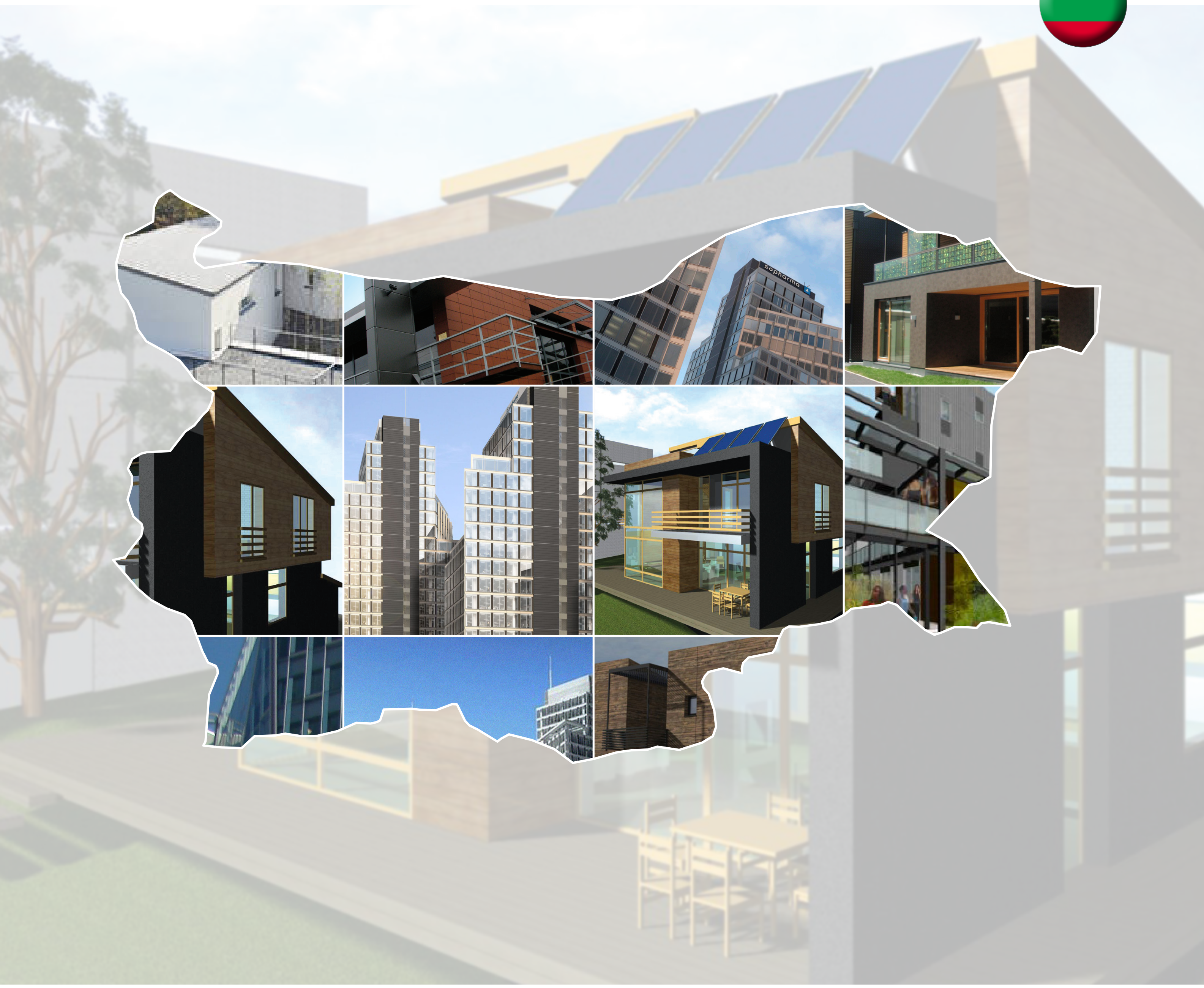
IMPLEMENTING NEARLY ZERO-ENERGY BUILDINGS (nZEB) IN BULGARIA –
TOWARDS A DEFINITION AND ROADMAP

EXECUTIVE SUMMARY



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The Building Performance Institute Europe (BPIE) is an independent not-for-profit organisation dedicated to improving the energy performance of buildings across Europe, and thereby helping to reduce CO_2 emissions from the energy used by European buildings. Our main focus lays on policy analysis, implementation and dissemination of knowledge through studies, policy briefs and best practices.

