# IMPLEMENTING NEARLY ZERO-ENERGY BUILDINGS (nZEB) IN ROMANIA –

## TOWARDS A DEFINITION AND ROADMAP

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# 1. SETTING THE STAGE

The building stock is responsible for a large share of greenhouse gas emissions (GHG) in the European Union. Major emission reductions can be achieved through changes in this sector. With more than one quarter of the 2050s building stock still to be built, a large amount of GHG emissions are not yet accounted for. To meet the EU's ambitious reduction targets, the energy consumption of these future buildings needs to be close to zero, which makes finding and agreeing on an EU-wide definition or guidelines for "nearly Zero-Energy Buildings" (nZEB) essential in the effort to reduce domestic greenhouse gases to 80% of 1990 levels by 2050.

The recast of the Energy Performance of Buildings Directive (EPBD) introduced, in Article 9, "nearly Zero-Energy Buildings" (nZEB) as a future requirement to be implemented from 2019 onwards for public buildings and from 2021 onwards for all new buildings. The EPBD defines a nearly Zero-Energy Building as follows: [A nearly Zero-Energy Building is a] "building that has a very high energy performance… [ ]. The nearly zero or very low amount of energy required should to a very significant extent be covered by energy from renewable sources, including renewable energy produced on-site or nearby".

Acknowledging the variety in building culture, climate and methodological approaches throughout the EU, the EPBD does not prescribe a uniform approach for implementing nZEBs. Each EU Member State has to elaborate its own definition. The EPBD requires EU Member States to draw up specifically designed national plans for implementing nZEBs which reflect national, regional or local conditions. The national plans will have to translate the concept of nZEB into practical and applicable measures and definitions to steadily increase the number of these buildings. EU Member States are required to present their nZEB definition and roadmaps to the European Commission by 2013.

The nZEB criteria as defined in the EPBD are of a very qualitative nature with much room for interpretation and way of execution. Indeed, there is little guidance for Member States on how to concretely implement the Directive and on how to define and realise this type of building. Therefore a clear definition needs to be formulated that can be taken into account by EU Member States for elaborating effective, practical and well thought-out nZEBs.

The aim of this study is to actively support this process in Romania by providing a technical and economic analysis for developing an ambitious yet affordable nZEB definition and implementation plan. Starting from country data reflecting current construction practices, economic conditions and existing policies, different technological options are simulated for improving the energy performance of offices and single- and multi-family buildings. We have evaluated the economic implications of the various options in view of an implementation plan.

# 2. AIM AND METHODOLOGY

The current study builds on the previous report "Principles for nearly Zero-Energy Buildings"[1] and evaluates through indicative simulations whether these principles hold true for the situation in Romania. The objective is to offer an independent and research-based opinion proactively supporting national efforts to draw up an affordable yet ambitious definition and an implementation roadmap for nearly Zero-Energy Buildings (nZEBs) in Romania.

The project started with an in-depth survey of the Romanian building stock, construction practices, market prices for materials and equipment, existing legislation and support measures. We defined and evaluated new reference buildings (actual practice) for the following building types:

- Detached single family house (SFH)
- Multi-family house (MFH)
- Office buildings (OFFICE)

Detached single family houses and multi-family blocks of flats represent around 95% of the residential building stock in Romania. Office buildings represent around 13% of the non-residential building stock but registered a high rate of construction over the last decade.

Altogether, these three building types account for around 87% of the Romanian building stock. We consider them to be representative.

With these three reference buildings we undertook several simulations using variants of improved thermal insulation and equipment for heating, cooling, ventilation and hot water. To improve the $CO_2$ balance and the renewable energy share of the building, we considered photovoltaic compensation. These simulations were evaluated for compliance with the nZEB principles as elaborated in the BPIE study. Moreover, the economic and financial implications of each variant were analysed in order to determine the most suitable and affordable solutions under the country's specific circumstances. Finally, the selected optimal solutions were extrapolated at national level to determine the direct and indirect benefits and impacts. Besides the $CO_2$ saving potential, impacts on job creation and the industry/technology development were also considered. The last chapter presents key policy recommendations and an indicative roadmap for the implementation of nZEBs in Romania.

This report was conceptualized, coordinated and finalised by BPIE. The overall data aggregation and selection, simulations and analysis were executed by Ecofys Germany as a lead consultant. The provision of data concerning Romanian buildings, policies and market prices, the definition and selection of reference buildings and the revision of the final study were made by the national consultant[2].

The building simulations were undertaken with the TRNSYS[3] software tool. The economic analysis was performed by using the Ecofys analytical tool Built Environment Analysis Model (BEAM2)[4].

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[1] BPIE (2011). Principles for nearly Zero-Energy Buildings - Paving the way for effective implementation of policy requirements. Available at www.bpie.eu<http://www.bpie.eu.

[2] Horia Petran, INCD URBAN-INCERC - Sucursala INCERC Bucuresti, Sectia Performante energetice ale constructiilor durabile, Romania

[3] TRNSYS is, a transient systems simulation program, commercially available since 1975, which has been used extensively to simulate solar energy applications, conventional buildings, and even biological processes. More details at: http://www.trnsys.com/

[4] Further information: http://www.ecofys.nl/com/news/pressreleases2010/documents/2pager_Ecofys_BEAM2_ENG_10_2010.pdf

# 3. DEFINITION OF nZEB OPTIONS AND SOLUTIONS

Based on the research results and information about the local building stock, the simulations highlight the specific national situation in Romania, which differs in many respects from the overall EU situation as presented in the general European study "Principles for nearly Zero-Energy Buildings".

To analyse the impact of different nZEB options, three reference buildings have been defined, based on current construction practices in Romania:

1. Detached single family houses (SFH)
2. Multi-family houses (MFH)
3. Office buildings

The reference buildings selected should match the range of building types found in Romania (taking into account typical shapes, sizes, characteristics and usage of new buildings). The aim of the simulation is to analyse the technical and economic impact of moving towards nZEB starting from the current situation in an effective and realistic manner and by minimizing transition costs.

The SFH is by far the dominant building type in Romania. Within this category the detached SFH has the highest share. The second largest amount of floor space ($m^2$ ) was indicated for urban MFH. In the non-residential buildings sector, the share of retail, educational and healthcare buildings is higher than for office buildings. However, the retail buildings sector is characterised by a high diversity of subtypes and the definition of many reference buildings would be necessary to produce an accurate picture.

In addition, there is a very low dynamic of constructing new educational and healthcare buildings. The existing stock, however, is well established and in need of improved renovation quality, renovation depth and rate. Indeed, the construction rate of office buildings is much higher than for the other two categories and there are less subtypes. Public administration buildings are included in the office buildings category. The EPBD indicates that public administration buildings should play a leading role and adopt more timely and ambitious nZEB requirements. Based on this, we chose office buildings to be the third relevant reference building category for this study.

