IMPLEMENTING NEARLY ZERO-ENERGY BUILDINGS (nZEB) IN POLAND –

TOWARDS A DEFINITION AND ROADMAP

EXECUTIVE SUMMARY

BPIE

Project coordinator:
Bogdan Atanasiu (BPIE)

This study is elaborated in cooperation with:

Ecofys Germany GmbH:
Markus Offermann
Bernhard v. Manteuffel
Jan Grözinger
Thomas Boermans

and

BuildDesk Polska:
Piotr Pawlak
Konrad Witczak
Arkadiusz Dębowy

Editing team:
Ingeborg Nolte (BPIE)
Nigel Griffiths (Griffiths & Company)
Oliver Rapf (BPIE)
Alexandra Potcoava (BPIE)

Acknowledgements: BPIE thanks Mr. Marek Zaborowski and Mr. Andrzej Gula from the Institute of Environmental Economics, Poland, and to Mr. Henryk Kwapisz from Saint-Gobain Poland for supporting the elaboration of this study.

Graphic Design
Lies Verheyen - Mazout.nu

Cover photos © courtesy of Sapphire Ventures Sp z o.o.
DOM EKoLOGICZNY (arhitect Piotr Kuczia) and ADD Autonomiczny Dom Dostępny (Architect: Adam)
(c) Courtesy of Polish Green Buildings Council and Green Buildings Council Europe Regional Network

Published in October 2012 by Buildings Performance Institute Europe (BPIE)

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.

BPIE acts both as European centre of expertise and as the European partner for a Global Buildings Performance Network.

CONTENTS

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 and the building sector is crucial to achieving the EU's reduction targets. 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 nearly Zero-Energy Buildings (nZEBs) and each EU Member State has to elaborate its own nZEB definition. The EPBD also 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 nearly Zero-Energy Buildings into practical and applicable measures and definitions to steadily increase the number of nearly Zero-Energy Buildings. EU Member States are required to present their nZEB definition and roadmaps to the European Commission by 2013.

So far the nZEB criteria, as defined in the EPBD, are of a very qualitative nature with much room left 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 nearly Zero-Energy Buildings. Therefore, a more concrete and clear definition of nZEB needs to be formulated which includes common principles and methods that can be taken into account by EU Member States for elaborating effective, practical and well thought-out nearly Zero-Energy Buildings.

The aim of this study is to actively support this elaboration process in Poland by providing a technical and economic analysis for developing an ambitious yet affordable nZEB definition and implementation plan. Starting from country data on 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 and offer recommendations for 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 Poland.

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 Poland.

The project started with an in-depth survey of the Polish 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 around 88% of the residential building stock in Poland and 94% in terms of net floor area. The office buildings represent around 26% of the non-residential building stock.
Altogether, these three building types account for around 77% of the Polish building stock. Therefore we consider them to be representatives enough to be selected for this study as the main building typology in the country.

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[1]. 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 last chapter presents key policy recommendations and an indicative roadmap for the implementation of nZEBs in Poland.

This report was conceptualised, 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 Polish buildings, policies and market prices, the definition and selection of reference buildings and the revision of the final study were made by BuildDesk Polska's team as national consultants.

[1] BPIE (2011). Principles for nearly zero-energy buildings - Paving the way for effective implementation of policy requirements. Available at www.bpie.eu

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 Poland, 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 Poland:

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 Poland (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 Poland. Within this category, the detached SFH has the highest share. The second largest amount of floor space (m^2) was indicated for urban MFH.

As presented in the previous chapter, the share of office buildings within the non-residential buildings is among the highest. The other non-residential buildings such as the retail buildings sector are 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 in the construction of new educational and healthcare buildings. The existing stock, however, is well established and in need of improved renovation quality, renovation depth and rate. Overall, while the actual construction rates are very low, office buildings are more uniform and there are fewer subtypes than in the case of other non-residential building types. 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 as 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.

The building simulations were undertaken with the TRNSYS[2] software tool. The economic analysis was performed by using the Ecofys analytical tool Built Environment Analysis Model (BEAM2)[3].

