Refurbishment of the Public Building Stock Towards Near Zero Energy Buildings

A European Commission funded project
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<tr>
<th>Project consortium</th>
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<tr>
<td><strong>BME</strong> - Budapest University of Technology and Economics, Hungary</td>
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<td><strong>Coordinator for the assessment of the current status of refurbishment to nZEB</strong></td>
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<td>The biggest technical university of Hungary. About 1100 lecturers, 400 researchers and other degree holders. Approximately 800 of the university's 14,000 students are from 50 countries abroad.</td>
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<tr>
<td><strong>BRE</strong> - Building Research Establishment Ltd</td>
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<td><a href="http://www.bre.co.uk">www.bre.co.uk</a></td>
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<td><strong>Coordinator for communication and dissemination</strong></td>
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<td>BRE is an independent and impartial, research-based advisory, testing and training organisation, offering expertise in every aspect of the built environment and associated industries.</td>
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<td><strong>BSERC</strong> - Black Sea Energy Research Centre, Bulgaria</td>
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<td><strong>Coordinator for the analysis of the public building stock</strong></td>
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<td>BSERC is a non-governmental organization, active in the research, policy and promotion of sustainable energy in Bulgaria and the countries of the Black Sea region.</td>
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<td><strong>CRES</strong> - Centre for Renewable Energy Sources and Saving, Greece</td>
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<td><strong>Partner</strong></td>
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<td>CRES is a public entity active in the fields of Renewable Energy Sources, Rational Use of Energy and Energy Saving. Its aim is to promote technological applications at a national and international level.</td>
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<td><strong>CTI</strong> - Italian Thermotechnical Committee, Italy</td>
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<td><a href="http://www.cti2000.it">www.cti2000.it</a></td>
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<td><strong>General coordinator</strong></td>
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<td>CTI develops technical standards in the thermotechnical field at national (UNI) and international level (CEN, ISO). Co-operates with national authorities for developing regulations for the building sector.</td>
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<td><strong>EIHP</strong> - Energy Institute Hrvoje Pozar, Croatia</td>
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<td><strong>Partner</strong></td>
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<tr>
<td>EIHP is a non-profit scientific institution financed on a per-project basis in energy sector in strategic planning; development; energy efficiency; RES; energy audits and certification of buildings.</td>
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<td><strong>NIRD URBAN-INCERC</strong> - National Institute for Research and Development in Construction, Urban Planning and Sustainable Spatial Development, Romania</td>
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<td><strong>Partner, responsible for the analysis of public buildings stock and for national activities</strong></td>
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<td>URBAN-INCERC contributes to Romania's European integration policy, with the object of theoretical and experimental research in the field of products, processes and technologies in construction.</td>
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<td><strong>IREC</strong> - Catalonia Institute for Energy Research, Spain</td>
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<td>IREC is a research institute and aims to generate knowledge with a long/intermediate term in the field of energy and to collaborate with industry to create new technical solutions.</td>
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<td><strong>LNEG</strong> - National Laboratory for Geology and Energy, Portugal</td>
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<td><strong>Coordinator for the definition of strategies and guidelines towards nZEB</strong></td>
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<td>LNEG makes R&amp;D oriented to the needs of society. Investing in a sustainable research ensures that its areas of expertise allow an adequate response to the needs of the business sector.</td>
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<td><strong>MACEF</strong> - Macedonian Centre for Energy Efficiency, Macedonia</td>
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<td><strong>Partner</strong></td>
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<td>MACEF is a multi-disciplinary scientific organization, providing intellectual, technical and project management support services in the energy and environmental fields nationally and worldwide.</td>
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<td><strong>POLITO</strong> – Politecnico di Torino - Department of Energy (DENERG), Italy</td>
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<td><strong>Coordinator of the cost-benefit analysis of the packages of measures</strong></td>
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<td>POLITO-DENERG is expert in energy performance modelling and in support to energy policy. Has as vast experience in building physics, energy systems in buildings, energy retrofitting and energy audits.</td>
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<td><strong>ZRMK</strong> - Building and Civil Engineering Institute, Slovenia</td>
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<td><a href="http://www.gi-zrmk.si/en">www.gi-zrmk.si/en</a></td>
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<tr>
<td><strong>Partner</strong></td>
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<tr>
<td>Conducts research in the field of efficient sustainability and sustainable construction. Co-operates with national authorities for forming the technical bases for regulations for the building sector.</td>
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### The challenges