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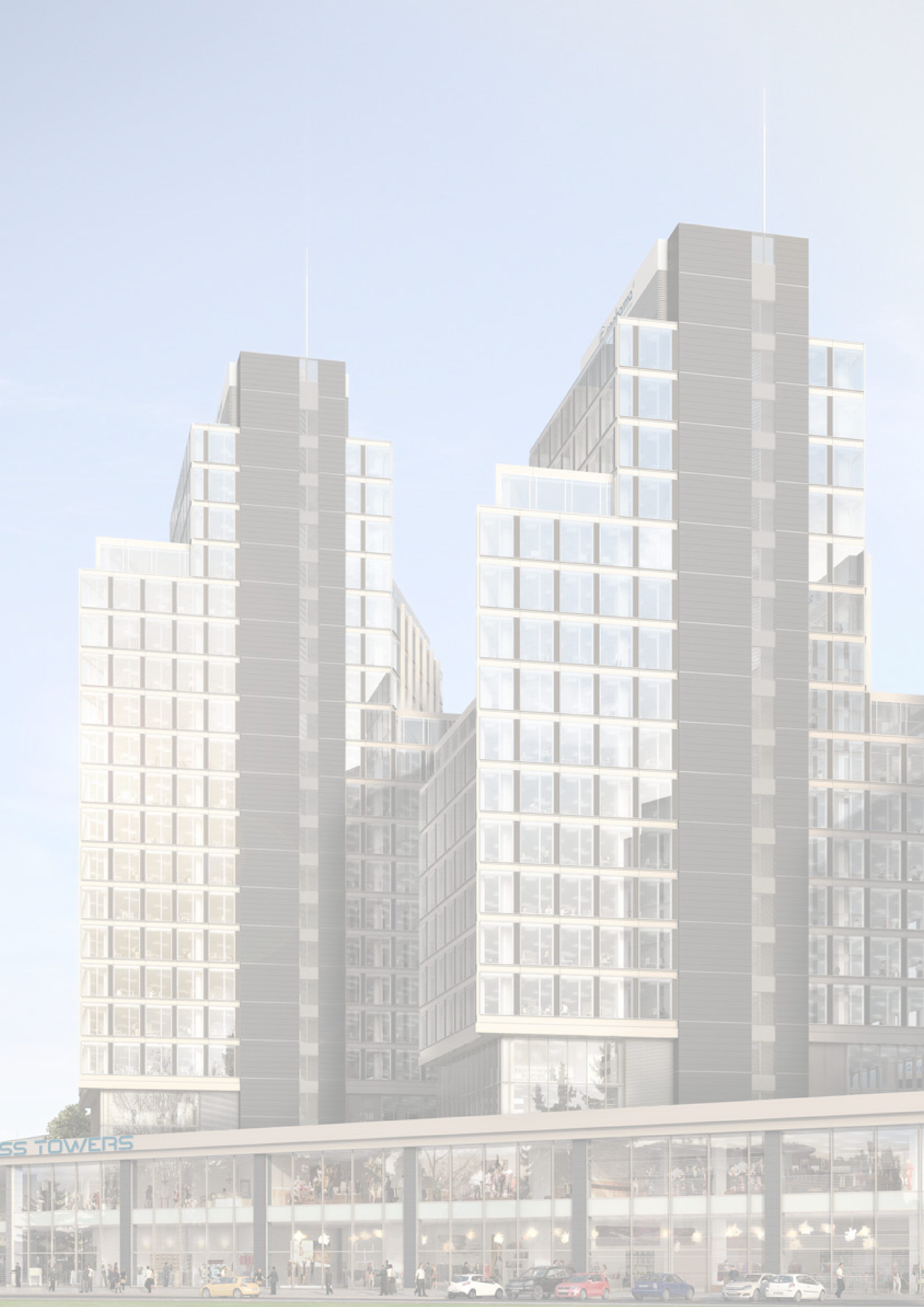
SS TOWERS

1. SETTING THE STAGE

The building stock is responsible for a large share of the 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 2050 building stock still to be built, a large volume 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 it essential to find and agree on an EU-wide definition or guidelines for "nearly Zero-Energy Buildings" (nZEB) 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 draw up 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 or on how to define and realise this type of building. Therefore, a clear definition that can be taken into account by EU Member States for elaborating effective, practical and well thought-out nZEBs needs to be formulated.

The aim of this study is to actively support this process in Bulgaria 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" and evaluates through indicative simulations whether these principles hold true for the situation in Bulgaria.

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 Bulgaria.

The project started with an in-depth survey of the Bulgarian building stock, construction practices, market prices for materials and equipment, existing legislation and support measures. We defined and evaluated new reference buildings (current 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 almost 90% of the residential building stock in Bulgaria and around 97% of the net floor area in the residential sector. Office buildings represent around 27% of the non-residential building stock and almost 39% of the non-residential floor area.

Altogether, these three building types account for around 89% of the Bulgarian building stock and around 85% of the overall net floor area of the Bulgarian buildings. Therefore, we consider single family, multi-family and office buildings as being representative for the building stock and consequently we selected them for the nZEB analysis.

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 industry/technology development were also considered.

The final chapter presents key policy recommendations and an indicative roadmap for the implementation of nZEBs in Bulgaria. This report was conceptualised, coordinated and finalised by BPIE. The overall data aggregation and selection, simulations and analysis were executed by Ecofys Germany as lead consultant. The provision of data concerning Bulgarian buildings, policies and market prices, the definition and selection of reference buildings and the revision of the final study were made by EnEffect as the national consultant.

The building simulations were undertaken with the TRNSYS[1] software tool. The economic analysis was performed by using the Ecofys analytical tool Built Environment Analysis Model (BEAM2)[2] .

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[1] 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/

[2] Further information on BEAM2 model available at: 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 Bulgaria, 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 Bulgaria:

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 Bulgaria (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 minimising transition costs.

The SFH is by far the dominant building type in Bulgaria and within this category the detached SFH has the highest share in the residential sector (55% of net floor area). The second largest amount of floor space was indicated for urban MFH (i.e. 42% of the net floor area in residential sector). In the non-residential buildings sector, office buildings are the dominant building type, followed by educational, retail and healthcare 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.