---

[2] 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/

[3] Further information on BEAM2 model available at: http://www.ecofys.nl/com/news/pressreleases2010/documents/2pager_Ecofys_BEAM2_ENG_10_2010.pdf

Table 1: Identified reference buildings for new construction in Poland

Parameter	Reference SFH	Reference MFH	Reference Office
Number of conditioned floors	2	6	3
Net floor area	183.5 m^2	2870 m^2	886 m^2
Room height	2.65 m	2.73 m	3.00 m
U-walls	0.23 W/(m^2.K)	0.60 W/(m^2.K)	0.30 W/(m^2.K)
U-roof	0.20 W/(m^2.K)	0.28 W/(m^2.K)	0.25 W/(m^2.K)
U-floor	0.59 W/(m^2.K)	0.47 W/(m^2.K)	0.45 W/(m^2.K)
U-windows, frame fraction	1.40 W/(m^2.K); 25%	1.70 W/(m^2.K), 25%	1.80 W/(m^2.K), 21%
Window fraction (window/wall-ratio)	20%	23%	50%
Shading	None	None	Internal blinds
Air tightness	Moderate	Moderate	Moderate
Heating system	Gas boiler (set point: 20°C); Heating efficiency: 0.9 Heating efficiency: 0.92	District Heating (set point: 20°C); Heating efficiency: 0.95	District heating, hot water distribution, fan coils (set point: 20°C), Heating efficiency: 0.95
DHW system	Same as for heating DHW efficiency: 0.85	Same as for heating; DHW efficiency: 0.95	Same as for heating, DHW efficiency: 0.95
Ventilation system	Natural/window ventilation	Natural/window ventilation (0.5 1/h)	Mechanical ventilation with 80% heat recovery (0.5 ... 3.0 1/h, zone dependent)
Ventilation rates during system operating time (6 am till 6 pm)	n.a.	n.a.	Office spaces: 1.5 1/h Conference rooms: 3 1/h Other rooms: 0.5 1/h
Cooling system	None	None	Central chiller, fan coils, (set point: 26°C), SEER: 4
Internal gains[4]	16 W/m^2	21 W/m^2	7.4 W/m^2 (office area) and 3.1 W/m^2 (auxiliary 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: 1 Person/30 m^2
Installed lighting power[5]	5 W/m^2	10 W/m^2	20 W/m^2
Automatic lighting control	No	No	Yes

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

5 This value is to be understood as the 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 if they are not optimum for a very low-energy building. Table 2 shows the variants considered for dynamic thermal simulations with TRNSYS.

Table 2: Polish SFH, nZEB variants

Variants	U-value Opaque Shell	U-Value Window	Heat Recovery Rate	Solar Collector for DHW	Brief Description
VO	U-Wall: 0.23 W/m².K U-Roof: 0.20 W/m².K U-Floor: 0.59 W/m².K	1.4 W/m².K	0%	No	Reference
V1	U-Wall: 0.23 W/m².K U-Roof: 0.20 W/m².K U-Floor: 0.59 W/m².K	1.4 W/m².K	80%	No	+ mech. ventilation with heat recovery
V2	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.15 W/m².K	0.8 W/m².K	0%	No	+ improved building shell
V3	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.15 W/m².K	0.8 W/m².K	90%	No	Improved building shell + improved mech. ventilation with heat recovery
V4	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.15 W/m².K	0.80 W/m².K	90%	Yes	Improved building shell + improved 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 supply options are considered:

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

[7] V1 and V2 will be considered to have a low temperature floor heating system to get a better system efficiency
[8] Idem 5

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: Polish 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/m².K U-Roof: 0.28 W/m².K U-Floor: 0.47 W/m².K	1.7 W/m².K	0%	No	Reference
V1	U-Wall: 0.28 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: 0.60 W/m².K U-Roof: 0.28 W/m².K U-Floor: 0.47 W/m².K	1.7 W/m².K	85%	No	Mech. ventilation with heat recovery
V3	U-Wall: 0.28 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: 0.28 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 for mould formation. It is, therefore, strongly recommended that an adequate ventilation concept is developed if this variant is to be considered for implementation.