The identified reference buildings for each category are presented in Table 1 on the next page.

**Table 1: Identified reference buildings for new construction in Romania**

| Parameter | Reference SFH | Reference MFH | Reference Office |
|---|---|---|---|
| Number of conditioned floors | 2 | 6 | 3-5 |
| Net floor area | 99.7 $m^2$ | 2 870 $m^2$ | 2 817 $m^2$ |
| Room height | 2.5 m | 2.73 m | 3.30 m |
| U-walls | 0.56 W/($m^2$K) | 0.6 W/($m^2$K) | 0.61 W/($m^2$K) |
| U-roof | 0.35 W/($m^2$K) | 0.24 W/($m^2$K) | 0.33 W/($m^2$K) |
| U-floor | 0.52 W/($m^2$K) | 0.60 W/($m^2$K) | 0.64 W/($m^2$K) |
| U-windows, frame fraction | 1.30 W/($m^2$K); 30% | 1.30 W/($m^2$K), 30% | 1.30 W/($m^2$K), 15% |
| Window fraction (window/wall-ratio) | 12% (no windows on North facade) | 23% | 55% (East side without glazing) |
| Air tightness | Moderate | Moderate | Moderate |
| Heating and DHW systems | Gas boiler (set point: 20°C), Heating and DHW efficiency: 0.9 | Gas boiler (set point: 20°C), Heating and DHW efficiency: 0.9 | Gas boiler, fan coils (set point: 20°C), Heating and DHW efficiency: 0.9 |
| Ventilation system | Natural/window ventilation (0.5 1/h) | Natural/window ventilation (0.5 1/h) | Mechanical ventilation, (0.46...2.72 1/h, zone dependent) |
| Ventilation rates during system operating time (6 am till 6 pm) | - | - | Office spaces: 1.36 1/h<br>Conference rooms: 2.72 1/h<br>Other rooms: 0.46 1/h |
| Cooling system | Split system (set point: 26°C), SEER[5]: 2.75 | Split system (set point: 26°C), SEER: 2.75 | Central chiller, fan coils, (set point: 26°C), SEER: 2.7 |
| Internal gains[6] | 5 W/$m^2$ | 5 W/$m^2$ | 3.5 W/$m^2$ |
| Person density in office areas (considered as an additional internal load) | - | - | 0 am – 8 am and 6 pm - 0 am: no persons<br>8 am – 12 am and 2 pm – 6 pm: 1 person/15 $m^2$<br>12 am – 2 pm: 1 Person/30 $m^2$ |

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[5] SEER=Seasonal Energy Efficiency Ratio. The SEER rating of a unit is the cooling output during a typical cooling-season divided by the total electric energy input in watt-hours during the same period. The higher the unit's SEER rating the more energy efficient it is.

[6] This value is to be understood as maximum value. For persons, lighting, appliances and other internal gains schedules exist taking into consideration e.g. how many persons are at the moment in the respective zone.

## 3.1. DEFINITION OF nZEB OPTIONS, BASIC ASSUMPTIONS AND SIMULATION APPROACH

### 3.1.1. nZEB solutions for single family houses (SFH)

For all variants – for comparison reasons – the geometry of the reference buildings has not been changed, even if they are not optimum for a very low-energy building. The reference building identified by the national expert included the cellar with the subterrain garage as part of the heated area. However, this was assumed to be unheated with insulation at the cellar ceiling (0.52 W/m²K). Table 2 shows the variants considered for simulations made with TRNSYS.

**Table 2: Romanian SFH, nZEB variants**

| Variants | U-value Opaque Shell | U-Value Window | Heat Recovery Rate | Solar Collector for DHW | Brief Description |
|---|---|---|---|---|---|
| **VO** | U-Wall: 0.56 W/m².K<br>U-Roof: 0.35 W/m².K<br>U-Floor: 0.52 W/m².K | 1.3 W/m².K | 0% | No | Reference |
| **V1** | U-Wall: 0.15 W/m².K<br>U-Roof: 0.12 W/m².K<br>U-Floor: 0.36 W/m².K | 1.0 W/m².K | 0% | No | Improved building shell |
| **V2** | U-Wall: 0.15 W/m².K<br>U-Roof: 0.12 W/m².K<br>U-Floor: 0.36 W/m².K | 1.0 W/m².K | 0% | Yes | Improved building shell + solar collectors |
| **V3** | U-Wall: 0.15 W/m².K<br>U-Roof: 0.12 W/m².K<br>U-Floor: 0.36 W/m².K | 1.0 W/m².K | 80% | No | Improved building shell + mech. ventilation with heat recovery |
| **V4** | U-Wall: 0.12 W/m².K<br>U-Roof: 0.10 W/m².K<br>U-Floor: 0.36 W/m².K | 0.80 W/m².K | 90% | No | Passive house standard[7] |
| **V5** | U-Wall: 0.12 W/m².K<br>U-Roof: 0.10 W/m².K<br>U-Floor: 0.36 W/m².K | 0.80 W/m².K | 90% | Yes | Passive house standard + solar collectors |

Based on local conditions and practices, for each of the four base variants the following four heating supply options are considered:

1. Wood pellet boiler
2. Air source heat pump
3. Ground collector brine heat pump
4. Gas condensing boiler

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[7] Passive house standard: major shell improvements, no heat bridges, airtight construction, highly efficient mechanical ventilation (> 90%), useful heating and cooling demand < 15 kWh/m²a

### 3.1.2. nZEB solutions for multi-family house (MFH)

As for the SFH, all solutions are based on the same geometrical data of the identified reference MFH. Table 3 shows the variants simulated with TRNSYS.