The Energy Performance of Buildings Directive (Directive 2010/31/EU - EPBD) in 2010 and the Energy Efficiency Directive in 2012 present challenges both to the building industry and to the Member States. Prominent amongst them is the progress towards new nearly Zero-Energy Buildings (nZEB) as required by Article 9 of the EPBD: “by 31 December 2020, all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings”.

The Energy Efficiency Directive sets EU countries the challenge to make energy efficient renovations to at least 3% of buildings owned and occupied by central government. Further, EU governments should only purchase buildings which are highly energy efficient.

The public sector is seen as a ‘flag-bearer’ in terms of adopting and demonstrating nZEB as part of the broader sustainability agenda. However, the implementation of these requirements, especially with respect to nZEBs, depends on the engagement and mutual support of many stakeholders, including local and central government, contractors, designers, building owners and managers, material and technology suppliers, social groups, researchers and NGOs.

### The RePublic_ZEB project

The core objective of the RePublic_ZEB project was to define costs-benefit optimized "packages of measures" based on efficient and quality guaranteed technologies to refurbish public buildings that are standardized and can easily be adopted by builders and building owners. Thus, the aim was to promote to the market a set of robust technical solutions.

The underlying objectives were to assess the public building stock, define reference buildings, engage stakeholders and authorities through communication and dissemination activities and develop a common framework and harmonised methodology for the definition of the nZEB concept.

The project mainly focused on the Mediterranean and the South-East European countries in which there are common conditions of climate, energy performance (both cooling and heating are important) and available RES potential.

### What is meant by “Refurbishment towards nZEB”?

RePublic_ZEB’s definition of nZEB refurbishment is illustrated in the figure below.

Each point represents the impact of retrofit measures (packages of measures) on an existing building in terms of energy performance and differential global cost. This is with respect to the performance of the unimproved existing building.

The **energy performance** is the primary energy consumed by the building (only the *non-renewable* primary energy is generally considered).

The **differential global cost** is the difference in costs (defined as the actualised expenditures for investment, operations and maintenance generally over a 30-year period) between the existing and the refurbished building.

The figure shows that, according to RePublic_ZEB’s recommendations, the nZEB range is located beyond the cost-optimal range and encompasses packages of measures with an equal or higher global cost than the existing building.

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“Transformation of an existing public building to nZEB means to apply renovation technologies that enable the building to reach a target share of RES and deliver energy performance or CO₂ emissions better than the cost-optimal case but still cost effective.”

**RePublic_ZEB project definition**
**Why are nZEB important?**

A building refurbished to nZEB is, by definition, not as cost-effective as one adopting a cost-optimal solution, but technological evolution will make them more cost-effective over time. In the figure below it is assumed this is a period of $\Delta n$ years (e.g. 5-10 years). Consequently, an nZEB becomes "cost-optimal" in the year "$n + \Delta n"$, when more advanced targets for nZEB requirements should be defined. This process leads to a continuous improvement in the energy performance that approaches the axis origin. Conversely, it is probably necessary to review the existing target. Note that everything is based, essentially, on a reduction of the costs of the packages of measures over time. Here, it is assumed that the nZEB range is slightly more cost-effective than the existing building.

**nZEB is a “sliding” concept**

The dissemination of nZEBs can promote technological evolution and reduce the costs of refurbishment. In this way public buildings can play an important and strategic role.