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

1. Wood pellet boiler
2. Air source heat pump[9]
3. Ground collector brine heat pump[10]
4. Gas condensing boiler
5. District heating

[9] V1 and V2 will be considered to have a low temperature floor heating system to get a better system efficiency
[10] Idem 7

3.1.3. nZEB solutions for office buildings

Similarly, for the office buildings simulation, the geometry of the reference was kept, even if it is not optimal for an nZEB. Table 4 shows the variants simulated with TRNSYS.

Table 4: Polish 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: 0.30 W/m^2.K U-Roof: 0.25 W/m^2.K U-Floor: 0.45 W/m^2.K	1.8 W/m^2.K	80%	None	50%	Automatic controlled lighting	No	Reference
V1	U-Wall: 0.15 W/m^2.K U-Roof: 0.12 W/m^2.K U-Floor: 0.45 W/m^2.K	1.0 W/m^2.K	80%	None	50%	Automatic controlled lighting	No	Improved building shell
V2	U-Wall: 0.15 W/m^2.K U-Roof: 0.12 W/m^2.K U-Floor: 0.45 W/m^2.K	1.0 W/m^2.K	80%	Automatic	50%	Automatic controlled lighting	No	Improved building shell + external shading
V3	U-Wall: 0.15 W/m^2.K U-Roof: 0.12 W/m^2.K U-Floor: 0.45 W/m^2.K	1.0 W/m^2.K	80%	Automatic	50%	Automatic controlled lighting +LEDs	No	Improved building shell + external shading + improved lighting
V4	U-Wall: 0.12 W/m^2.K U-Roof: 0.10 W/m^2.K U-Floor: 0.20 W/m^2.K	0.8 W/m^2.K	90%	Automatic	50%	Automatic controlled lighting +LEDs	No	Close to Passive house standard[11]

For each of the five base variants, the following five heating options will be 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

[11] Passive house standard: Major shell improvements, no heat bridges, airtight construction, highly efficient mechanical ventilation (> 90%), useful heating and cooling demand < 15 kWh/m^{2}a

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

The simulation results for each solution are shown in Tables 5-7. They reflect 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). Total final and primary energy demand for residential buildings include the energy consumption within the scope of the EPBD: heating, cooling, ventilation and domestic hot water. For office buildings, this also includes lighting energy consumption. The colour code used for different nZEB options is in line with the nZEB principles defined in the previous BPIE study[12].

