Promoting nZEB through Cost Optimality

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Why do we talk about nZEB?

1997: Kyoto Protocol
2008: EU Climate and Energy Package
Target 20-20-20
Energy Roadmap 2050

in Europe


in Italy


National Implementation → Legge 3 agosto 2013, n. 90: "Conversione in legge, con modificazioni, del decreto-legge 4 giugno 2013, n. 63, recante disposizioni urgenti per il recepimento della Direttiva 2010/31/UE del Parlamento europeo e del Consiglio del 19 maggio 2010, sulla prestazione energetica nell’edilizia per la definizione delle procedure d’infrazione avviate dalla Commissione europea, nonché altre disposizioni in materia di coesione sociale"

EPBD recast introduced the nZEB concept
‘nearly zero-energy building’ means 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, including energy from renewable sources produced on-site or nearby.

‘energy performance of a building’ means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting.

‘cost-optimal level’ means the energy performance level which leads to the lowest cost during the estimated economic lifecycle [...].

Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels. [...].
Nearly-zero energy building (nZEB)

A building that has a very high energy performance whose 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.

Energy performance of a building

Calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting.

DISPOSITIONS

31 December 2018

New buildings occupied and owned by PUBLIC authorities are nZEBs.

31 December 2020

All new buildings are nZEBs.
At a national level it is possible to fix minimum energy performance requirements of about 0 kWh/(m²a). The achievement of these low consumptions is technically feasible through optimal combination of energy efficiency measures and technologies for the exploitation of renewable energy sources, which may or may not be cost-optimal. The exploitation of renewable sources is fundamental for reaching the nearly or net-zero energy target.

nZEB ≠ NZEB

nearly Zero Energy Building

Energy use > 0 kWh/(m²a)

Net Zero Energy Building

Energy use = 0 kWh/(m²a)

grid connected Zero Energy Buildings, with a balance between energy taken from and supplied back to the energy grid over a year
What does nZEB mean?

nZEB
Zero Energy
Which “energy”?

SITE Energy
Balance between the renewable energy produced on-site and the building’s energy uses (LOAD/GENERATION balance)

PRIMARY Energy
Balance between the building primary energy demand and the renewable energy produced on site

Energy COST
Balance between the incomes due to renewable energy production and the building’s energy costs

Energy EMISSIONS
Balance between the emissions credits gained by producing renewable (zero emissions) energy and the CO2 emissions related the building’s energy uses
Boundary conditions

Energy needs for:
- Heating
- Cooling
- Ventilation
- DHW
- Lighting
- Appliances

Energy uses

Energy from renewable sources

On site renewable energy w/o fuels

Delivered energy on site
- Electricity
- District heat
- District cooling
- Fuels (renewable and non-renewable)

Exported energy on site
- Electricity
- Heating en.
- Cooling en.
What’s new in High Performing Houses?

- Amount of space heating has got significantly smaller in the total heating needs

![Graph showing total heating needs for TEK07, Low-Energy, and PassiveHouse, with a large portion dedicated to Space heating and a smaller portion to DHW]

- Large rate of DHW needs
- Energy needs of electricity is becoming predominant (→ all-electric homes)
Project assessment by Cost Optimality

**DESIGN TEAM**
- Building designer
- Energy consultant
- Economic evaluator

Achieve the **energy performance level** which leads to the **lowest cost** during the estimated economic lifecycle

[EPBD recast 2010/31/EU]

**ECONOMIC FEASIBILITY**

**COST CONTROL**

Evaluation between preliminary and final design

Customer’s awareness

**Cost Optimal Analysis**

- **Global cost**
- **Primary Energy Consumption**
Cost-optimal analysis

Energy performance

Global cost

Investment costs
Energy costs
Maintenance costs
Replacement costs
Final value

Energy needs for:
- Heating
- Cooling
- Ventilation
- DHW
- Lighting
- Appliances

\[ C_g(\tau) = C_I + \sum_j \left[ \sum_{i=1}^{\tau} (C_{a,i}(j) \times R_d(i)) - V_{f,\tau}(j) \right] \]
Cost-optimal curve – an example

PACKAGES OF EEMs

-50% -30% -20%

Global cost (€/m²)

Primary energy (kWh/m² year)

Cost optimal range
Minimum energy requirements are set without considering cost-optimal level nor nZEB level.

Minimum energy requirements are cost-optimal; nZEB requirements are set but are not cost-optimal.

Minimum energy requirements are cost-optimal and coincident with nZEB level.
Energy Efficiency Measures (EEMs) and packages

Which combination leads to the cost optimal level?

Combination of building envelope EEMs

Combination of building system EEMs

Combination of EEMs that exploit renewable energy sources

PACKAGES OF EEMs
Energy Efficiency Measures (EEMs) and packages

- Measures affecting Envelope components
- Measures affecting HVAC Systems
- Measures affecting the Lighting system

Renewables
CASE STUDY
CorTau House in Piemonte (Italy)

Design Team: M. Luciano, S.P. Corgnati
Typology of intervention: refurbishment of a traditional rural building (2014)
Features: concrete structure, rockwool external insulation, triple-glazed LowE windows, water-to-water heat pump, radiant panels for heating and cooling, PV panels ($7 \text{ kW}_{\text{peak}}$), mechanical ventilation system with heat recovery

nZEB
ALL ELECTRIC house: all building energy needs are covered by energy produced on-site with PV system

The PLAYERS
the Investor: Valentina Taulino
the Architect: M. Luciano
the Energy Designer: S.P. Corgnati
Building features:

- Conditioned area = 183 m²
- Total area = 200 m²
- Conditioned Volume = 623 m²
- Total Volume = 671 m²

**CorTau House in Piedmont (Italy)**

**first concept**

Basement/ground floor

First floor
CorTau House: first concept

System Boundary of Primary Energy

System Boundary of delivered Energy

Energia Primaria
87.08 kWh/m²a

Energia elettrica
3.71 kWh/m²a

Split
Raffrescamento
13.88 kWh/m²a

VMC
Ventole

Gas naturale
40.19 kWh/m²a

Energia elettrica
1.18 kWh/m²a

Caldiaia
Riscaldamento
38.72 kWh/m²a

Energia elettrica
31.9 kWh/m²a

Pompe

Energia elettrica
5.38 kWh/m²a

Luce e app. elettriche

Boiler ACS

Solare Termico
11.53 kWh/m²a

Preliminary design phase
Basic HVAC System
Energy Fluxes
CorTau House: new concept
Fig. 3. Layout of the building technical system 1 (BTS1).
**CorTau House: Cost Optimal**

Cost optimal level – Package 2C

Turin’s regulation thermal insulation level + Heat pump + PV 7kW_p

Positive energy N-ZEB

same “global cost” different performances

Global cost [€/m²]

Primary energy need [kWh/m² year]
Sensitivity analysis: national tax deductions
- 65% → Eco-bonus
- 50% → Refurbishment
CorTau House

Construction site phases
THANK YOU FOR YOUR ATTENTION