Public administration buildings, included in the office buildings category, receive particular attention from the EPBD which 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 Bulgaria

Parameter	Reference SFH	Reference MFH	Reference Office
Number of conditioned floors	2	6	3
Net floor area	127 m^2	2870 m^2	886 m^2
Room height	2.65 m	2.73 m	3.00 m
U-walls	0.34 W/(m^2K)	0.64 W/(m^2K)	0.46 W/(m^2K)
U-roof	0.27 W/(m^2K)	0.30 W/(m^2K)	0.32 W/(m^2K)
U-floor	0.55 W/(m^2K)	0.55 W/(m^2K)	0.46 W/(m^2K)
U-windows, frame fraction	1.70 W/(m^2K); 21%	1.70 W/(m^2K), 15%	1.70 W/(m^2K), 15%
Window fraction (window/wall-ratio)	13% (only 5% on North and West facades)	23%	50%
Shading	None	None	Internal blinds, manual control
Air tightness	Moderate	Moderate	Moderate
Thermal bridges	Yes	Yes, significant thermal bridges considered	Yes
Heating system	Wood boiler (set point: 20°C) Heating efficiency: 0.82	District Heating (set point: 20°C) Heating efficiency: 0.99	Heat pump, fan coils (set point: 20°C) Heating efficiency: 3.3
DHW system	Combination of wood boiler and electric heater DHW efficiency: 0.93 (40% Wood = 0.82 60% electric heater = 1.00)	Same as for heating DHW efficiency: 0.99	Decentralised direct electric
Specific DHW demand	15.8 kWh/(m^2a)	20.4 kWh/(m^2a)	0.8 kWh/m^2a
Ventilation system	Natural/window ventilation (0.35 1/h)	Natural/window ventilation (0.5 1/h)	Mechanical ventilation 70% heat recovery Ventilation rates (6:00-18:00): Office spaces: 1.36 1/h Conference rooms: 2.72 1/h Other rooms: 0.46 1/h
Cooling system	Split system (set point: 26°C) SEER: 3.2	None	Compression chillers, fan coils (set point: 24°C) SEER: 3.3
Internal gains[3]	13.5 W/m^2	20 W/m^2	30 W/m^2
Installed lighting power[4]	11.7 W/m^2	10 W/m^2	25 W/m^2
Automatic lighting control	No	No	Only in service area
Person density in office areas (considered as an additional internal load)	-	-	0 am – 8 am and 6 pm - 0 am: no persons 8 am – 12 am and 2 pm – 6 pm: 1 person/15 m^2 12 am – 2 pm: 1person/30 m^2

[3] This value is to be understood as a maximum value. For persons, lighting and other internal gains schedules exist taking into consideration for example the number of persons who are at a certain moment in the respective zone.

[4] This value is to be understood as a maximum value. For the hourly demand individual schedules for every zone have been considered.

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 though it is far from optimum for an nZEB. Table 2 shows the solutions, which have been examined by dynamic thermal simulations.

Table 2: Bulgarian SFH, nZEB variants

Variants	U-value Opaque Shell[5]	U-Value Window	Heat Recovery Rate	Solar Collector for DHW	Brief Description
V0	U-Wall: 0.34 $W/m^2.K$ U-Roof: 0.27 $W/m^2.K$ U-Floor: 0.55 $W/m^2.K$	1.7 $W/m^2.K$	0%	No	Reference
V1	U-Wall: 0.12 $W/m^2.K$ U-Roof: 0.10 $W/m^2.K$ U-Floor: 0.20 $W/m^2.K$	1.0 $W/m^2.K$	0%	No	improved building shell
V2	U-Wall: 0.12 $W/m^2.K$ U-Roof: 0.10 $W/m^2.K$ U-Floor: 0.20 $W/m^2.K$	1.0 $W/m^2.K$	0%	Yes	improved building shell + solar collectors
V3	U-Wall: 0.12 $W/m^2.K$ U-Roof: 0.10 $W/m^2.K$ U-Floor: 0.20 $W/m^2.K$	1.0 $W/m^2.K$	80%	No	improved building shell + mech. ventilation with heat recovery
V4	U-Wall: 0.10 $W/m^2.K$ U-Roof: 0.09 $W/m^2.K$ U-Floor: 0.20 $W/m^2.K$	0.80 $W/m^2.K$	92%	No	Nearly passive house standard[6]
V5	U-Wall: 0.10 $W/m^2.K$ U-Roof: 0.09 $W/m^2.K$ U-Floor: 0.20 $W/m^2.K$	0.80 $W/m^2.K$	92%	Yes	Nearly passive house standard + solar collectors

The comparison between variants V1, V2 and V3 will show the individual impacts of a shell improvement, solar thermal collectors and mechanical ventilation with heat recovery. It should be mentioned that an airtight construction without controlled ventilation increases the risk of mould foundation. It is, therefore, strongly recommended to develop an adequate ventilation concept.
For each of the five base variants, the following four heating supply options will be considered:

1. Air source heat pump[7]
2. Ground collector brine heat pump[8]
3. Wood pellet boiler
4. Gas condensing boiler

[5] Heat bridges have been included in the calculation of the U-values.
[6] Passive house standard: major shell improvements, no heat bridges, airtight construction, highly efficient mechanical ventilation (> 90%), useful heating and cooling demand < 15 kWh/m^2yr
[7] Solutions will be considered to have a low temperature floor heating system to get a better system efficiency
[8] cf. previous footnote

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

As for the SFH, the geometry of the reference buildings has not been changed, even though it is not optimum for an nZEB. Table 3 shows the variants simulated with TRNSYS.