[12] 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/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	111	123.0	22.5	0%	0	n.a	n.a.	n.a.	0.0
V1 - Air heat pump	30.1	60.2	7.6	35%	-1.2	3.9	0.5	129%	2.9
V1 - Brine heat pump	24.2	48.4	6.1	35%	-0.7	0.0	0.0	135%	2.8
V1 - Bio boiler	101.8	26.9	0.9	98%	1.4	19.6	0.0	101%	1.9
V1 - Gas boiler	101.4	114.9	20.7	1%	1.3	58.6	13.6	29%	5.3
V2 - Air heat pump	19.7	39.3	4.9	35%	-3.2	0.0	0.0	135%	-0.4
V2 - Brine heat pump	15.7	31.3	3.9	35%	-2.7	0.0	0.0	135%	-0.5
V2 - Bio boiler	68.7	15.0	0.2	99%	-1.1	8.9	0.0	104%	-0.6
V2 - Gas boiler	69	76.5	14.0	0%	-1.8	20.2	6.9	41%	2.3
V3 - Air heat pump	16	31.9	4.0	35%	-2	0.0	0.0	135%	0.3
V3 - Brine heat pump	13.9	27.7	3.5	35%	-1.6	0.0	0.0	135%	0.4
V3 - Bio boiler	50.4	14.9	0.7	97%	0.4	8.8	0.0	103%	0.9
V3 - Gas boiler	51.2	58.6	10.5	2%	-0.4	2.3	3.4	57%	3.6
V4 - Air heat pump	13.2	26.3	3.3	35%	-1	0.0	0.0	135%	0.9
V4 - Brine heat pump	10.4	20.7	2.6	35%	-0.7	0.0	0.0	135%	0.8
V4 - Bio boiler	37	13.2	0.8	94%	1	6.8	0.0	103%	1.5
V4 - Gas boiler	37	43.5	7.6	3%	-0.2	-5.6	1.4	70%	3.4
	<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	101.6	133.3	68.6	21%	0	n.a.	n.a.	n.a.	0
V1 - Air heat pump	24.1	48.3	6.1	35%	1.3	21.1	2.7	91%	2.3
V1 - Brine heat pump	19.9	39.9	5.0	35%	1.7	12.7	1.6	103%	2.7
V1 - Bio boiler	81.5	18.7	0.3	99%	2	16.0	0.0	101%	2.1
V1 - Gas boiler	83.6	93.2	17.0	1%	2.6	66.0	13.5	17%	3.5
V1 - District heating	77.3	101.5	52.2	21%	-0.9	74.3	48.8	39%	0.0
V2 - Air heat pump	25.7	51.6	6.5	35%	2.6	24.4	3.1	88%	3.6
V2 - Brine heat pump	21.8	43.8	5.5	35%	2.9	16.6	2.1	97%	3.9
V2 - Bio boiler	81.1	23.1	1.0	97%	3.3	15.5	0.0	102%	3.5
V2 - Gas boiler	77.1	88.2	15.8	2%	3.5	61.0	12.3	19%	4.5
V2 - District heating	77.1	102.9	51.0	22%	0.4	75.7	47.5	39%	1.3
V3 - Air heat pump	19.1	38.5	4.8	35%	1.4	11.2	1.4	106%	2.5
V3 - Brine heat pump	16.9	33.9	4.3	35%	1.7	6.7	0.8	115%	2.7
V3 - Bio boiler	55.8	17.4	0.9	96%	2	10.5	0.0	102%	2.2
V3 - Gas boiler	53.1	61.6	10.9	2%	2	34.4	7.5	28%	3.0
V3 - District heating	53.1	71.6	34.8	22%	0	44.4	31.4	48%	1.0
V4 - Air heat pump	17	34.1	4.3	35%	2	10.0	1.3	106%	2.8
V4 - Brine heat pump	14.2	28.5	3.6	35%	2.1	4.4	0.6	120%	3.0
V4 - Bio boiler	46.1	15.8	0.9	95%	2.2	8.5	0.0	103%	2.4
V4 - Gas boiler	43.9	51.6	9.1	3%	1.9	27.5	6.0	30%	2.8
V4 - District heating	43.9	59.7	28.4	22%	-0.5	35.6	25.4	50%	0.3

	<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: Primary energy demand [kWh/m²/yr]	Without CO_2 compensation: CO_2 emissions [kgCO_2/m²/yr]	Without CO_2 compensation: Renewable share [%]	Without CO_2 compensation: Total additional annualised costs [Euro/m²/yr]	With CO_2 compensation (by additional PV): Primary energy demand* [kWh/m²/yr]	With CO_2 compensation (by additional PV): CO_2 emissions [kgCO_2/m²/yr]	With CO_2 compensation (by additional PV): Renewable share [%]	With CO_2 compensation (by additional PV): Total additional annualised costs [Euro/m²/yr]
V0 - Reference	118	187.3	59.9	27%	0	n.a.	n.a.	n.a.	0
V1 - Air heat pump	62	124.3	15.6	35%	1.1	63.5	8.0	84%	3.9
V1 - Brine heat pump	56.8	113.7	14.3	35%	1.8	52.9	6.7	88%	4.6
V1 - Bio boiler	89.1	110.0	12.9	63%	0.2	49.2	5.2	97%	3.1
V1 - Gas boiler	89.1	144.1	20.6	20%	1.7	83.3	12.9	54%	4.6
V1 - District heating	87.1	149.1	37.4	29%	-1	88.3	29.8	64%	1.8
V2 - Air heat pump	57.5	115.4	14.5	35%	9.1	54.6	6.9	88%	11.9
V2 - Brine heat pump	53.6	107.3	13.5	35%	9.9	46.5	5.9	92%	12.7
V2 - Bio boiler	84.8	101.0	11.7	64%	8.2	40.2	4.1	100%	11.0
V2 - Gas boiler	84.8	135.5	19.5	19%	9.7	74.7	11.8	55%	12.6
V2 - District heating	82.8	140.5	36.5	29%	7	79.7	28.9	66%	9.8
V3 - Air heat pump	45.4	90.7	11.4	35%	9.8	29.9	3.8	102%	12.6
V3 - Brine heat pump	41.6	82.9	10.4	35%	10.6	22.1	2.8	108%	13.4
V3 - Bio boiler	75.7	75.0	8.4	71%	9	14.2	0.7	112%	11.8
V3 - Gas boiler	75.7	113.2	17.0	15%	10.7	52.4	9.3	56%	13.5
V3 - District heating	73.5	118.8	35.8	27%	7.7	58.0	28.2	57%	10.6
V4 - Air heat pump	43.8	87.8	11.1	35%	15.1	27.0	3.4	104%	17.9
V4 - Brine heat pump	40.5	81.1	10.2	35%	15.8	20.3	2.6	110%	18.6
V4 - Bio boiler	66.7	75.7	8.7	66%	14.2	14.9	1.1	112%	17.1
V4 - Gas boiler	66.7	104.6	15.2	18%	15.9	43.8	7.6	64%	18.7
V4 - District heating	65	108.9	29.5	28%	13.5	48.0	21.8	75%	16.2
	<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: Compensation of a 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 does not necessarily supply the energy demand of the building within the EPBD scope (i.e. energy for heating, cooling, ventilation, domestic hot water and, in the 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-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, for example, improved building insulation, by improved building geometries or higher system efficiencies. However, the 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, we selected the three most appropriated solutions for each building type (fulfilling the nZEB principles as defined in the 2011 BPIE study). The selection mainly takes into consideration the additional annualised costs of the systems. Table 8 presents these suggestions with the right column presenting the percentage of the additional annualised costs or cost savings in relation to the construction costs (capital costs) plus user costs (running and energy costs) of the variants compared to the reference case.

