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

TOWARDS A DEFINITION AND ROADMAP

BPIE

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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 and the building sector is crucial to achieving EU 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" (nZEBs) 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 Building 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 Romania 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 situation 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. PRINCIPLES FOR IMPLEMENTING NEARLY ZERO-ENERGY BUILDINGS IN EUROPE

In 2011 BPIE conducted a study on "Principles for nearly Zero-Energy Buildings"[1] (nZEBs) which aimed to support the public debate around this EPBD requirement by analysing the key implementation challenges and proposing a set of general principles to be taken into account for implementing a sustainable, realistic and cost-effective nZEB definition at national level. Based upon the analysis of the technical and economic implications of the proposed principles, the study makes general recommendations for moving towards nearly Zero–Energy Buildings in Europe.

The study identified 10 main challenges that should be addressed when shaping the nZEB definition at national level (Figure 1), leading to important implications in terms of energy efficiency, renewable energy supply and associated carbon emissions of the nZEB. The proposed nZEB principles offer general indications for defining the boundaries in the building's operational energy flow and for setting thresholds for energy demand/need, renewable energy share and associated carbon emissions of the building (Tables 1 and 2).various options and offer recommendations for an implementation plan.

Figure 1: Challenges to be addressed for implementing a sustainable nZEB definition

Policy	Technical	Beyond EPBD
Meeting the EU low-carbon 2050 goals	(nearly) zero CO_2 and zero energy building	Single building vs. groups of buildings
Convergence with EPBD cost-optimality requirement	Renewables temporal/ local disparities	Household electricity for appliances
	Balance between energy efficiency and renewable energy supply	Life cycle energy
	Transferability to varied climate and building types	
	Flexible and open nZEB definition	

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

Table 1: Principles for nearly Zero –Energy Buildings: defining the boundaries in the energy flow of the building

First nZEB Principle: Energy demand	Second nZEB Principle: Renewable energy share	Third nZEB Principle: Primary energy and CO_2 emissions
There should be a clearly defined boundary in the energy flow related to the operation of the building that defines the energy quality of the energy demand with clear guidance on how to assess corresponding values.	There should be a clearly defined boundary in the energy flow related to the operation of the building where the share of renewable energy is calculated or measured with clear guidance on how to assess this share.	There should be a clearly defined boundary in the energy flow related to the operation of the building where the overarching primary energy demand and CO_2 emissions are calculated with clear guidance on how to assess these values.
Implementation approach		
This boundary should include the energy need of the building, i.e. the sum of useful heat, cold and electricity needed for space cooling, space heating, domestic hot water and lighting (the latter only for non-residential buildings). It should also include the distribution and storage losses within the building. Addendum: While it is not specifically requested by the EPBD, the electricity consumption of appliances (plug load) and of other building technical systems (i.e. lifts, fire security lighting etc.) may also be included in the nZEB definition as an additional indicative fixed value.	This boundary could be the sum of energy needs and system losses, i.e. the total energy delivered into the building from active supply systems incl. auxiliary energy for pumps, fans etc. The eligible share of renewable energy represents all energy produced and delivered to the building from on-site (including the renewable share of heat pumps), nearby and offsite renewable sources. Double counting must be avoided.	This boundary should include the primary energy demand and should include the CO_2 emissions related to the total energy delivered into the building from active supply systems. Clear national rules and guidance should be provided on how to calculate the net export of the renewable energy produced on-site in the case when this exceeds the building's energy needs over the balance period.

Table 2: Corollary to the nZEB principles: fixing thresholds on energy demand/need, on renewable energy share and on associated CO2 emissions.