Table 3: Bulgarian MFH, nZEB variants

Variants	U-value Opaque Shell[9]	U-Value Window	Heat Recovery Rate	Solar Collector for DHW	Brief Description
VO	U-Wall: 0.64 W/m².K U-Roof: 0.30 W/m².K U-Floor: 0.55 W/m².K	1.7 W/m².K	0%	No	Reference
V1	U-Wall: 0.45 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.32 W/m².K	1.0 W/m².K	0%	No	Improved building shell
V2	U-Wall: 0.64 W/m².K U-Roof: 0.30 W/m².K U-Floor: 0.55 W/m².K	1.7 W/m².K	85%	No	Mech. ventilation with heat recovery
V3	U-Wall: 0.45 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.32 W/m².K	1.0 W/m².K	85%	No	Improved building shell + mech. ventilation with heat recovery
V4	U-Wall: 0.45 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.32 W/m².K	1.0 W/m².K	85%	Yes	Improved building shell + mech. ventilation with heat recovery + solar collectors

Variant V1 was created to examine the individual impact of a shell improvement. It should be mentioned that an airtight construction without controlled ventilation increases the risk of mould foundation. It is, therefore, strongly recommended to develop an adequate ventilation concept.

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

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

[9] Heat bridges have been included in the calculation of the U-values.

3.1.3. nZEB solutions for office buildings

As for the other reference buildings, the geometry of the reference buildings has not been changed, even though it is not optimum for an nZEB. Table 4 shows the variants simulated with TRNSYS.

Table 4: Bulgarian office building, nZEB variants

Variants	U-value Opaque Shell[10]	U-Value Window	Heat Recovery Rate	External shading	Light system	Solar Collector for DHW	Brief Description
VO	U-Wall: 0.46 $W/m^2.K$ U-Roof: 0.32 $W/m^2.K$ U-Floor: 0.46 $W/m^2.K$	1.7 $W/m^2.K$, 50% windows share	70%	None	Manual control	No	Reference
V1	U-Wall: 0.30 $W/m^2.K$ U-Roof: 0.25 $W/m^2.K$ U-Floor: 0.40 $W/m^2.K$	1.7 $W/m^2.K$, 50% windows share	70%	Automatic	Manual control	No	Improved building shell + external shading
V2	U-Wall: 0.30 $W/m^2.K$ U-Roof: 0.25 $W/m^2.K$ U-Floor: 0.40 $W/m^2.K$	1.7 $W/m^2.K$, 50% windows share	70%	Automatic	Automatic controlled lighting +LEDs	No	Improved building shell + external shading + improved lighting
V3	U-Wall: 0.30 $W/m^2.K$ U-Roof: 0.25 $W/m^2.K$ U-Floor: 0.40 $W/m^2.K$	1.0 $W/m^2.K$, 50% windows share	85%	Automatic	Automatic controlled lighting +LEDs	No	Improved building shell + external shading + improved lighting + improved windows + improved heat recovery