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[13] [%]
SFH	V2b	+ mech. ventilation with heat recovery + improved building shell	Brine heat pump	- 0.5	-0.9%
SFH	V2c	+ mech. ventilation with heat recovery + improved building shell	Bio Pellet	- 0.6	-1.1%
SFH	V3a	Passive house standard	Air heat pump	0,3	0,5%
MFH	V1c	Improved building shell	Bio Pellet	2.1	3.6%
MFH	V3c	Mech. ventilation with heat recovery	Bio Pellet	2.2	3.8%
MFH	V4b	Improved building shell + mech. ventilation with heat recovery + solar collectors	Brine heat pump	3.0	5.2%
OFFICE	V3b	Improved building shell + external shading + improved lighting	Brine heat pump	13.4	17.9%
OFFICE	V3c	Improved building shell + external shading + improved lighting	Bio Pellet	11.8	15.8%
OFFICE	V4c	Nearly Passive house standard[14]	Bio Pellet	17.1	22.9%

[13] The percentage of the additional annualised costs was based on the following assumptions: turnkey costs for SFH: 825 €/m², MFH: 950 €/m² and office: 1000 €/m² (estimation by BuilDesk Poska, 2012). The lifetime of residential buildings were assumed to be 50 years for residential building and 30 years for offices.

[14] Major shell improvements, no heat bridges, airtight construction, highly efficient mechanical ventilation (> 90%), useful heating and cooling demand < 15 kWh/m²a.

In the residential sector in Poland, in the case of the single family house, the cost-optimal variants V2b and V2c would result in annualised cost savings of between 0.9% and 1.4%, whereas the implementation of variant V3a would increase the annualised additional costs by about 0.5%. In the case of the multi-family house, the implementation of the cost-optimal variant would result in annualised additional costs from 3.6% to 5.2%, depending on shell, heating system and type of building.

For the offices the implementation of the cost-optimal variants would result in additional annualised costs between 15.8% and 22.9%. This is also due to a shorter lifetime assumed for the office building in the calculation.

In this study the district heating solutions for multi-family houses turned out to be above the CO_2 emission target of 3 kg/m² per year. However, it was considered that the actual Polish DH renewable energy share of about 20% and for the analysed nZEB solutions is not sufficient to bring down the CO_2 emissions to or below the required 3 kg/m² per year. If the renewable energy share of district heating systems in Poland will consistently increase, district heating may, therefore, be a viable and potentially cheap nZEB solution. Consequently, district heating systems with a large share of renewable energy may be a key issue for the heating strategy in Poland and fits very well in the context of increasing the energy performance of buildings towards nZEB levels.

