Cost Optimal towards nZEB

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Summary of the presentation

• Definition and assessment of EP and of GC
• Recall of the “cost-optimal” approach in major refurbishments
• Definition of nZEB according to different approaches: EPBD reast, CEN, national, RePublic_ZEB
• Relation between cost-optimal solutions and nZEBs
• Example of application of the above concepts.
Mandates of the European Commission to technical standardisation bodies

Mandate 343:2004

Mandate 480:2010

Elaboration and adoption of standards for a methodology calculating the integrated energy performance of buildings and promoting the energy efficiency of buildings
Energy performance and global cost

Diagram showing the flow of energy from on-site renewable energy to various energy needs and uses within a building. The diagram outlines the energy use system boundary and the energy need system boundary, with arrows indicating the flow of energy for heating, cooling, electricity for lighting, and electricity for appliances. The diagram also shows the delivered energy on site and the exported energy on site, with net primary energy exiting the system.
Principles of energy rating

\[ E_P = \sum (E_{\text{del},i} f_{P,\text{del},i}) - \sum (E_{\text{exp},i} f_{P,\text{exp},i}). \]

Some basic issues:

- Building energy **assessment boundary**
- Energy from **renewable sources produced on-site**
- Primary energy **conversion factor** (renewable and non-renewable)
- Exported energy **assessment**
- Share of **renewable energy**
Energy assessment boundary
Global Energy Performance

• The *Energy Performance* (EP) is expressed as the building *global primary energy demand* divided by the *conditioned area*.

• The *global* primary energy refers to all the EPB energy services (heating, cooling, DHW, ventilation, lighting) and is calculated according to the European Standards.

• EP can either include only *non-renewable energy* \( (E_{\text{Pnren}}) \), or include *both non-renewable energy and renewable energy* \( (E_{\text{Ptot}}) \):

\[
E_{\text{Ptot}} = E_{\text{Pnren}} + E_{\text{Pren}}
\]
Renewable Energy Ratio

• The **Renewable Energy Ratio (RER)** is the ratio of the renewable primary energy to the total primary energy:

\[
RER = \frac{EP_{\text{ren}}}{EP_{\text{tot}}}
\]

• The Energy Performance is fully described by a couple of indicators:
  – \( EP_{\text{tot}} \) and \( EP_{\text{nren}} \), or alternatively
  – \( EP_{\text{tot}} \) and \( RER \)
Global Cost

• The *Global Cost* (GC) is the net present value of all costs (referred to the starting year), determined according to EN 15459.

• The Global Cost is linked to the calculation period (usually 30 years) and includes:
  – investment costs for refurbishment;
  – replacement costs;
  – running annual costs.

• The differential Global Cost ($\Delta$GC) considers the extra-costs referred to a baseline building
Cost optimality (EPBD recast)

• 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.

• Member States shall take account of the cost-optimal levels of energy performance when providing incentives for the construction or major renovation of buildings.

• The Member States are allowed to provide incentives for new buildings, renovations or building elements which go beyond the cost-optimal levels.
Cost optimality (EPBD recast)

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

• The cost-optimal level shall lie within the range of performance levels where the cost benefit analysis calculated over the estimated economic lifecycle is positive.
Cost optimal solution and Pareto front
Nearly Zero-Energy Buildings (EPBD recast)

- Member States shall ensure that:
  - all new buildings are nearly zero-energy buildings (by 31/12/2020);
  - new buildings occupied and owned by public authorities are nearly zero-energy buildings (after 31/12/2018).

- Member States shall draw up national plans for increasing the number of nearly zero-energy buildings.
Nearly Zero-Energy Building (definition)

According to the EPBD recast a nZEB 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.
nZEB according to CEN standards (prEN ISO/DIS 52000-1:2015)

• A methodological proposal rather than a binding definition of nZEB is provided.