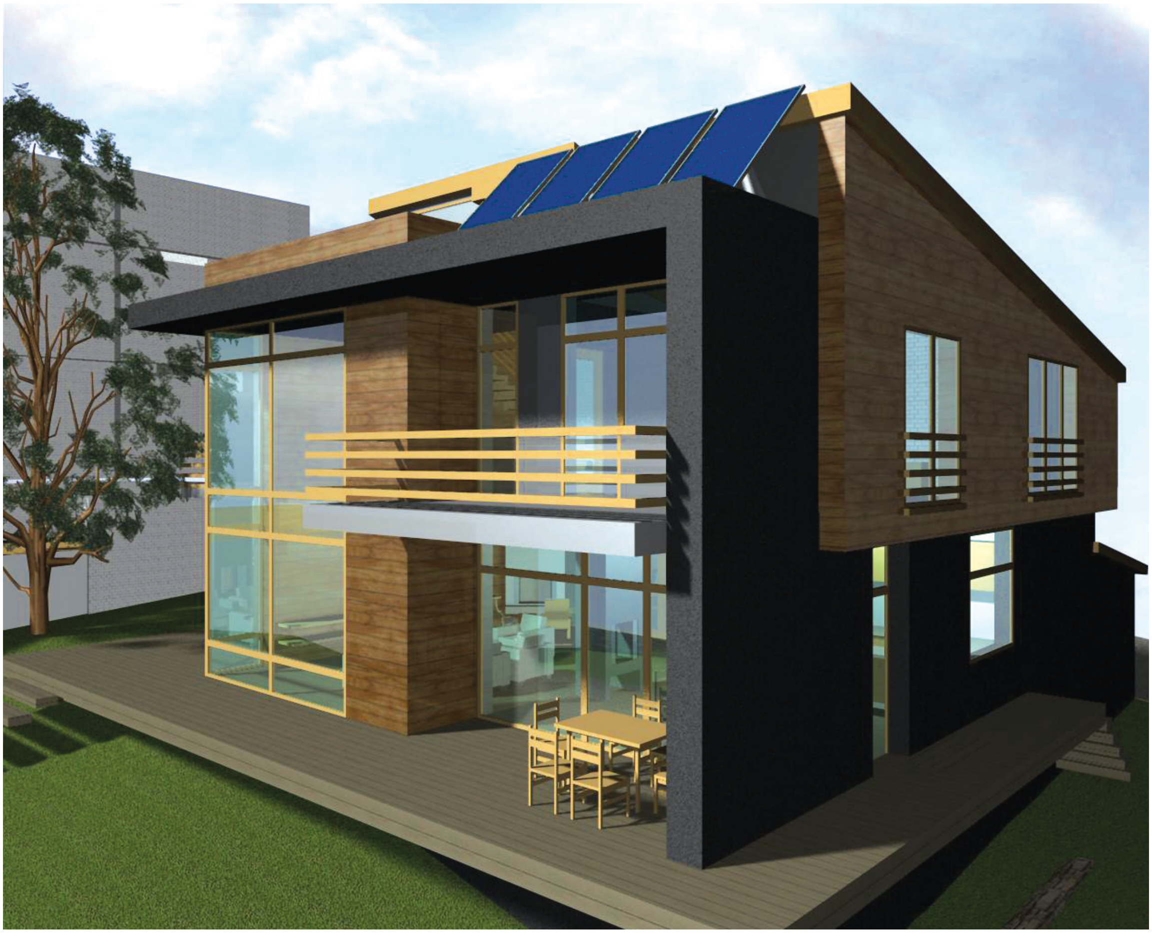
For each of the three base variants, the following five heating options have been considered:

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

[10] Heat bridges have been included in the calculation of the U-values.

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[11].



[11] 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/m²/yr]	CO_2 emissions [$kgCO_2/m^2/yr$]	Renewable share [%]	Total additional annualised costs [Euro/m²/yr]	Primary energy demand* [kWh/m2/yr]	CO_2 emissions [$kgCO_2/m^2/yr$]	Renewable share [%]	Total additional annualised costs [Euro/m²/yr]
V0 - Reference	169.9	86.4	45.1	90%	0	n.a	n.a.	n.a.	0
V1 - Air heat pump	25.5	51.1	6.4	35%	-11.23	0	0	135%	-7.73
V1 - Brine heat pump	21.2	42.5	5.4	35%	-6.37	0	0	135%	-3.46
V1 - Bio boiler	91	21.9	0.5	99%	-4.28	11.6	0	104%	-3.57
V1 - Gas boiler	91	102	18.5	1%	-5.58	36.4	10.2	37%	-1.07
V2 - Air heat pump	19.4	39	4.9	35%	-9.78	0	0	135%	-7.11
V2 - Brine heat pump	15	29.9	3.8	35%	-4.95	0	0	135%	-2.9
V2 - Bio boiler	71	16.6	0.3	99%	-3.93	6.3	0	106%	-3.22
V2 - Gas boiler	71	79.4	14.4	1%	-5.23	26.1	7.7	38%	-1.57
V3 - Air heat pump	20.8	41.8	5.3	35%	-8.78	0	0	135%	-5.92
V3 - Brine heat pump	18.1	36.4	4.6	35%	-5.69	0	0	135%	-3.2
V3 - Bio boiler	72.1	18.8	0.6	98%	-2.96	8.5	0	105%	-2.26
V3 - Gas boiler	72.1	81.6	14.7	1%	-4.27	15.9	6.4	47%	0.23
V4 - Air heat pump	15.6	31	3.9	35%	-7.12	0	0	135%	-4.99
V4 - Brine heat pump	13.5	27.1	3.4	35%	-4.85	0	0	135%	-2.99
V4 - Bio boiler	49.4	13.2	0.5	98%	-2.75	2.9	0	108%	-2.04
V4 - Gas boiler	49.4	55.9	10.1	1%	-3.51	-9.7	1.8	68%	1
	<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/m²/yr]	Without CO_2 compensation				With CO_2 compensation (by additional PV)			
		Primary energy demand [kWh/m²/yr]	CO_2 emissions [kgCO_2/m²/yr]	Renewable share [%]	Total additional annualised costs [Euro/m²/yr]	Primary energy demand* [kWh/m²/yr]	CO_2 emissions [kgCO_2/m²/yr]	Renewable share [%]	Total additional annualised costs [Euro/m²/yr]
V0 - Reference	87.1	11.9	59.5	0%	0%	n.a	n.a.	n.a.	0
V1 - Air heat pump	22.5	45.1	5.7	35%	-3.45	13	1.6	106%	-2.49
V1 - Brine heat pump	19.1	38.4	4.8	35%	0.1	6.3	0.8	119%	1.06
V1 - Bio boiler	78.5	18.1	0.3	99%	0.48	15.5	0	101%	0.53
V1 - Gas boiler	80.6	89.9	16.4	1%	-0.16	57.8	12.3	20%	0.8
V1 - District heating	71.5	45.5	7.8	54%	-0.63	13.4	3.8	76%	0.33
V2 - Air heat pump	21.4	43	5.4	35%	-1.09	10.9	1.4	110%	-0.14
V2 - Brine heat pump	18.9	37.8	4.8	35%	1.99	5.8	0.7	120%	2.95
V2 - Bio boiler	66.6	19.9	0.9	96%	1.9	12.6	0	102%	2.06
V2 - Gas boiler	60.9	70.3	12.5	2%	0.72	38.3	8.5	28%	1.68
V2 - District heating	60.9	42.2	7	53%	0.69	10.2	3	79%	1.64
V3 - Air heat pump	18.9	37.9	4.8	35%	-0.72	5.8	0.7	120%	0.24
V3 - Brine heat pump	16.8	33.7	4.2	35%	1.25	1.7	0.2	130%	2.21
V3 - Bio boiler	56	17.4	0.9	96%	1.83	10.5	0	102%	1.98
V3 - Gas boiler	51.2	59.5	10.5	2%	0.77	27.5	6.5	34%	1.73
V3 - District heating	51.2	36.1	6	53%	0.96	4	2	84%	1.91
V4 - Air heat pump	16.8	33.5	4.2	35%	-0.07	5,1	0.6	120%	0.78
V4 - Brine heat pump	14.1	28.3	3.6	35%	1.83	0	0	135%	2.67
V4 - Bio boiler	46.3	15.8	0.9	95%	1.86	8,5	0	103%	2.01
V4 - Gas boiler	42.4	49.9	8.8	3%	0.79	21,5	5.2	36%	1.64
V4 - District heating	42.4	30.9	5.1	52%	0.93	2,5	1.5	86%	1.78