**Table 3: Romanian MFH, nZEB variants**

| Variants | U-value Opaque Shell | U-Value Window | Heat Recovery Rate | Solar Collector for DHW | Brief Description |
|---|---|---|---|---|---|
| **VO** | U-Wall: 0.60 W/m²K<br>U-Roof: 0.24 W/m²K<br>U-Floor: 0.60 W/m²K | 1.3 W/m².K | 0% | No | Reference |
| **V1** | U-Wall: 0.20 W/m²K<br>U-Roof: 0.15 W/m²K<br>U-Floor: 0.40 W/m²K | 1.0 W/m².K | 0% | No | Improved building shell |
| **V2** | U-Wall: 0.60 W/m²K<br>U-Roof: 0.24 W/m²K<br>U-Floor: 0.60 W/m²K | 1.3 W/m².K | 80% | No | Mech. ventilation with heat recovery |
| **V3** | U-Wall: 0.20 W/m²K<br>U-Roof: 0.15 W/m²K<br>U-Floor: 0.40 W/m²K | 1.0 W/m².K | 80% | No | Improved building shell + mech. ventilation with heat recovery |
| **V4** | U-Wall: 0.20 W/m²K<br>U-Roof: 0.15 W/m²K<br>U-Floor: 0.40 W/m²K | 1.0 W/m².K | 80% | Yes | Improved building shell + mech. ventilation with heat recovery + solar collectors |

Based on the local conditions and practices, for each of the five base variants the following four heating source options have been considered:

1. Wood pellet boiler
2. Air source heat pump
3. Ground collector brine heat pump
4. Gas condensing boiler
5. District heating

### 3.1.3. nZEB solutions for office buildings

Consequently we kept the geometry of the reference also for the office buildings simulation, even though it is not optimum for an nZEB. Table 4 presents the variants simulated with TRNSYS.

**Table 4: Romanian office building, nZEB variants**

| Variants | U-value Opaque Shell | U-Value Window | Heat Recovery Rate | External shading | Window Share | Light system | Solar Collector for DHW | Brief Description |
|---|---|---|---|---|---|---|---|---|
| **VO** | U-Wall: 0.61 W/m$^2$.K<br>U-Roof: 0.33 W/m$^2$.K<br>U-Floor: 0.64 W/m$^2$.K | 1.3 W/m$^2$.K | 0% | None | 55% | Manual control | No | Reference |
| **V1** | U-Wall: 0.61 W/m$^2$.K<br>U-Roof: 0.33 W/m$^2$.K<br>U-Floor: 0.64 W/m$^2$.K | 1.3 W/m$^2$.K | 80% | None | 55% | Manual control | No | Mech. ventilation with heat recovery |
| **V2** | U-Wall: 0.15 W/m$^2$.K<br>U-Roof: 0.12 W/m$^2$.K<br>U-Floor: 0.23 W/m$^2$.K | 1.0 W/m$^2$.K | 80% | Automatic | 55% | Manual control | No | Mech. ventilation with heat recovery<br>+ Improved building shell<br>+ external shading |
| **V3** | U-Wall: 0.15 W/m$^2$.K<br>U-Roof: 0.12 W/m$^2$.K<br>U-Floor: 0.23 W/m$^2$.K | 1.0 W/m$^2$.K | 80% | Automatic | 36% | Manual control | No | Mech. ventilation with heat recovery<br>+ Improved building shell<br>+ external shading<br>+ reduced window share |
| **V4** | U-Wall: 0.15 W/m$^2$.K<br>U-Roof: 0.12 W/m$^2$.K<br>U-Floor: 0.23 W/m$^2$.K | 1.0 W/m$^2$.K | 80% | Automatic | 36% | Automatic controlled lighting | No | Mech. ventilation with heat recovery<br>+ Improved building shell<br>+ external shading<br>+ reduced window share<br>+ automatic lighting control |
| **V5** | U-Wall: 0.15 W/m$^2$.K<br>U-Roof: 0.12 W/m$^2$.K<br>U-Floor: 0.23 W/m$^2$.K | 1.0 W/m$^2$.K | 80% | Automatic | 36% | Automatic controlled lighting | Yes | Mech. ventilation with heat recovery<br>+ Improved building shell<br>+ external shading<br>+ reduced window share<br>+ automatic lighting control<br>+ improved cooling: efficient high temperature concrete activation |

For each of the five base variants, the following five heating options have been considered:

1. Central air/water heat pump
2. Central brine/water heat pump
3. Central wood pellet boiler
4. Central gas condensing boiler
5. District heating

# 4. INDICATIVE nZEB DEFINITION BASED ON (COST-) OPTIMAL VARIANTS

The results of the simulation for each solution in terms of primary energy consumption, renewable share, associated $CO_2$ emissions and total annualised additional costs (investment, energy cost savings and other running costs such as maintenance) are shown in tables 5-7. Total final and primary energy demand for residential buildings includes the energy consumption within the EPBD scope: heating, cooling, ventilation, domestic hot water. For office buildings, this also includes lighting energy consumption. The colour code used for highlighting the results of the different nZEB options considered in this study is in line with the nZEB principles as they were defined in the previous BPIE study[8].

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[8] BPIE (2011). Principles for nearly Zero-Energy Buildings - Paving the way for effective implementation of policy requirements. Available at www.bpie.eu

**Table 5: Overview of the results for the single family building**

| Variants | final specific demand [kWh/m2/yr] | Without CO$_2$ compensation | | | | With CO$_2$ compensation (by additional PV) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | primary energy demand [kWh/m$^2$/yr] | CO$_2$ emissions [kgCO$_2$/m$^2$/yr] | Renewable share [%] | total additional annualised costs [Euro/m$^2$/yr] | primary energy demand* [kWh/m2/yr] | CO$_2$ emissions [kgCO$_2$/m$^2$/yr] | Renewable share [%] | total additional annualised costs [Euro/m$^2$/yr] |
| V0 - Reference | 161.6 | 180.8 | 32.8 | 0 | 0 | n.a. | n.a. | n.a. | 0 |
| V1 - Air heatpump | 24.6 | 49.3 | 6.2 | 40% | 2.5 | 0 | 0 | 140% | 5.7 |
| V1 - Brine heatpump | 20.3 | 40.7 | 5.1 | 40% | 10.7 | 0 | 0 | 140% | 13.2 |
| V1 - Bio boiler | 76 | 22.3 | 1 | 100% | 7.7 | 7.9 | 0 | 110% | 8.6 |
| V1 - Gas boiler | 76 | 87.2 | 15.6 | 0 | -1.5 | -24.2 | 1,5 | 80% | 5.4 |
| V2 - Air heatpump | 18.9 | 37.8 | 4.8 | 40% | 6.4 | 0 | 0 | 140% | 8.7 |
| V2 - Brine heatpump | 14.3 | 28.7 | 3.6 | 40% | 14.4 | 0 | 0 | 140% | 16.2 |
| V2 - Bio boiler | 56.5 | 17.5 | 0.9 | 100% | 11.3 | 3.1 | 0 | 110% | 12.1 |
| V2 - Gas boiler | 56.5 | 65.3 | 11.6 | 0 | 3.4 | -26.8 | 0 | 80% | 9.2 |
| V3 - Air heatpump | 18.8 | 37.6 | 4.7 | 40% | 1.2 | 0 | 0 | 140% | 3.6 |
| V3 - Brine heatpump | 16.9 | 33.7 | 4.2 | 40% | 7 | 0 | 0 | 140% | 9.2 |
| V3 - Bio boiler | 53.4 | 19.4 | 1.2 | 90% | 8.6 | 5 | 0 | 110% | 9.5 |
| V3 - Gas boiler | 53.4 | 63.1 | 11 | 0 | 0.1 | -24.4 | 0 | 90% | 5.5 |
| V4 - Air heatpump | 15.6 | 31.2 | 3.9 | 40% | 3.4 | 0 | 0 | 140% | 5.3 |
| V4 - Brine heatpump | 13.6 | 27.1 | 3.4 | 40% | 8.1 | 0 | 0 | 140% | 9.9 |
| V4 - Bio boiler | 41.2 | 16.2 | 1.1 | 90% | 12.8 | 1.8 | 0 | 110% | 13.8 |
| V4 - Gas boiler | 41.2 | 49.3 | 8.5 | 0 | 5.1 | -18.6 | 0 | 90% | 9.3 |
| V5 - Air heatpump | 10.3 | 20.6 | 2.6 | 40% | 5.7 | 0 | 0 | 140% | 7 |
| V5 - Brine heatpump | 8.7 | 17.4 | 2.2 | 40% | 10.6 | 0 | 0 | 140% | 11.7 |
| V5 - Bio boiler | 21.7 | 14.1 | 1.4 | 80% | 15.1 | -0.3 | 0 | 120% | 16 |
| V5 - Gas boiler | 21.7 | 28.8 | 4.7 | 10% | 10.5 | -8.2 | 0 | 90% | 12.8 |
| | <40 | <40 | <4 | >50 | <5 | <40 | <4 | >50 | <5 |
| | 40<x<60 | 40<x<70 | 4<x<7 | 30<x<50 | 5<x<10 | 40<x<70 | 4<x<7 | 30<x<50 | 5<x<10 |
| | >60 | >70 | >7 | <30 | >10 | >70 | >7 | <30 | >10 |