• The use of only one requirement, e.g. the numeric indicator of primary energy use) is misleading. Different requirements are combined to a coherent assessment of a nZEB:
  – indoor environmental conditions;
  – thermal characteristics of the building;
  – HVAC installation, DHW supply, built-in lighting installation, optimising the energy use of technical building systems;
  – active solar systems and other systems based on energy from renewable sources;
  – district or block heating and cooling systems.
nZEB according to CEN standards (prEN ISO/DIS 52000-1:2015)

Four classes of requirements are proposed:

- Energy needs (building fabric)
- Total primary energy use
- Non-renewable primary energy use
  - without compensation between energy carriers
  - with compensation between energy carriers
Requirements on the building fabric (prEN ISO/DIS 52000-1:2015)

These requirements take into account:

- the **quality** of the building envelope (e.g. insulation, windows);
- the **bioclimatic design** (e.g. solar gains, natural lighting);
- the **inertia**, the zoning;
- the need to guarantee adequate **indoor environmental** conditions in order to avoid possible negative effects such as poor indoor air quality (due to lack of ventilation) or hygrothermal problems (such as mould).
Requirements on the total primary energy use (prEN ISO/DIS 52000-1:2015)

- The **total primary energy use** is a coherent way for setting technical building system requirements by considering systems losses outside the building assessment boundary (e.g. electricity generation).

- Only **energies delivered through the assessment boundary** from the perimeters defined (e.g. nearby and/or distant) are taken into account to link the total primary energy use with the energy counters. The total primary energy factor takes into account the losses outside the assessment boundary.
Requirements on non-renewable primary energy use (prEN ISO/DIS 52000-1:2015)

- This class of requirements reflects the contribution of energies from renewable sources (e.g. active solar systems or other systems based on energy from renewable sources, district heating and cooling systems).

- There are two options:
  a) only the energy that is used to provide on-site services (heating, ventilations, etc.) is taken into account
  b) Also the compensation between energy carriers and the effect of exported energy is taken into account (e.g. between delivered gas and on-site PV).
The nZEB requirements according to the Italian regulations

- Limit values of the following parameters:
  - Mean thermal transmittance of the envelope ($H'_T$)
  - Summer effective solar area per unit floor area ($A_{sol,sum}/A_f$)
  - Total global energy performance ($EP_{gl,tot}$);
  - Energy needs for heating ($EP_{H,nd}$) and cooling ($EP_{C,nd}$);
  - Seasonal efficiencies of heating, cooling and domestic hot water systems ($\eta_H$, $\eta_C$, $\eta_W$).

- Obligations of contribution from renewable sources:
  - Minimum value of the Renewable Energy Ratio (RER) for DHW and for heating, cooling and DHW
  - Minimum electrical power from renewable sources produced on-site per unit footprint of the building area
nZEB according to RePublic_ZEB project

- For the purposes of RePublic_ZEB project, a building should be considered as nearly Zero Energy when the following requirements are met:
  - the EP is lower than the cost-optimal level (a nZEB is more energy efficient than the cost-optimal building);
  - the differential Global Cost ($\Delta GC$) is negative (a nZEB refurbishment should be cost effective);
  - the national minimum energy performance requirements for nZEBs are fulfilled.

*It could be discussed whether a very high energy efficiency, but slightly non cost-effective solution could be acceptable.*
nZEB according to RePublic_ZEB project

The diagram illustrates the relationship between energy performance and differential global cost. The x-axis represents energy performance in kWh/m², and the y-axis represents the differential global cost in €/m². The diagram shows a range where nZEB is cost-effective and optimal, with a comparison to existing building energy performance. The legal minimum EP requirement is indicated on the diagram.
Case study: School

CITY: Torino
CLIMATIC ZONE: E - 2617 HDD
PERIOD OF CONSTRUCTION: 1965
Building characteristics

Building envelope:
• Average thermal transmittance: 2.69 W/m²K

Heating technical system:
• Generator: 3 gas boiler, Pn 2512 kW each one, $\eta_g = 0.77$
• Emitters: radiators in the classrooms, fancoil in the gym
• Control: climatic

DHW technical system:
• Generator: gas boiler, Pn 167 kW, $\eta_g = 0.86$
• Storage: 1500 litres

NO mechanical ventilation
NO cooling system
Cost-optimal retrofit

- Thermal insulation of all the envelope components
- Advanced control system
- Replacement of the heating and the DHW generator with the district heating.
- Installation of PV panels
- Installation of mechanical ventilation
- Replacement of lamps and lighting control
nZEB retrofit

• Cost-optimal retrofit package
  plus
  ✓ Biomass generator + solar shading (nZEB1)
  ✓ Combined HP (nZEB2)
  ✓ Combined HP + LED lamps (nZEB3)
The nZEB solutions: energy performance

### School

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<th>EP&lt;sub&gt;gl,nren&lt;/sub&gt;</th>
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The nZEB solutions: global cost

- Operating & Maintenance
- Investment
- Energy
The nZEB solutions: cost/benefits

![Graph showing cost/benefits of nZEB solutions for a school](image-url)