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[Energy Performance (EP - kWh/m²)]

**Differential Global Cost (€/m²)**

**Existing building**

**EP_{opt. year n}**

**EP_{nZEB year n}**

**EP_{nZEB year n + \Delta n}**

**EP_{existing building}**

**Technological evolution**

**year n**

**year n + \Delta n**

**nZEB range (year n)**

**nZEB range (year n + \Delta n)**
What are the “packages of measures”?

To refurbish public buildings, different EEMs (energy efficiency measures) can be applied. The interventions are generally related to the insulation of the building envelope (including windows), the adoption of efficient HVAC and DHW systems, Building Management System (BMS), efficient lighting and power generation systems as well as technologies based on renewable energy sources use. The EEMs have national characteristics and their required level of performance can be different in the specific countries. The packages of measures are combinations of different EEMs and the “optimal packages” are those that minimise the cost. To achieve these results, RePublic_ZEB has established a database of technical and economic information on the measures available in each country and has produced a tool (as an Excel worksheet) to find, for every specific building, the “optimal packages”.

The database and the RePublic_ZEB tool

A database of energy efficiency measures and a tool to select the “optimal packages of measures” have been made available by RePublic_ZEB.

Making RePublic_ZEB successful in defining a methodology to identify reference buildings and cost-efficient solutions for their refurbishment to nZEB

The project defined a methodology to identify representative reference buildings and chose specific cases to determine cost-optimal packages of measures for Southern and Eastern EU Member States as well as approaches and packages of EEMs that can potentially deliver nZEBs. The project has promoted the results to a wide range of key actors, engaging them and developing also memoranda of understanding (MOUs) and the basis of model contracts (EPC). This will help to increase the uptake of the packages of measures and increase the number of nZEB. In this context, a number of case studies (based on the reference buildings chosen in each participating country) have been developed using of the data-base and the tool and then discussed with the key-actors. The aim was to raise awareness and to trigger initiatives mostly among “public building owners” (primarily public administrations), professionals and industry (i.e. designers, engineers and architects, manufacturers of technologies, builders, etc.).

Energy packages are combinations of energy efficiency measures (EEM) that can be adopted for the refurbishment of buildings.
Making RePublic_ZEB successful involving key-actors

RePublic_ZEB has engaged with different key actors, divided into three main groups:

- **Policy developers and decision makers** of national or regional authorities responsible for the implementation and the development of the EPBD.

- **Operators of the building sector** such as manufacturers, professionals, associations and organizations, distributors, builders, energy utility companies and ESCOs. All of them have been engaged at the different stages of the project.

- **Public buildings owners**, that represent an essential target group as they can influence both the performance of the building by their own behaviour (saving energy, controlling the indoor environment etc.) and the decisions regarding building management and eventual refurbishment.

Policy developers have been engaged through “one to one” meetings; professionals, industrial subjects and public building owners were engaged through specific meetings, training sessions, open days and dissemination seminars. The project has also produced a regular newsletter and press releases, distributed through an extended mailing data-base and the project web-site. The final results have been distributed also to a selected list of “VIPs” in each country who have been identified as having the most influence on the implementation of nZEB.
Examples of RePublic_ZEB case studies

Romanian school

Year of construction: 1970
Conditioned area: 2.026 m²

Optimal package of measures:
- external insulation (15 cm EPS)
- ground insulation (6 cm EPS)
- roof insulation (15 cm EPS)
- PVC windows with triple glass low-e
- district heating
- heat recovery system
- solar thermal and PV
- LED
- advanced BAC
Bulgarian hospital

Year of construction: 1979
Conditioned area: 2.564 m²

Optimal package of measures:
- external insulation (7 cm EPS)
- roof insulation (10 cm EPS)
- PVC windows with triple glass low-e
- Biomass boiler
- mechanical ventilation and heat recovery system
- solar thermal
- LED
- advanced BAC

Italian office

Year of construction: 1960
Conditioned area: 4.521 m²

Optimal package of measures:
- external insulation (14 cm mineral wool)
- roof insulation (18 cm XPS)
- solar shadings
- heat pump
- mechanical ventilation and recovery system
- solar thermal
- fluorescent lamps T8
- advanced BAC
Some project impacts

Due to its short duration (2.5 years), RePublic_ZEB could not initiate actual refurbishment projects, but it was successful in preparing the ground needed to launch such projects. In fact, from the start of the activity, it was clear that awareness of nZEB by public administrators and other key actors was poor. This is the main problem and, together with the general lack of specific financial sources, this is delaying nZEB refurbishments and, in general, the fulfilment of the EPBD objectives.