**Table 6: Overview of the results for the multi-family building**

| Variants | final specific demand [kWh/$m^2$/yr] | Without CO$_2$ compensation | | | | With CO$_2$ compensation (by additional PV) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | primary energy demand [kWh/$m^2$/yr] | CO$_2$ emissions [kgCO$_2$/$m^2$/yr] | Renewable share [%] | total additional annualised costs [Euro/$m^2$/yr] | primary energy demand* [kWh/$m^2$/yr] | CO$_2$ emissions [kgCO$_2$/$m^2$/yr] | Renewable share [%] | total additional annualised costs [Euro/$m^2$/yr] |
| V0 - Reference | 80.7 | 91 | 16.4 | 0 | 0 | n.a. | n.a. | n.a. | 0 |
| V1 - Air heatpump | 20.4 | 40.8 | 5.1 | 40% | 3 | 5.7 | 0,7 | 120% | 3.8 |
| V1 - Brine heatpump | 17.8 | 35.5 | 4.5 | 40% | 2.9 | 0.4 | 0,1 | 130% | 3.7 |
| V1 - Bio boiler | 62.3 | 18 | 0.8 | 100% | 1.7 | 11.9 | 0 | 100% | 1.8 |
| V1 - Gas boiler | 62.3 | 71.3 | 12.7 | 0 | -1.2 | 36.2 | 8.3 | 30% | -0.5 |
| V1 - District heating | 59.3 | 55.7 | 8.7 | 50% | -4.3 | 20.5 | 4.3 | 80% | -3.5 |
| V2 - Air heatpump | 22 | 43.9 | 5.5 | 40% | 5.5 | 8.8 | 1.1 | 110% | 6.3 |
| V2 - Brine heatpump | 19.5 | 39.1 | 4.9 | 40% | 5.6 | 3.9 | 0.5 | 120% | 6.4 |
| V2 - Bio boiler | 62.2 | 21.9 | 1.3 | 90% | 3.3 | 11.4 | 0 | 100% | 3.5 |
| V2 - Gas boiler | 62.2 | 73.2 | 12.8 | 0 | 1.6 | 38.1 | 8.4 | 30% | 2.4 |
| V2 - District heating | 59.3 | 58.1 | 8.9 | 50% | -0.3 | 23 | 4.5 | 80% | 0.6 |
| V3 - Air heatpump | 20.5 | 41.1 | 5.2 | 40% | 5.1 | 6 | 0.8 | 120% | 5.9 |
| V3 - Brine heatpump | 18.5 | 37.1 | 4.7 | 40% | 5.1 | 2 | 0.2 | 130% | 6 |
| V3 - Bio boiler | 55.1 | 21.2 | 1.4 | 90% | 3.1 | 9.9 | 0 | 100% | 3.4 |
| V3 - Gas boiler | 55.1 | 65.7 | 11.4 | 0 | 1.7 | 30.6 | 7 | 40% | 2.5 |
| V3 - District heating | 52.5 | 52.7 | 8 | 50% | 0.4 | 17.5 | 3.6 | 80% | 1.2 |
| V4 - Air heatpump | 18.4 | 36.8 | 4.6 | 40% | 6.4 | 5.7 | 0.7 | 120% | 7.1 |
| V4 - Brine heatpump | 15.8 | 31.6 | 4 | 40% | 6.3 | 0.5 | 0.1 | 130% | 7.1 |
| V4 - Bio boiler | 45.4 | 19.5 | 1.5 | 90% | 4.2 | 7.9 | 0 | 100% | 4.5 |
| V4 - Gas boiler | 45.4 | 55.2 | 9.5 | 0 | 3.1 | 2.1 | 5.5 | 40% | 3.8 |
| V4 - District heating | 43.3 | 44.7 | 6.8 | 50% | 1 | 13.6 | 2.8 | 80% | 1.7 |
| | | | | | | | | | |
| | <40 | <40 | <4 | >50 | <5 | <40 | <4 | >50 | <5 |
| | 40<x<60 | 40<x<70 | 4<x<7 | 30<x<50 | 5<x<10 | 40<x<70 | 4<x<7 | 30<x<50 | 5<x<10 |
| | >60 | >70 | >7 | <30 | >10 | >70 | >7 | <30 | >10 |