	<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/m²/yr]	Without CO_2 compensation				With CO_2 compensation (by additional PV)			
		Primary energy demand [kWh/m²/yr]	CO_2 emissions [kgCO_2/m²/yr]	Renewable share [%]	Total additional annualised costs [Euro/m²/yr]	Primary energy demand* [kWh/m²/yr]	CO_2 emissions [kgCO_2/m²/yr]	Renewable share [%]	Total additional annualised costs [Euro/m²/yr]
V0 - Reference	68.7	209.2	55.3	13%	0	n.a	n.a.	n.a.	0
V1 - Air heat pump	63.9	127.8	16.1	35%	4.91	70.5	8.9	80%	6.16
V1 - Brine heat pump	58.2	116.4	14.7	35%	10.58	59.1	7.4	84%	11.83
V1 - Bio boiler	88.3	116.5	13.8	60%	9.98	59.2	6.6	92%	11.24
V1 - Gas boiler	88.3	146.6	20.6	22%	7.28	89.3	13.4	54%	8.53
V1 - District heating	86.6	129.2	17.2	42%	5.98	71.8	10	75%	7.23
V2 - Air heat pump	39.7	79.3	10	35%	2.99	22	2.8	107%	4.24
V2 - Brine heat pump	34.9	69.7	8.8	35%	8.8	12.4	1.6	117%	10.05
V2 - Bio boiler	67.8	68.3	7.7	71%	8.22	11	0.4	113%	9.47
V2 - Gas boiler	67.8	101.9	15.2	16%	5.51	44.6	8	58%	6.77
V2 - District heating	65.8	82.5	11.5	45%	4.26	25.1	4.2	89%	5.51
V3 - Air heat pump	38.5	77.1	9.7	35%	4.42	19.7	2.5	109%	5.68
V3 - Brine heat pump	32.8	65.6	8.3	35%	7.97	8.3	1	122%	9.22
V3 - Bio boiler	54.5	69.9	8.2	61%	9.27	12.5	1	114%	10.52
V3 - Gas boiler	54.5	89.5	12.6	21%	6.78	32.1	5.4	74%	8.04
V3 - District heating	53.4	78.1	10.5	42%	5.55	20.8	3.2	75%	6.81
V4 - Air heat pump	41.7	83.5	10.5	35%	10.56	26.2	3.3	104%	11.81
V4 - Brine heat pump	40.6	81.3	10.2	35%	14.37	24	3	105%	15.62
V4 - Bio boiler	53.8	77.9	9.4	55%	13.69	20.6	2.2	108%	14.94
V4 - Gas boiler	53.8	92.8	12.7	24%	12.07	35.5	5.5	77%	13.32
V4 - District heating	43.2	78.2	10	38%	10.06	20.9	2.8	104%	11.31
	<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: 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 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, for example, improved building insulation, improved building geometries or by 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 appropriate solutions for each building which completely fulfil the nZEB principles (as defined in the 2011 BPIE study) type were selected. All solutions are with PV compensation and the variations of the most suitable technologies and facade qualities are considered. Table 8 presents these suggestions.

