panels for DHW (130 m²) Photovoltaic Panels (13 kWp) Groundwater Heat Pump	36 Solar Thermal panels for DHW (55.3 kW installed capacity) Aero Thermal Heat Pumps (Installed capacity for Heating/ Cooling = 272.5/242.9 kW)	Geothermal system for DHW, HVAC through radiant floor. Made of 36 perforation sunks or boreholes of 90m depth each. Heating Capacity =250 kW
Lighting	100% low energy consumption lamps: 90% LED, 10% low consumption bulbs. Automatic lighting controls in public spaces	66% low energy consumption lamps: 43% LED, 23% fluorescent. Automatic lighting controls in public spaces Dimmable lighting in corridors	33% halogen, 46% LED, 21% low consumption bulbs. Automatic lighting controls in public spaces through occupancy detectors.
Energy Management and Monitoring System	Yes. Programmable automation controllers to monitor and enable the regulation of heating, ventilation, concrete core activation, water heating, solar panel system, buffer management, groundwater heat pump	Yes. BMS for controlling/ dimming lighting, temperature set points and controlling for cooling and heating.	Yes. BMS for controlling/ dimming pumping, DHW systems, boilers, AHU, HVAC control to match occupancy patterns, humidification system, temperature set points and controlling for cooling and heating Grid analyzer for electricity monitoring in each floor.
Efficient energy use guidance for guests and staff	Yes	Yes	Yes

[1]Abbreviations appearing in the table are defined in Nomenclature.

[2]Data for Delivered Energy, Primary Energy and RES % result from simplified calculations, based on energy data provided by the hotels in the preliminary phases of the neZEH project.

neZEH PILOT PROJECTS

In order to demonstrate the feasibility of refurbishment projects leading to nZEB status, neZEH will implement 10-14 pilot projects in the 7 target countries. These hotels were chosen following a 3 steps procedure (**Figure 4**):

a) Public call: each country by informing hoteliers through their associations, targeted workshops and industry events, through partners' websites and other appropriate means. The candidates were able to fill-in an application form on the website www.nezeh.eu. This initial phase resulted in a pool of 85 applications.

b) Evaluation of applications and initial selection of 35 hotels (5 candidate per neZEH country): a set of criteria, mainly having to do with the hotel's commitment and maturity to achieving nZE status and the distribution of selected hotels in different climate zones and different typologies.

c) Energy pre-audits: the selected hotels went through energy pre-audits in order to assess, at an initial phase, their potential and capability of reaching nZE targets. More accurate energy and economic data helped in filtering and ranking the hotels to lead to the selection of 2 pilot hotels per country.
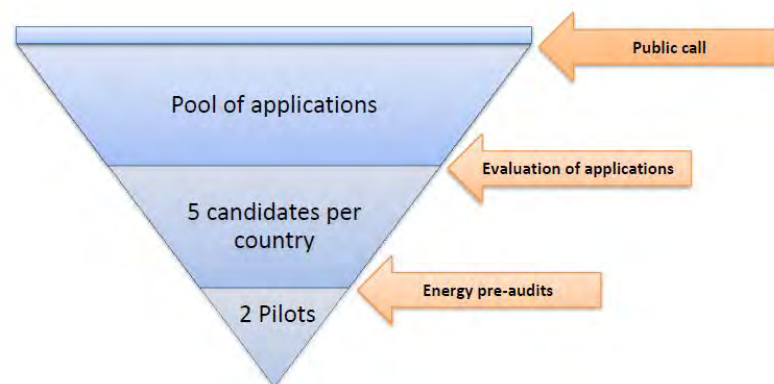
Figure 4　　　　Pilot hotels selection procedure

Climate zones

As mentioned previously, 5 European climatic zones (**Figure 3**) were taken into account in the benchmark calculations. These climatic zones are also used as reference throughout the implementation of the action, meaning that outcomes should be representative for each of these zones, to make sure that there are replicable examples for all the regions of Europe.

Hotel typologies

For the scope of the project, four hotel typologies were defined: (i) Coastal; (ii) Mountain; (iii) Urban; (iv) Rural (neZEH, 2013f). Each of the target countries had pre-defined the hotel typologies within its region, so as the 5 candidates going to the pre-audits phase would represent these typologies.

The selected pilot hotels will benefit an energy audit, suggesting the most appropriate technical solutions in order to reach nZE levels. Following this, a feasibility study for each hotel will be conducted, that will assist in the decision making. The hotels will receive advice on available funding resources and will be assisted in the tender preparation and selection of contractors. Furthermore, training will be provided to the hotel owners and staff, guiding them on how to achieve the maximum efficiency and best use of the implemented solutions. Finally, the pilot hotels will receive increased visibility at national and EU level and promotional tools to communicate efficiently their neZEH profile to potential customers.