**Table 7: Overview of the results for the office building**

| Variants | final specific demand [kWh/m$^2$/yr] | Without CO$_2$ compensation | | | | With CO$_2$ compensation (by additional PV) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | primary energy demand [kWh/m$^2$/yr] | CO$_2$ emissions [kgCO$_2$/m$^2$/yr] | Renewable share [%] | total additional annualised costs [Euro/m$^2$/yr] | primary energy demand* [kWh/m$^2$/yr] | CO$_2$ emissions [kgCO$_2$/m$^2$/yr] | Renewable share [%] | total additional annualised costs [Euro/m$^2$/yr] |
| V0 - Reference | 109.6 | 165.1 | 24.6 | 20% | 0 | n.a. | n.a. | n.a. | 0 |
| V1 - Air heatpump | 60 | 120.1 | 15.1 | 40% | 8.1 | 69.8 | 8.8 | 80% | 8.1 |
| V1 - Brine heatpump | 58.1 | 116.3 | 14.6 | 40% | 8.2 | 66 | 8.3 | 80% | 8.2 |
| V1 - Bio boiler | 75.7 | 111.3 | 13.4 | 50% | 5.5 | 61 | 7.1 | 90% | 5.5 |
| V1 - Gas boiler | 75.7 | 131.5 | 18 | 20% | 3.6 | 86.6 | 12.3 | 50% | 3.5 |
| V1 - District heating | 33.9 | 125.5 | 16.4 | 40% | 0.3 | 83 | 11.1 | 70% | 0.3 |
| V2 - Air heatpump | 44.4 | 89.2 | 11.2 | 40% | 8.5 | 38.9 | 4.9 | 90% | 8.6 |
| V2 - Brine heatpump | 43.4 | 87.2 | 11 | 40% | 8.9 | 36.9 | 4.6 | 90% | 8.9 |
| V2 - Bio boiler | 53 | 84 | 10.3 | 50% | 6.8 | 33.7 | 3.9 | 100% | 6.8 |
| V2 - Gas boiler | 53 | 95.1 | 12.8 | 30% | 5.6 | 44.8 | 6.4 | 70% | 5.6 |
| V2 - District heating | 27.6 | 91.8 | 11.9 | 40% | 4.4 | 41.5 | 5.6 | 90% | 4.4 |
| V3 - Air heatpump | 41.3 | 82.6 | 10.4 | 40% | 5.6 | 32.3 | 4.1 | 100% | 5.5 |
| V3 - Brine heatpump | 40.4 | 80.9 | 10.2 | 40% | 5.8 | 30.6 | 3.9 | 100% | 5.9 |
| V3 - Bio boiler | 49.1 | 77.9 | 9.5 | 50% | 4.2 | 27.6 | 3.2 | 100% | 4.2 |
| V3 - Gas boiler | 49.1 | 88.1 | 11.8 | 30% | 3.1 | 37.8 | 5.5 | 80% | 3.1 |
| V3 - District heating | 48.5 | 85.1 | 11 | 40% | 2 | 34.8 | 4.7 | 80% | 2 |
| V4 - Air heatpump | 30.4 | 61.1 | 7.7 | 40% | 4.4 | 10.8 | 1.4 | 120% | 4.4 |
| V4 - Brine heatpump | 29.6 | 59.4 | 7.5 | 40% | 4.7 | 9.1 | 1.2 | 120% | 4.7 |
| V4 - Bio boiler | 38.3 | 56.4 | 6.8 | 50% | 3.1 | 6.1 | 0.5 | 120% | 3.1 |
| V4 - Gas boiler | 38.3 | 66.7 | 9.1 | 20% | 2 | 16.4 | 2.8 | 90% | 2 |
| V4 - District heating | 24 | 63.7 | 8.3 | 40% | 0.4 | 13.4 | 2 | 110% | 0.3 |
| V5 - Air heatpump | 25.9 | 51.9 | 6.5 | 40% | 9.3 | 1.6 | 0.2 | 130% | 9.3 |
| V5 - Brine heatpump | 25.1 | 50.3 | 6.3 | 40% | 9.6 | 0 | 0 | 140% | 9.6 |
| V5 - Bio boiler | 33.8 | 47.2 | 5.7 | 60% | 7.7 | 2.3 | 0 | 120% | 7.7 |
| V5 - Gas boiler | 33.8 | 57.5 | 8 | 20% | 8.4 | 7.2 | 1.6 | 100% | 8.3 |
| V5 - District heating | 33.2 | 54.5 | 7.2 | 40% | 5.4 | 4.2 | 0.8 | 120% | 5.5 |
| | <40 | <40 | <4 | >50 | <5 | <40 | <4 | >50 | <5 |
| | 40<x<60 | 40<x<70 | 4<x<7 | 30<x<50 | 5<x<10 | 40<x<70 | 4<x<7 | 30<x<50 | 5<x<10 |
| | >60 | >70 | >7 | <30 | >10 | >70 | >7 | <30 | >10 |

**Important note:** **Important note: compensating the building's $CO_2$ emissions by introducing an additional onsite PV system improves significantly the primary energy demand of the building. However, the PV compensation doesn't necessarily supply the energy demand of the building within the EPBD scope (i.e. energy for heating, cooling, ventilation, domestic hot water and, in case of commercial buildings, for lighting), but the overall energy demand of the building (including the electricity for household appliances). In this case, the PV compensation helps reduce the primary energy demand and associated $CO_2$ emissions towards or below zero in the overall trade-off with the energy grids. Hence, the PV compensation may have a significant contribution to a nearly zero whole energy demand. For simplifying the evaluation methodology in this study only a PV compensation is considered . The PV compensation may be replaced in practice by any other renewable energy system. The amount of the compensation can be reduced by e.g. improved building insulation by improved building geometries or higher system efficiencies. However, PV compensation has a significant direct impact in the case of office buildings where lighting electricity consumption is within the EPBD scope and represents a significant share of the overall energy demand of the buildings.*

On the basis of the economic analysis the three most appropriated solutions for each building type were selected which fulfil entirely the nZEB principles (as defined in the 2011 BPIE study). All solutions are with PV compensation and the variations of the most suitable technologies and facade qualities are considered. Figure 8 presents these suggestions.

**Table 8: Overview of the (cost-) optimal variants and the additional costs in per $m^2$ and in percentage of the full costs**

| Building type | Variant | Brief Description | Heating system | Additional annualized costs (Base year 2010)[9] [€/$m^2$yr] | Additional annualised costs comparing with average reference actual price[10] [%] |
|---|---|---|---|---|---|
| SFH | V3a | Improved building shell + mech. ventilation with heat recovery | Air heat pump | 3.6 | 4.4% |
| | V3c | | Bio Pellet | 9.5 | 11.7% |
| | V4a | Passive house standard | Air heat pump | 5.3 | 6.5% |
| MFH | V1c | Improved building shell | Bio Pellet | 1.8 | 2.8% |
| | V2c | Mech. ventilation with heat recovery | Bio Pellet | 3.5 | 5.5% |
| | V4b | Improved building shell + mech. ventilation with heat recovery + solar collectors | Brine heat pump | 7.1 | 11.2% |
| OFFICE | V4c | Mech. ventilation with heat recovery + Improved building shell + external shading reduced window share + automatic lighting control | Bio Pellet | 3.1 | 5.0% |
| | V4e | | District heat | 0.3 | 0.5% |
| | V5c | Mech. ventilation with heat recovery + improved building shell + external shading + reduced window share + automatic lighting control + improved cooling: efficient high temperature concrete activation | Bio Pellet | 7.7 | 12.3% |

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[9] The cost are annualized over 30 yrs which is widely accepted to be the usual period of time until a new building should be renovated. For financial analysis it is considered the actual interest rate on the Romanian market, i.e. 8%.