Table 8: Overview of the (cost-) optimal variants

Building type	Variant	Brief Description	Heating system	Additional annualized costs (Base year 2010) [€/m²yr]	Additional annualised costs comparing with average reference actual price[12] [%]
SFH	V1a	Improved building shell	Air heat pump	-7.73	-14.7%
	V3b	Improved building shell + mech. ventilation with heat recovery	Brine heat pump	-3.20	-6.1%
	V3c		Bio Pellet	-2.26	-4.4%
MFH	V1c	Improved building shell	Bio Pellet	0.53	1.15%
	V3b	Improved building shell + mech. ventilation with heat recovery	Brine heat pump	2.21	4.8%
	V4c	Improved building shell + mech. ventilation with heat recovery + solar collectors	Bio Pellet	2.01	4.4%
OFFICE	V2a	Improved building shell + external shading + improved lighting	Air heat pump	4.24	12.15%
	V2c		Bio Pellet	9.47	27%
	V3b	Improved building shell + external shading + improved lighting + improved windows + improved heat recovery	Brine heat pump	9.22	26.3%

[12] The percentage of the additional annualised costs was based on the following assumptions: turnkey costs for SFH: 450 €/m², MFH: 363 €/m² and office: 275 €/m² (Andreev, Bulgarian Expert, 2012). The lifetime of residential buildings were assumed to be 50 years for residential building and 30 years for offices.

In the residential sector in Bulgaria, the selected cost-optimal nZEB solutions have additional annualised costs of new buildings by between -14.7% and 26.2%, higher than actual market prices for a new building in this category. The most cost-effective solutions are for SFH where all optimal nZEB solutions are very effective with additional costs between -14.7% and -4.4%, as compared to the reference building according to actual practice. For MFH, the nZEB cost-optimal solutions indicate additional costs between 1.1% and 4.8%, as compared to the cost of the reference building.

For offices, the additional annualised costs are by 12.0% and 26.2%, higher than actual market prices for a new building in this category. This is also due to a shorter lifetime assumed for the office building in the calculation.

District heating in Bulgaria with a high share of renewable energy may be an important point for the heating strategy in Bulgaria and work well in the context of increasing the energy performance of buildings and the nZEB implementation. District heating may provide cheap nZEB solutions especially for multi-family and office buildings.

However, in Bulgaria nearly all district heating plants are currently still operating with natural gas or coal. There is only one very small plant operating with wood chips in the town of Bansko and one experimentally reconstructed boiler in Veliko Tarnovo Plant. According to our estimations, the actual share of renewable energy for district heating is about 1%. Overall the DH systems built before 1990 have been developed on a very large scale covering large parts of the city areas and due to this uncontrolled extension are inefficient and have a bad public perception. Consequently, if it is intended to transform DH into an effective solution for the future, a radical rethinking of the actual systems is necessary.

In this study the district heat solutions for multi-family buildings, without CO_2 compensation, turned out to be above the CO_2 emission target of 3 kg/m² per year, although the district heat was calculated with a share of about 54% renewable energies. For the examined solutions, this share of renewable energies is still not sufficient to bring CO_2 emissions down to or below the required 3 kg/m² per year.

As suggested in the BPIE study defining principles for nZEB[13], the strategy for district heating (DH) systems should be developed in strong relationship with buildings policies, in order to better identify future needs and to shape the economic instruments for reaching an overall sustainable buildings sector. District heating systems may offer a higher flexibility than other alternatives in changing the energy carriers and may be an important nZEB solution.

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 Bulgaria (Table 9).

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

Table 9: Proposed nZEB definitions for Bulgaria

Building type	Minimum requirements	Year		
		2015/2016	2019	2020
Single family buildings	Primary energy [$kWh/m^2/yr$]	60-70		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$][14]	<8		<3-5
Multi-family buildings	Primary energy [$kWh/m^2/yr$]	60-70		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$][15]	<8		<3-5
Office buildings	Primary energy [$kWh/m^2/yr$]	100		60-80
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$][16]	<15		<8-10
Public office buildings (exemplary role)	Primary energy [$kWh/m^2/yr$]	100	40-60	
	Renewable share [%]	>20	>50	
	CO_2 emissions [$kgCO_2/m^2/yr$][17]	<12	<5-8	

The thresholds suggested above for an nZEB definition in Bulgaria are fairly ambitious yet affordable when comparing to the actual practice. 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 $kgCO_2/m^2yr$ (and aiming at: 0 kg/m^2yr), 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 Bulgarian 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 the significant optimisation potential of the buildings' geometries towards those recommended by passive houses design which will lead to additional cost reductions. Moreover, implementing ambitious nZEB requirements in the Bulgarian building codes will generate a wider market deployment of the energy efficient and renewable technology 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 current interest rate in the Bulgarian market, i.e. 7.5%/yr. However, according to the estimated economic evolution, the interest rates are likely to decrease consistently by 2020 when the nZEB requirement has 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 on 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.

[14] For more details on the strategies of other EU countries 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, the public budget and society as a whole.

The benefits of implementing 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 to 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].

[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 a national level, e.g. (average energy and CO_2 savings per m^2) x (m^2 built new per year) x 30 years (2020-2050). In Table 10, we present the estimated macro-economic impact by 2050 in terms of additional investments, new jobs (only direct impact in the construction industry), CO_2 and energy savings.