In this context, RePublic_ZEB has contributed in the following areas (some concrete examples are presented below):

- creation of a better background for the definition (or the revision of the definition) of refurbishment to nZEB at national level;
- promotion of specific financial incentives for renovation to nZEB.

RePublic_ZEB helps to overcome financial barriers in Italy

The project has shown that applying the Italian legislation to the renovation of public buildings requires significant investment, which is generally not affordable by public administrations and ESCOs in terms of servicing the debt.

This problem was underlined in the “one to one” meetings and the following discussion led to a specific financial provision of 200 M€ for public buildings for the period 2016-20. This equates to 150-200 refurbishments to nZEB.

RePublic_ZEB helps to improve the nZEB legislation in Bulgaria and the national renovation strategy in Romania

BSERC ascertained that applying the national regulations to nZEB assessments lead to significant variations in the results. Consequently, an amendment that will affect the calculation of primary energy and the share of RES has been proposed. A second proposal aims to introduce more flexibility in the nZEB definition with the use of district heating from cogeneration.

In Romania, the project led to recommendations for the national "Strategy for mobilizing investment in the renovation of existing national building stock" and for a higher level of ambition in upgrading the efficiency of public buildings. Thus, the project made an important contribution to the definition of indicators for the renovation of buildings and to set the performance requirements in the call for projects under the Regional Operational Programme 2014-20,

RePublic_ZEB helps to increase awareness of nZEB in Greece, Catalonia, Macedonia and Portugal

Although the potential to refurbish the existing public building stock into nZEB has been demonstrated, the Greek government has delayed developing its strategies to comply with the EU Directives. The project has put a significant effort in assisting both the public sector and the industry to overcome these barriers preventing the rapid uptake of nZEB practices. This is demonstrated by the nine MOUs signed by public authorities, associations and companies.

In Catalonia IREC signed a MoU with the Catalan Energy Agency (ICAEN) to increase the confidence in nZEB concepts with a particular focus on public building managers. The national activity of the project has also created an “nZEB working group”.

In Macedonia, the project has been instrumental in opening the market to energy efficient buildings, raising awareness of nZEB and facilitating the inclusion of the nZEB concept into both the National Energy Efficiency Action Plan and the draft of the Legislative Stepping Stone for further improvement.

In Portugal, the nZEB calculation methodology is not yet defined in legislation and the approach proposed by the project has given valuable help to raise awareness of the subject through the dissemination activities that were very well received by stakeholders and the contribution of the partner LNEG to define national reference buildings.
Looking at the lessons learned from the work carried out by the RePublic_ZEB partners, the main barriers to overcome are the following:

- The generic definition of nZEB given in the EPBD has generated and is still generating delays in adopting the concept, and the great variety of regional definitions and proposed definitions are unlikely to help the general understanding of the various issues and could create confusion in the sector.
- As a consequence, most of the decision makers, at all levels, often have not appreciated the concept of nZEB. The prevailing idea is that an nZEB is a building with a very low energy consumption (in physical terms) but this situation is almost always uneconomical. In this context, probably the meaning of “very low consumption” has been misunderstood.
- The launch of renovation projects depends greatly on the planning and maintenance schedules that administrators manage. Despite the great work done by the EC, the awareness of public building managers of nZEB is still low. This is delaying the adoption of the nZEB concept and does not help the inclusion of renovation in managers’ schedules.
- In countries where the legal definition of nZEB exists, it often leads to disappointing economic results. As a rule of thumb, projects are judged feasible if the payback period is less than ten years. With longer payback periods, projects become very difficult to set up as Energy Performance Contracts (EPCs). This situation is common in South-east countries.
- In the countries where the analytical legal definition does not exist yet, the concept of nZEB is vague. It therefore becomes more difficult to launch concrete initiatives unless the term nZEB is used generically to identify a building that simply stands out through the application of some energy saving measures and renewable energy sources (like an attractive but unregulated brand for the market).