[10] The percentage of the additional annualised costs was based on the following assumptions: turnkey costs for SFH: 900 Euro/mp, MFH: 725 Euro/mp and office: 550 Euro/mp. Data are provided in a private communication with ARACO-Romanian Association of Construction Entrepreneurs (2011). The lifetime of residential buildings were assumed to be 50 years for residential building and 30 years for offices.

In the residential sector in Romania, the selected cost-optimal nZEB solutions have additional annualized costs of new buildings by between 2.8 to 11.7% higher than actual market prices for a new building in this category. This cost increase is dependent on building shell, heating system and type of building. For offices, the additional annualized costs are by 0.5 to 12.3% higher than actual market prices for a new building in this category.

District heating solutions for multi-family houses exceeded the $CO_2$ emission target of 3 $kgCO_2/m^2$/yr in situations where the renewable energy share of future district heating was not well above 50%, as was assumed in this evaluation.  For most of the solutions examined this renewable energy share is not sufficient to bring $CO_2$ emissions down to or below the required 3 $kgCO_2/m^2$/yr. The reason for this is the low efficiency of the district heating systems (assumed here to be 40%) and the insufficient share of renewable energies.

According to a recent study on Romanian district heating systems[11] it seems that there are some good practices for green district heating (DH), and it appears to be a good economic option. DH in Romania with a high share of renewable energy may be a key issue for the heating strategy in Romania and work perfectly in the context of increasing the energy performance of buildings (including the nZEB).

As suggested in the Principles for nZEB study[12], the district heating (DH) systems strategy has to be developed in close relationship with buildings policies (to better identify future needs, to shape the economic instruments for reaching sustainability sector etc.). Also the office buildings should continue to be included in the DH networks as an additional nZEB solution because they are more flexible in changing the energy carriers.

Based on the above analysis, on the simulation results shown in tables 5-7 and taking mainly into consideration the additional costs and results for basic variants without PV compensation, the following levels are proposed for consideration as nZEB definitions for Romania (Table 9).

**Table 9: Proposed nZEB definitions for Romania**

| Building type | Minimum requirements | Year | | |
|---|---|---|---|---|
| | | 2016[13] | 2019 | 2020 |
| **Single family buildings** | Primary energy [kWh/m2/yr] | 100 | | 30-50 |
| | Renewable share [%] | >20 | | >40 |
| | $CO_2$ emissions [$kgCO_2$/m2/yr] | <10 | | <3-7 |
| **Multi-family buildings** | Primary energy [kWh/m2/yr] | 70 | | 30-50 |
| | Renewable share [%] | >20 | | >40 |
| | $CO_2$ emissions [$kgCO_2$/m2/yr] | <10 | | <3-7 |
| **Office buildings** | Primary energy [kWh/m2/yr] | 100 | | 40-60 |
| | Renewable share [%] | >20 | | >40 |
| | $CO_2$ emissions [$kgCO_2$/m2/yr] | <13 | | <5-8 |
| **Public office buildings** | Primary energy [kWh/m2/yr] | 100 | 40-60 | |
| | Renewable share [%] | >20 | >50 | |
| | $CO_2$ emissions [$kgCO_2$/m2/yr] | <13 | <5 | |

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[11] PWC (2011). Challenges and opportunities for the district heating system in Romania. Available: http://www.pwc.com/ro/en/publications/assets/assets_2011/Provocari_Oportunitati_Energie_Termica.pdf. PWC, Bucharest, Romania.

[12] BPIE (2011b). Principles for nearly Zero-Energy Buildings - Paving the way for effective implementation of policy requirements. Buildings Performance Institute Europe (BPIE). Available at: http://www.bpie.eu.

[13] According to the EPBD, Article 9, paragraph 3b, the EU MSs have to provide , intermediate targets for improving the energy performance of new buildings, by 2015, with a view to preparing the implementation of' nearly zero-energy buildings.

The thresholds suggested above for an nZEB definition in Romania are fairly ambitious yet affordable as several options evaluated in this study have additional specific annualised costs below 5 Euro/m$^2$/yr.

However, these thresholds are significantly less ambitious than in other Western Europe countries which aim to reach climate neutral, fossil fuel free or even energy positive new buildings[14] by 2020. Thinking long term, it should be ensured that the building concept can be improved towards specific $CO_2$ emissions below 3 kg$CO_2$/m$^2$yr (and aiming at: 0 kg/m$^2$yr), which is the identified EU average minimum requirement for achieving the EU 2050 decarbonisation goals.

Therefore, the nZEB definition should still be gradually improved after 2020 and it is likely to lead by 2030 to energy and climate neutral levels. Beyond implementing an EU Directive requirement, the significant reduction in energy consumption and related $CO_2$ emissions of the building sector will have a major impact on the country's energy supply security, by creating new activities and jobs and by contributing to a better quality of life for Romanian citizens:

It is important to highlight the fact that the financial and energy analysis are based on very conservative assumptions, using the actual interest rates and technology prices and according to the actual practices in construction. For instance, it is a significant optimisation potential of the buildings' geometries towards those recommended by passive houses design which will lead to additional costs reductions. Moreover, by implementing ambitious nZEB requirements in the Romanian building codes will generate a wider market deployment of the energy efficient and renewable tehcnology which will consequently reduce their prices and will overall generate lower costs for nZEB.

In addition, the financial evaluation of the nZEB solutions considered the actual interest rate on Romanian market, i.e. 8%/yr. However, according to the estimated economic evolution, the interest rates are likely to decrease consistently by 2020 when the nZEB requirement have to become legally binding. Additional support policies may also consider a potential subsidy of the interest rate in order to ease the transition to nZEB and to make them competitive with buildings at today's standards. Overall, a reduction of the interest rate may impact positively in the financial analysis and may even make nZEB investments profitable over a given period of time, as is the case in other EU countries already having better conditions.