As suggested in the BPIE study presenting nZEB principles[15], the district heating (DH) strategy has to be harmonised with building policies to better align future needs and to shape the economic instruments. 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, and based on the simulation results in Tables 5-7 and taking into consideration the additional costs and results for basic variants without PV compensation, the following levels are proposed for consideration as nZEB definitions for Poland (Table 9).

Table 9: Proposed nZEB definitions for Poland

Building type	Minimum requirements	Year		
		2015/2016	2019	2020
Single family buildings	Primary energy [kWh/m²/yr]	70		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$][16]	<10		<3-6
Multi-family buildings	Primary energy [kWh/m²/yr]	90		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$][17]	<10		<3-6
Office buildings	Primary energy [kWh/m²/yr]	100		50-60
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$][18]	<15		<8-10
Public office buildings	Primary energy [kWh/m²/yr]	80	40-60	
	Renewable share [%]	>20	>50	
	CO_2 emissions [$kgCO_2/m^2/yr$][19]	<12	<5-8	

[15] Based on emission factors specified in Table 15
[16] Based on emission factors specified in Table 15
[17] Based on emission factors specified in Table 15
[18] Based on emission factors specified in Table 15
[19] Based on emission factors specified in Table 15

The above-suggested thresholds for an nZEB definition in Poland are relatively ambitious but yet affordable, as several options have low additional specific annualised costs. Also several nZEB options for SFH are economically feasible.

However, these thresholds are significantly less ambitious than in other Western Europe countries, which are aiming to reach climate neutral, fossil fuel free or even energy positive new buildings[20] by 2020. Thinking long term, it is necessary to ensure that the building concepts are improved to keep 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 necessary for achieving the EU 2050 decarbonisation goals. The nZEB definition should therefore be gradually improved after 2020. It is likely to lead to energy and climate neutral levels by 2030. Beyond implementing an EU Directive requirement, the significant reduction of the energy consumption and related CO_2 emissions of the building sector will have a major impact on the security of energy supply, national economy and the quality of life of Polish citizens.

[20] 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

Investing in more sustainable, energy efficient buildings contributes substantially to increased energy security, environmental protection, job creation and improved quality of life. It also contributes to the sustainable development of the construction sector and supply chain industry. While the upfront investment is relatively high and the return on investment usually longer than for other economic activities, there are multiple benefits that are shared among building users and owners, the construction industry, the public sector and society as a whole.

The benefits of implementing nZEBs are wider than simply 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 current practice. An adequate design of the building and a high quality construction include cost-saving possibilities that cover the additional costs of an energy-efficient building envelope almost entirely. Higher quality of life through better (thermal) comfort. The nearly Zero-Energy Building provides good indoor air quality. Fresh filtered air continuously delivered by the ventilation system. It is more independent of outdoor conditions (climate, air pollution). Concerning the noise protection, the thick and well-insulated structures provide effective sound insulation;
- Ambient benefits arise through reduced energy demand that reduces wider environmental impacts of energy extraction, production and supply;
- There are environmental benefits from improving local air quality;
- Social benefits arise through the alleviation of fuel poverty;
- Health benefits are possible through improved indoor air quality and reducing 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 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[21].

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

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 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 tech). Moreover, moving towards very efficient buildings and increasing the need for new technology will mainly have an impact on new job profiles such as renewable systems and heat pumps installers. There will be, therefore, an increased need for these new activities all over the country, driven not only by additional investment as we considered in this study, but also by the local needs for such new job profiles[22]. Consequently, it is very likely to have a much higher job creation potential than is estimated in this study.

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

Indicator	Effect
CO_2 emissions savings in 2050	31 M t CO_2
Cumulative energy savings in 2050	92 TWh
Additional annual investments	€ 242-364 M
Additional new jobs[23]	4 106- 6 185 Full time employees

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

[22] 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 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 a few times higher).