Some key recommendations from the lessons learned from RePublic_ZEB:

- Public buildings owners still require a lot of basic information and training. The information needs to be practical and suggest reliable and affordable technical solutions.
- The generic definition of nZEB given by the EPBD and industry current practice suggest that member countries in Southeast Europe need more precise guidance, while maintaining flexibility. For example, it should make clear that an nZEB must not be necessarily characterized by a “very low” energy consumption, but it must simply be better than a cost-optimal building achieving, if possible, a reasonable cost-effectiveness. Only in this way, will it be possible to start the virtuous path towards “zero”.
- Encouraging the use of renewables must be balanced. In fact, the higher costs of refurbishment are often due to the high proportion required for RES. This proportion depends also on its formal national definition that can be excluded or included in the balance of exported energy (mainly generated by PV). If it is excluded it is difficult to reach a high RES proportion, but it is considerably easier if it is included.
- The economic parameters used by the EC to set the strategic objectives of nZEB are probably too optimistic for the countries of the Southeast Europe and should be re-considered. For example, it is challenging for ESCOs to manage projects with return periods longer than 10 years and have limited ability to service such debts. RePublic_ZEB has shown that, considering the EC directions, the payback periods of refurbishment projects are often over 12-15 years and this drastically reduces the number of feasible EPC contracts.
- **Preliminary Assessment of Public Building Stock**
  Presents key data concerning the general features and energy consumption of public buildings in the countries covered by the project.

- **Method and results in defining national reference buildings**
  Presents the preliminary selection of reference buildings and the analyses carried out on the public building stock.

- **Report on the national implementation of the EPBD**
  Describes policy mapping comprising assessment of existing national plans, policies and regulatory frameworks of target countries, including existing barriers and best practices.

- **Common criteria and principles for public building nZEB definition in South and East European countries**
  Presents a harmonized methodology and proposes three indicators to be used to specify nZEB public buildings.

- **Report on best practices and lists of technologies useful for the refurbishment of buildings**
  Analyses best practice CO₂ emission-saving refurbishments in the target countries and details measures that can be applied.

- **Report on the country assumptions for the application of the energy use evaluation methodology to the case studies**
  There is a common methodology covered by RePublic ZEB. However, different countries have different prevailing factors, and this report outlines the assumptions for each of them.

- **Report on the country assumptions for the application of the cost optimal methodology to the case studies**
  Explains the common methodology to calculate the optimal levels of minimum energy performance requirements towards nZEB and the country assumptions for the global cost evaluation.

- **Report on national results to the reference buildings and energy efficiency measures**
  The energy performance (kWh/m²/year) of each reference building was calculated before and the cost-optimal and nZEB refurbishment packages identified.

- **Report on the sensitivity analysis approach and on the medium/long terms technologies development perspectives**
  Describes how the global cost and the pay-back periods for each nZEB package changed in response to variations to key variables: investment and the operating and maintenance costs, energy costs and the discount rate.

- **Report on nZEB approach for existing public building and energy recommendations**
  Summarises the status of nZEB in each country and describes partner meetings with national or regional authorities, energy agencies etc. to understand policies that support nZEBs and gives recommendations to improve their uptake.

- **Guidelines on best practice**
  Presents the headline results for the nZEB packages applied to many of the reference buildings assessed by the project.

- **Model contract and financing schemes**
  Summarises the status of EPC contracts and of financing schemes in each country and discuss how the transformation of existing building towards nZEB could be included.
ZEROING IN ON ENERGY

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www.republiczeb.org

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