Energy audits and feasibility study

Each of the neZEH pilot hotels will receive an energy audit; a complete on-site inspection and analysis of energy flows for energy conservation to reduce the amount of energy needed. The audit consists of the following main elements:

- Collection and compilation of data (drawings, energy statistics, utility bills, etc.).
- Site inspection including study of energy and ventilation systems, lighting standards, windows and insulation standards
- Precise calculation of present energy flows (inputs and losses).
- Proposals for measures with calculation of impact on energy use and future costs
- Compilation of a report with a proposed action plan

Following the completion of the energy audit, a feasibility study will take place, which will include an assessment of the most suitable technological solutions and a cost scenario and calculation of the Return of Investment (ROI). The proposed technological solutions that a pilot project should take to reach nZE levels will take the following into consideration:

- The specific characteristics of each hotel (position, orientation, primary energy consumption, seasonality, etc.)
- The cost of each technical/technological solution
- Funding opportunities and possible tax reliefs or credit facilities for specific solutions
- Calculations about the period for hotel owners to recover their investment

TOOLS

Hotel Energy Solutions e-Toolkit

While the above neZEH tool is able to rank technologies, according to their profitability, the Hotel Energy Solutions (HES) e-Toolkit (developed in the frame of the Hotel Energy Solutions project, co-funded by the European Commission under the Intelligent Energy Europe Programme) enables hotels to assess their current energy use and compare it with an energy benchmark. The HES benchmarks have been set based on review and analysis of data available on energy use by hotels in Europe (HES, 2011). The tool also provides recommendations in energy efficiency and RES applications in the hotel according to the hotel's characteristics, geographical location, main available natural resources, and easy-to-implement actions that could be useful for the hotel. It classifies them according to whether they require no investments, small investment or high investment and calculates the ROI of proposed solutions based on the hotel's energy performance. The hotel manager can use the e-toolkit to track the hotel's progress over time. The tool's methodology is shown in **Figure 5**.
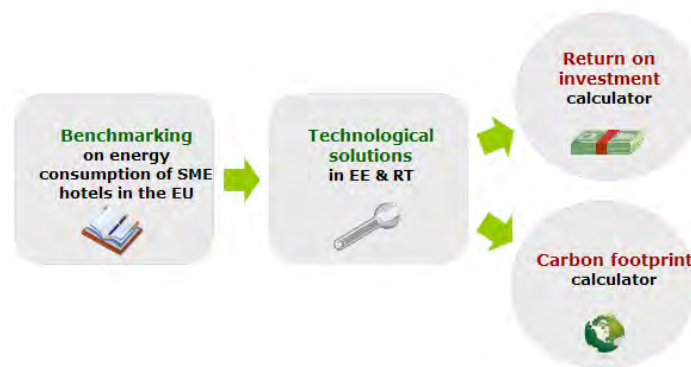

Figure 5   HES e-Toolkit methodology diagram (HES, retrieved 2014)

Hoteliers have to insert information about their energy bills and any RES systems installed at their hotel, through the process of filling in a questionnaire on a web-based platform. Once they complete it, they get access to the following reports: energy performance, energy solutions and a carbon footprint report.

HES e-toolkit will be updated with the neZEH benchmarks, so that a hotel using the tool is able to assess how far its energy consumption is from the neZEH level and what actions could be appropriate to reach it.