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

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

Indicator	Residential sector						Non residential sector		
	SFH			MFH					
	V2b	V2c	V3a	V1c	V3c	V4b	V3b	V3c	V4c
Annual CO_2 emissions savings [$kgCO_2/m^2yr$]	22	22	22	69	69	68	57	59	59
CO_2 emissions savings in 2050 [Mio t CO_2]	5.0	5.0	5.0	9.4	9.4	9.3	17	17	17
Annual energy savings [kWh/m^2yr]	123	114	123	117	123	129	165	173	172
Cumulative energy savings in 2050 [TWh]	27	25	27	17	16	17	48	51	51
Additional annualized investment costs per m^2 [€/m^2yr]	9.1	4.6	9.9	2.4	4.3	8.5	22.1	20.1	25.8
Annual additional investments [Mio €]	67	34	73	11	19	39	216	196	252
Job effects [no of new jobs]	1,145	585	1,244	187	331	655	3,679	3,335	4,285

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

Based on the analysis of the specific national situation, the previous BPIE study on nZEB principles and on related studies; there are some key recommendations that can be made when designing an nZEB implementation roadmap:

1. Different instruments should be part of a wider holistic policy package, which should include regulatory, facilitation and communication aspects. The German investment bank KfW is a strong example of good communication. They managed to raise awareness about their financial products to such extent that commercial banks and construction companies on their side advertise their offers. Targeted communication campaigns are key to a scheme's success.
2. In addition, wide public consultation with relevant stakeholders is necessary at all implementation stages of buildings policies.
3. Impact assessment (ex-ante, interim and ex-post) of the planned policies is needed together with a simple but effective monitoring and control mechanism.
4. Higher energy performance of buildings should be rewarded by better financial support, i.e. higher grant 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 combine long-term programmes to provide stable frameworks and facilitate long-term planning for all stakeholders.
6. The buildings strategy should be synchronised with national energy and climate strategy as well as with EU strategy.
7. Different policy instruments need to be aligned to ensure success. One example is the Carbon Emissions Reduction Target (CERT) in the UK which is closely coordinated with other instruments[24]. Overlapping with supporting financial instruments should be avoided .

[24] EuroACE (2010). Making money work for buildings: Financial and fiscal instruments for energy efficiency in buildings. Available at: http://www.euroace.org/PublicDocumentDownload.aspx?Command=Core_Download&EntryId=133

6.1. PROPOSAL FOR AN nZEB ROADMAP IN POLAND

The proposed policy implementation roadmap for nZEB outlines the necessary steps to be taken in order to achieve the start of the implementation after 2020.

The roadmap adds a timeline to the recommendations described in the country specific policy recommendations. New regulations should always be accompanied by financial support schemes, capacity building programmes and awareness-raising campaigns. For the adaptation of the building code there are various paths that could be chosen and this largely depends on the implementation timeline of policy processes.

Generally, for implementing an ambitious, but realistic policy implementation roadmap for nZEB in Poland, the following considerations are recommended:

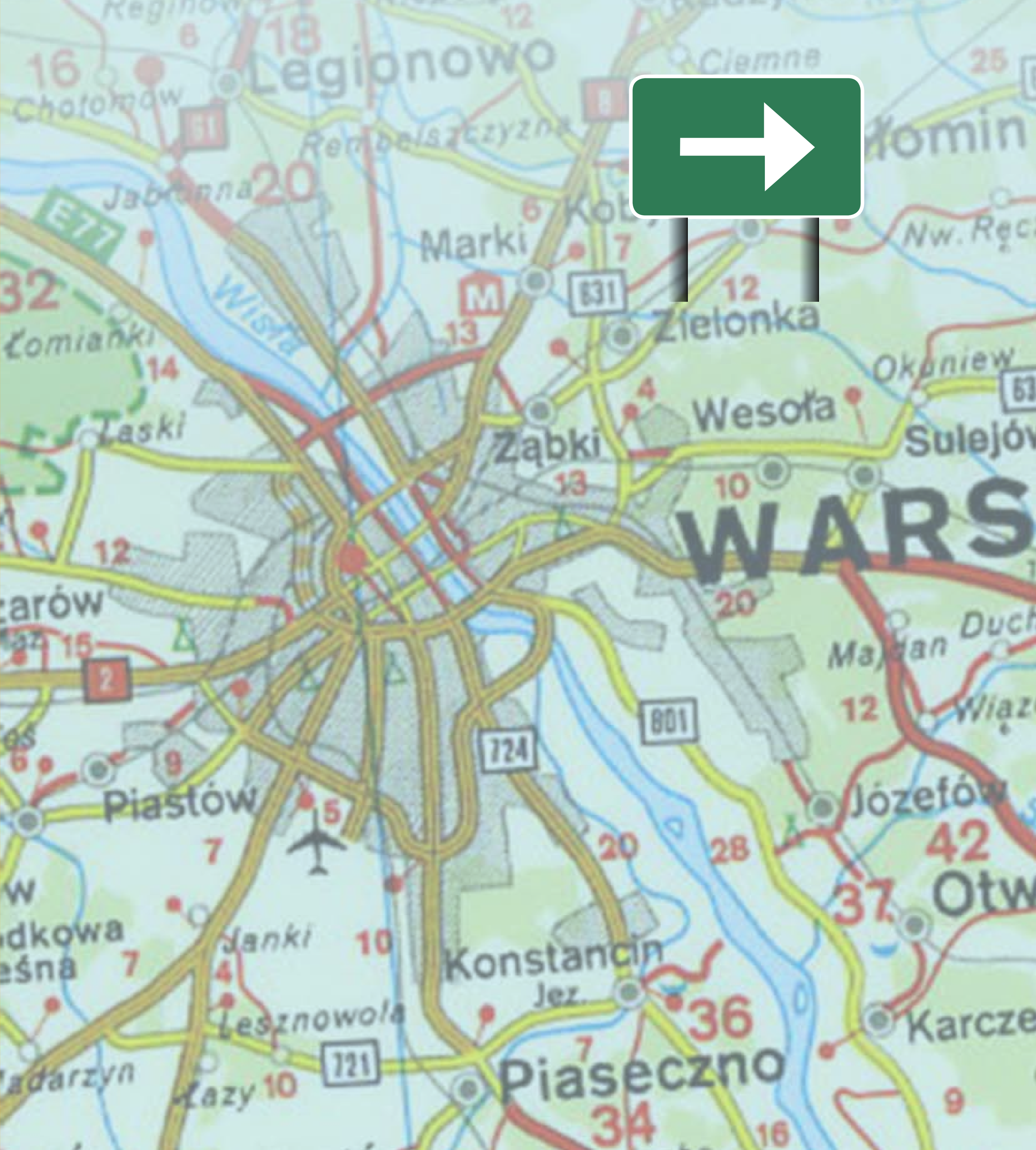
1. To tighten the ambition levels of the building envelope and of the maximum primary energy use.
2. In parallel to gradually move actual subsidies on fossil energies and on energy prices to support energy efficiency measures and renewable energies in buildings.
3. To adapt the structure of the regulation, including obligations regarding the building envelope quality, primary energy use, CO_2 emissions and the use of renewable energy. The actual bypassing options should be removed.

In a previous chapter it has been shown that the additional financial effort for moving towards nearly Zero-Energy Buildings may be managed by introducing support schemes and for some options are even economically viable. We have also identified that by improving the thermal insulation of new buildings and by increasing the share of renewable energy use in the building's energy consumption, the implementation of nearly Zero-Energy Buildings in Poland can generate macro-economic and social benefits.

There are multiple benefits for business and society, but for ensuring a cost-effective and sustainable market transformation, concerted actions are needed. It is important to develop the appropriate policies and to increase institutional capacities. In addition, it is vital to prepare as soon as possible an implementation roadmap. This roadmap should be based on a wide public consultation involving all relevant stakeholders and an ongoing information campaign. Future measures should be announced in time to allow the market to adapt their practices to future requirements.

To support the national efforts, this study proposes a 2020 roadmap for nZEB implementation on the following pages. It takes into account all necessary improvements at the level of policies, building codes, capacity building, energy certification, workforce skills, public information and research. To allow for a coherent and sustainable transition, all proposed measures should get implemented in parallel. They are interlinked and ensure an overall consistence of the proposed implementation package, trying to preserve a balance between the increase in requirements and support policies.

A policy roadmap for implementing nZEB buildings in Poland



Buildings Performance Institute Europe (BPIE)
Rue de la Science | Wetenschapsstraat 23B
1040 Brussels
Belgium
www.bpie.eu

ISBN: 9789491143052