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. By way of example, the job creation impact is based on the job intensity of the 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 up-scaling the market and the indirect jobs in the administration of the processes (e.g. additional auditors and control bodies for new technologies). 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, there will be an increased 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	4.7-5.3 M t CO_2
Cumulative energy savings in 2050	15.3 -17 TWh
Additional annual investments	38 - 69 M Euro
Additional new jobs[17]	649 - 1180 Full time employees

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

[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 supposed to expand new qualifications as is the case for nZEBs, 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 a 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 will 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					
	V1a	V2a	V3a	V1a	V2a	V3a	V2a	V3a	V3b
Annual CO_2 emissions savings [$kgCO_2/m^2yr$]	15	15	15	58	43	56	52	54	53
CO_2 emissions savings in 2050 [Mt CO_2]	0.65	0.65	0.65	1.95	1.46	1.88	2.57	2.68	2.65
Annual energy savings [kWh/m^2yr]	86	86	78	98	82	100	184	195	198
Cumulative energy savings in 2050 [TWh]	3.80	3.80	3.43	3.29	2.76	3.36	9.15	9.69	9.82
Additional annualized investment costs per m^2 [€/m^2yr]	10.4	14.4	7.6	2.4	12.5	7.2	14.7	15.5	20.8
Annual additional investments [M €]	15	21	11	3	14	8	24	26	34
Job effects [no of new jobs]	260	358	190	45	237	137	415	436	584

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.

[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 IN POLAND

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 Bulgaria can generate macroeconomic and social benefits.

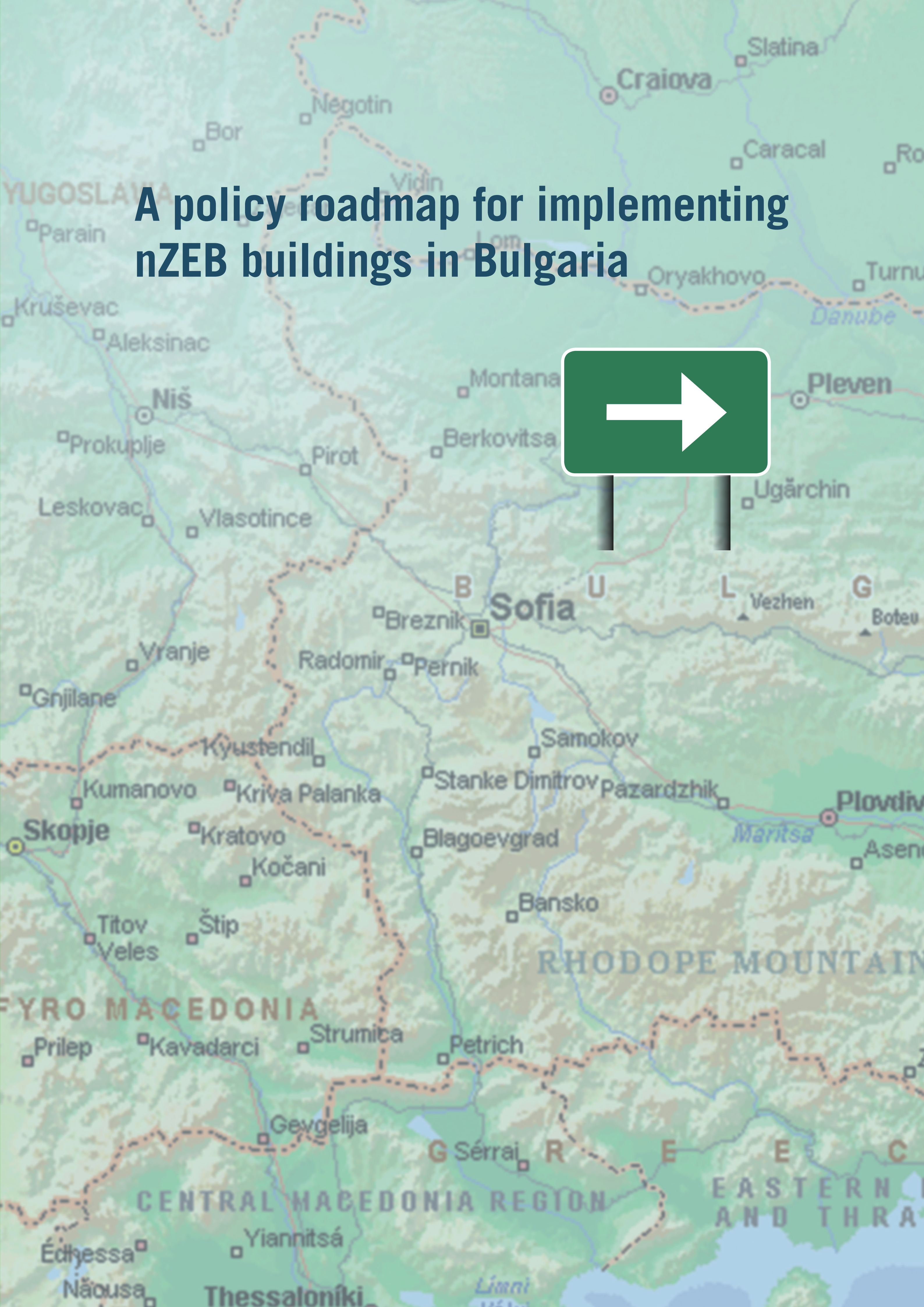
There are multiple benefits for both society and the business environment. But to ensure a cost-effective and sustainable market transformation, to develop appropriate policies and to increase institutional capacities, concerted action is needed. It is vitally important to start preparing as soon as possible 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 nZEB buildings in Bulgaria



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