Technologies Ranking Tool

Within the neZEH context the suitable solutions/techniques, to be implemented in hotels towards nZEB, were grouped (neZEH, 2013d). The solutions have been grouped in different categories i.e. energy management, reduction of heating and cooling demands, equipment efficiency, system efficiency and renewable energy. A software tool has been developed to rank – at national level - the identified solutions according to three ranking aspects: potential energy savings, size of the financial investment and profitability of the financial investment (neZEH, 2013g). Each of the solutions and technologies corresponds to a typical potential energy saving percentage (%) and a price (€/item). Appropriate values for prices can be inserted, depending on the country's local conditions. The tool also incorporates climatic data (heating and cooling degree days for the 28 EU MS) enabling it to use correction factors to slightly change potential energy savings percentage (%) depending on the climatic zone a country lies in. A flux diagram in **Figure 6** depicts the methodology of the tool.
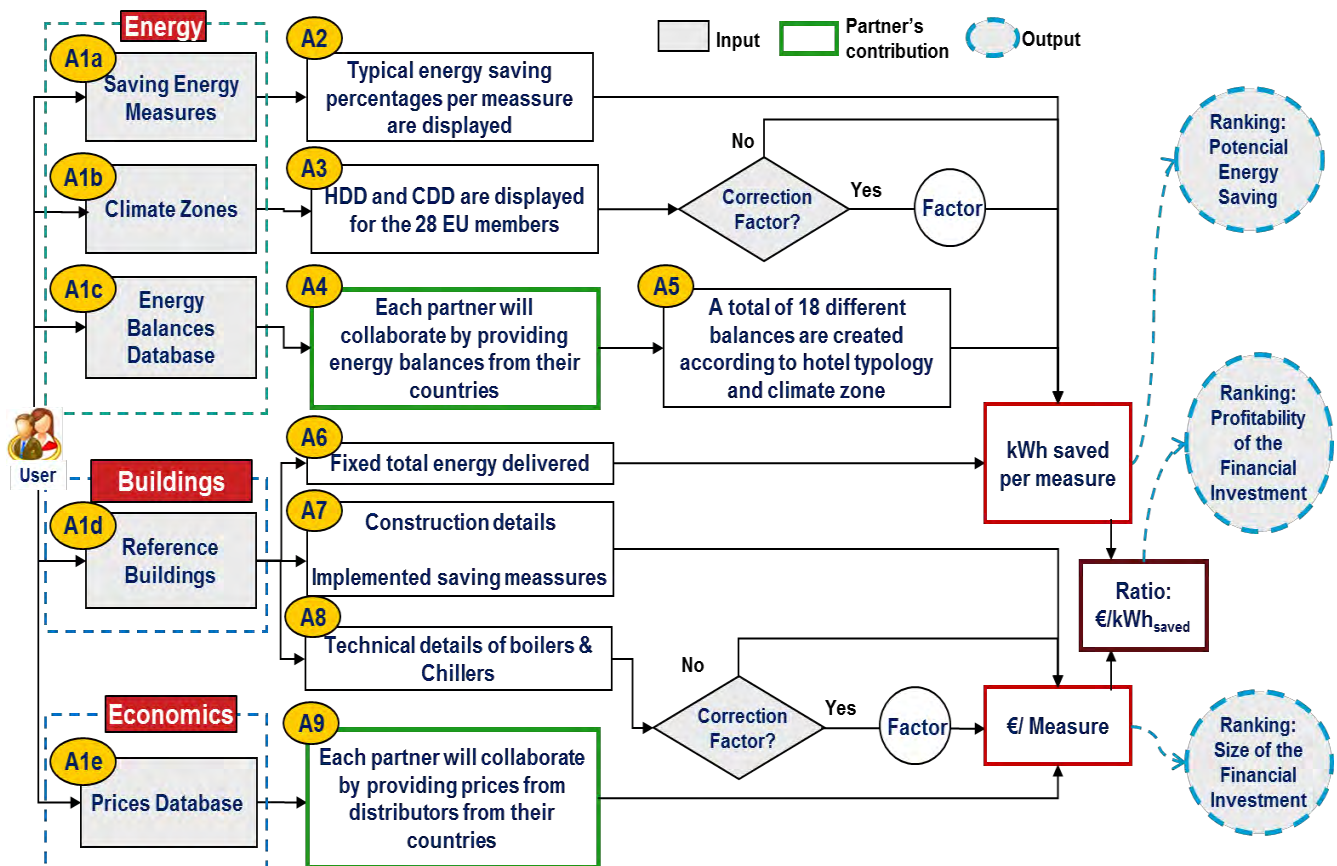

Figure 6   Flux diagram of the technologies/solutions ranking tool

CONCLUSION

The neZEH initiative will have a positive impact in reducing the building sector's CO_2 emissions before 2020. At the same time, it will encourage a wide visibility and endorsement of the nZEB concept demonstrating to the private sector the profitability of refitting buildings in order to reach the goals set in the Energy Roadmap for 2050.

To demonstrate the benefits of such an investment, fourteen (14) pilot projects in seven (7) countries will be implemented and it is anticipated that they will become powerful examples to inspire emulation by other hotel owners. The project's results will be disseminated widely, at both national and EU level, and it is expected that 15,000 hotel owners will be informed and gain access. Complimented with policy recommendations, the results will be made available to policy stakeholders, supporting the national transposition of the EPBD, especially with regards to hotel buildings. A key element of the neZEH initiative's success is the commitment of the tourism industry to increase the visibility and promote the neZEH hotels, challenging much more SME hotels to invest in refurbishment projects that achieve nZE levels.

neZEH, through its actions, aspires to contribute to the EU 2020 targets on energy efficiency and RES by triggering 160M cumulative investments in sustainable energy, 1,238 toe/year renewable energy production, primary energy savings up to 8,977 toe/year and 17,787 t CO_2e/ year reduction of GHGs by 2020. In the long-term, neZEH will support the hospitality sector to reduce operational costs and to enhance competiveness and sustainability.

ACKNOWLEDGMENTS

NOMENCLATURE

AC   =   Air Conditioning
AHU   =   Air Handling Unit
BMS   =   Building Management System
DHW   =   Domestic Hot Water
EED   =   Energy Efficiency Directive
EPBD   =   Energy Performance of Buildings Directive
EU   =   European Union
GHG   =   Green House Gases
HVAC   =   Heating, Ventilation, and Air-Conditioning
LED   =   Light Emitting Diode
MS   =   Member States
nZE   =   nearly Zero Energy
nZEB   =   nearly Zero Energy Buildings
nZEH   =   nearly Zero Energy Hotel
RES   =   Renewable Energy Sources
ROI   =   Return of Investment
SME   =   Small Medium Enterprise
VAC   =   Ventilation and Air-Conditioning
VRF   =   Variable Refrigerant Flow

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