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[14] For more details on other EU countries strategies for implementing nZEB by 2020, please see table 3 from BPIE (2011). Principles for nearly zero-energy buildings - Paving the way for effective implementation of policy requirements. Available at www.bpie.eu

# 5. DIRECT AND INDIRECT BENEFITS OF IDENTIFIED nZEB SOLUTIONS

This chapter presents the direct and indirect benefits of implementing nZEBs. Overall, the payback from investing in better buildings occurs over time. It contributes substantially to energy security, environmental protection, the social inclusion of people by creating or preserving jobs and offering a better quality of life, as well as supporting the sustainable development of the construction sector and supply chain industry. While the upfront investment is relatively high and the return on investment is usually longer than for other economic activities, there are multiple benefits for building users and owners, the construction industry, public budget and society as a whole.

The benefits of the implementation of nZEBs are much wider than simply leading to energy and $CO_2$ savings . They can be summarised as follows:

- The quality of life in a nearly Zero-Energy Building is better than in a building constructed according to the current practice. Cost-saving possibilities arising from the appropriate design of the building and high quality construction almost entirely cover the additional costs of the energy-efficient building envelope. The quality of life is greater through better (thermal) comfort. The nearly Zero-Energy Building provides good indoor air quality. Fresh filtered air is continuously delivered by the ventilation system. It is more independent of outdoor conditions (climate, air pollution etc.). The thick and well-insulated structures provide effective sound insulation and noise protection.
- Ambient benefits arise through reduced energy demand that reduces wider environmental impacts of energy extraction, production and supply.
- There are environmental benefits from improved local air quality.
- Social benefits arise through the alleviation of fuel poverty.
- Health benefits are possible through improved indoor air quality and reduced risks of cold homes, particularly for those on low-incomes or for elderly householders.
- Macro-economic benefits arise through the promotion of innovative technologies and creating market opportunities for new or more efficient technologies and through the provision of certain incentives for pilot projects and market transformation.
- Private economic benefits: higher investment costs may be outweighed by the energy savings over the lifetime of the building (the building offers less sensitivity to energy prices and to political disturbances). When a building is sold, the high standard can be rewarded through a re-sale price up to 30% higher in comparison with standard buildings.
- Job creation can arise through the manufacturing and installation of energy efficiency measures and of renewable energy technologies.
- There will be decreased energy dependence on fossil fuels and therefore on the future energy prices[15].

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[15] Paroc (2012). Web page: Benefits of passive house. Available at: http://www.energiaviisastalo.fi/energywise/en/index.php?cat=Benefits+of+Passive+House

In this study, the approach to quantifying some of the benefits is done in an approximate way by extrapolating results from the reference buildings to the national level, e.g. (average energy and CO2 savings per $m^2$) x ($m^2$ built new per year) x 30 years (2020-2050). Therefore, in Table 10 we present the estimated macro-economic impact by 2050 in terms of additional investments, additional new jobs, CO2 and energy savings.

However, this is a conservative approach without considering additional important factors that may positively influence the macro-economic benefits. As an example, the job creation impact is based on the job intensity of construction industry and reflects only the additional work places that may be created at the execution level and doesn't include the jobs in the supply chain industry induced by upscaling the market and the indirect jobs in the administration of the processes (e.g. additional auditors and control bodies for new tech). Moreover, by moving towards very efficient buildings and increasing the need for new technology will impact mainly on new job profiles such as renewable systems and heat pumps installers. Therefore, it will be an increase need for these new activities all over the country and driven not only by additional invested volumes as we considered in this study but also by the local needs for such new job profiles[16]. Consequently, it is very likely to have a much higher job creation potential than estimated in this study.

**Table 10: Effect of the implementation of nZEB after 2020 in 2050**

| Indicator | Effect |
|---|---|
| $CO_2$ emissions savings in 2050 | 6.8 million t $CO_2$ |
| Cumulative energy savings in 2050 | 40 TWh |
| Additional annual investments | 82-130 million euro |
| Additional new jobs[17] | 1 390-2 203 full-time employees |

Table 11 shows a detailed overview of the possible contribution of each variant in the residential and the non-residential sector.

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[16] As an example, additional investments in a very well established construction sector already having all necessary job profiles and spread all over the considered country or region, then the job impact is determined with a fair approximation by using the job intensity of the sector. However, if the additional invested capital suppose to expand new qualifications as is the case for nZEB, it is necessary to create all over the given country or region a critical mass of specialists for these new qualifications able to provide the requested services. In this case, the job creation potential is much higher than in the first case (even few times higher).

[17] This is the estimated job effect in the construction sector only and without considering the additional impact on the supply chain industry and other related sectors. It was considered that every 1 million euro invested would generate around 17 new jobs, as identified in several previous studies such as BPIE (2011) Europe's buildings under the microscope.

**Table 11: Effect of the implementation of nZEB after 2020 in 2050**

| Indicator | Residential sector | | | | | | Non residential sector | | |
|---|---|---|---|---|---|---|---|---|---|
| | SFH | | | MFH | | | | | |
| | V3a | V4a | V3c | V1c | V2c | V4b | V4c | V4e | V5c |
| **Annual $CO_2$ emissions savings [$kgCO_2/m^2yr$]** | 32.8 | 32.8 | 32.8 | 16.4 | 16.4 | 16.4 | 24.6 | 23.1 | 24.6 |
| **$CO_2$ emissions savings in 2050 [Mio t $CO_2$]** | 4.34 | 4.34 | 4.34 | 1.18 | 1.18 | 1.18 | 1.37 | 1.29 | 1.37 |
| **Annual energy savings [$kWh/m^2yr$]** | 181 | 181 | 181 | 91 | 91 | 91 | 165 | 165 | 165 |
| **Cumulative energy savings in 2050 [TWh]** | 23.9 | 23.9 | 23.9 | 6.6 | 6.6 | 6.6 | 9 | 9 | 9 |
| **Additional annualized investment costs per $m^2$ [€/$m^2$yr]** | 11.9 | 13.6 | 14.8 | 2.2 | 4.1 | 11.2 | 14.6 | 12.9 | 20.1 |
| **Annual additional investments [Mio €]** | 53 | 60 | 65 | 5 | 10 | 27 | 27 | 24 | 37 |
| **Job effects [no of new jobs]** | 893 | 1,023 | 1,111 | 88 | 165 | 457 | 461 | 409 | 635 |

# 6. A 2020 ROADMAP FOR IMPLEMENTING nZEBs IN ROMANIA AND POLICY RECOMMENDATIONS

Based on the analysis of the country situation as well as on the results of the previous study for defining the nZEB principles and on related studies, some key recommendations emerge that should be considered when designing an nZEB implementation roadmap:

1. Different instruments should be part of a wider holistic policy package which should comprise regulatory, facilitation and communication aspects. The German investment bank KfW is a good example of a strong communication policy that managed to raise awareness among the building owners to such an extent that the financial products and mechanisms for buildings are well known terms and are used by the commercial banks and construction companies to advertise their offers. Therefore implementing targeted communication campaigns is recommended because it is seen as key to a scheme's success.
2. Clear communication is indispensable since it provides information to consumers and market players about incentives and energy efficiency measures available to them. In addition, wide public consultation with relevant stakeholders is necessary at all implementation stages of buildings policy.
3. Impact assessment (ex-ante, interim and ex-post) of the planned policies together with a simple but effective monitoring and control mechanism are important in order to have a clear image of the necessary measures to be implemented, risks, challenges and benefits.
4. Higher energy performance of buildings should be rewarded by better financial support, i.e. higher grants or lower interest for dedicated loans. This is again another best practice from other countries, including the above mentioned KfW example.
5. Policy-makers should concentrate long-term programmes so as to provide stable frameworks and facilitate the long-term planning of all stakeholders.
6. The buildings strategies should be in line with the complementary energy and climate strategies at national and EU level to ensure that other important policy objectives are not harmed.
7. Within individual Member States, different instruments need to be coordinated with each other to ensure success. One example is the Carbon Emissions Reduction Target (CERT) in the UK which is closely coordinated with other instruments[18]. The overlapping of financial support instruments should be avoided so as to offer clear, simple and coherent market instruments.

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[18] EuroACE (2010). Making money work for buildings: Financial and fiscal instruments for energy efficiency in buildings. Available at: http://www.euroace.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=133&PortalId=0&TabId=84

## 6.1. PROPOSAL FOR AN NZEB ROADMAP FOR ROMANIA

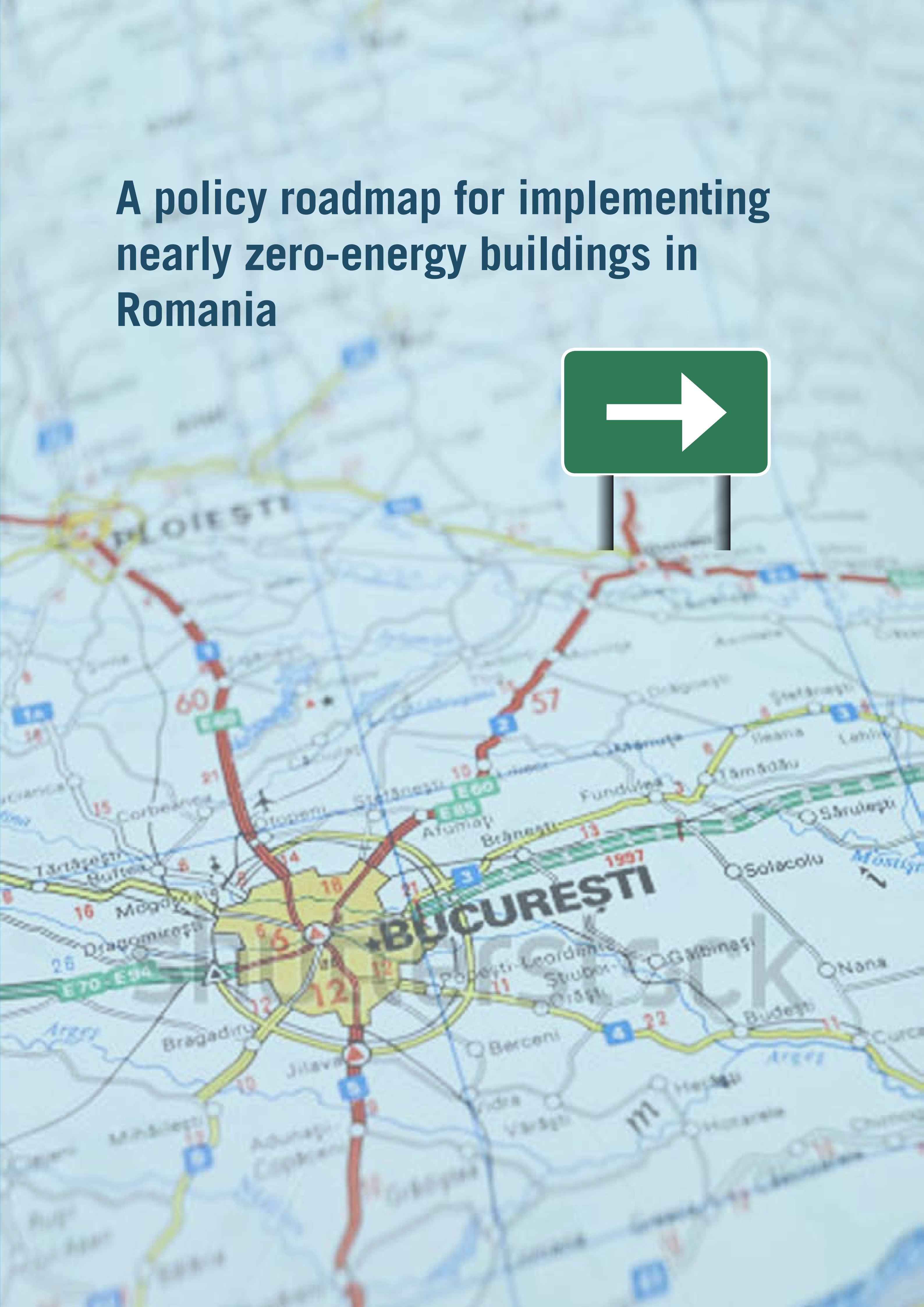
We demonstrate in this report that the additional financial efforts involved in moving towards nearly Zero-Energy Buildings are manageable with appropriate policy measures. By improving the thermal insulation of new buildings and by increasing the share of renewable energy use in a building's energy consumption, the implementation of nearly Zero-Energy Buildings in Romania can generate macro-economic and social benefits.

There are multiple benefits for both society and the business environment. But to ensure a cost-effective and sustainable market transformation, to develop appropriate policies and to increase institutional capacities, concerted action is needed. It is vitally important to start preparing today an implementation roadmap based on a major public consultation of all relevant stakeholders and linked to a continuous information campaign. Elaborating a policy roadmap and announcing the future measures in a timely way will provide the business sector and the market with the necessary predictability to adapt their practices to the upcoming requirements.

To support these national efforts, this study proposes a 2020 roadmap for nZEB implementation (see the nZEB Roadmap attached at the end of the study) which takes into account the required improvements at the level of policy, building codes, capacity building, energy certification, workforce skills, public information and research.

To have a coherent and sustainable transition, all proposed measures are to be implemented in parallel. They are interlinked and ensure an overall consistency in the proposed implementation package, while trying to preserve a balance between increase requirements and support policies. Half measures make any market transformation process longer and ineffective, putting at the same time additional burdens on society and economy.

# A policy roadmap for implementing nearly zero-energy buildings in Romania



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