Corollary of First nZEB Principle: **Threshold on energy demand**	Corollary of Second nZEB Principle: **Threshold on renewable energy share**	Corollary of Third nZEB Principle: **Threshold on CO_2 emissions in primary energy**
A threshold for the maximum allowable energy need should be defined.	A threshold for the minimum share of renewable energy demand should be defined.	A threshold for the overarching primary energy demand and CO_2 emissions should be defined.
Implementation approach		
For the definition of such a threshold, it could be recommended to give the Member States the freedom to move in a certain corridor, which could be defined in the following way: • The upper limit (least ambitious, maximum allowed energy demand) can be defined by the energy demand that develops for different building types from applying the principle of cost optimality according to Article 5 of the EPBD recast. • The lower limit (most ambitious) of the corridor is set by the best available technology that is freely available and well introduced on the market. Member States might determine their individual position within that corridor based on specific relevant national conditions.	A reasonable range for renewable energy share seems to be between 50% and 90% (or 100%). The share of energy delivered to the building from renewable sources should be increased step-by-step between 2021 and 2050. The starting point should be determined based on best practice with nZEB serving as a benchmark for what can be achieved at reasonable life-cycle cost.	For meeting the EU's long term climate targets, it is recommended that the buildings' CO_2 emissions linked to energy demand is below 3 kg $CO_2/(m^2yr)$. The EPBD requires improved energy performance from buildings by imposing a minimum requirement for primary energy consumption. However, the buildings should also follow the EU's long-term decarbonisation goals (by 2050). Consequently, introducing an indicator for the CO2 emissions of buildings (linked to the primary energy indicator for the energy demand) is the single way to ensure coherence and consistency between the long-term energy and environmental goals of the EU.

The above nZEB principles were simulated on two pre-defined reference buildings, a single-family house and an office building, for three European climate zones: cold climate (Copenhagen), moderate climate (Stuttgart) and warm climate (Madrid). The simulations analysed these reference buildings and estimated the impact of several technical options for heating, cooling and domestic hot water in primary energy demand, on renewable energy share and on CO_2 emissions. Table 3 gives an overview of the general findings of simulations as compared to the thresholds proposed in Table 2.

Table 3: Impact of different simulation options

Renewable energy share between 50% and 90%	CO_2 emissions below $3kgCO_2/(m^2yr)$
Fossil fired solutions without additional renewables are already struggling to achieve a renewable share of 50%. The impact of district heating systems depends largely on its renewable share; a 50% renewable DH system is not enough in some locations. In single-family buildings, heat pump solutions easily achieve a 50% renewable share. By using additional off-site green electricity or on-site renewables, the heat pump option can even secure a 100% renewable energy share. For single-family homes with heat consumption, it is possible to achieve a 90% share of renewable only by using a 100% heat supply from biomass-fired systems (boiler, CHP). In office buildings, biomass and heat pump solutions reach a 50% share of renewables. Office buildings have a higher relative share of electricity than residential buildings. Therefore green electricity is required by all considered options (except the fossil fuels options) in order to reach a 90% share, usually even including office equipment (appliances).	Without additional renewables, for the single-family building all fossil fired solutions (gas boiler, micro CHP and district heating with a small renewable share) are generally clearly above the limit of $3kgCO_2/(m^2yr)$. Heat pump solutions come close and bio solutions (biomass boiler, bio micro CHP) clearly stay below the threshold. For the single-family building, additional on-site renewables (i.e. PV in this simulation) improve the situation. The fossil solutions are still above the threshold even with the considered additional PV system (which is however quite small, but enough to reach a high renewable energy share). For office buildings, only the biomass micro CHP is below the threshold. Using green off-site electricity significantly decreases CO_2 emissions. For the single-family building, the fossil fired solutions generally fail to meet the target (with or without the consideration of appliances), except at locations with very little heating and hot-water-demand (in warm climate zones). In office buildings, because of the relatively high share of electricity all related variants stay below the threshold. Consideration of the electricity demand for the appliances and office equipment does not generally change this result. For office buildings, additional on-site renewables as CO_2 compensation is much less effective. Fossil fuel options in moderate and cold climate zones cannot meet the conditions even with additional on-site PV power.

3. AIM AND METHODOLOGY

The current study builds on the previous report "Principles for nearly Zero-Energy Buildings"[2] 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 (current practice) for the following building types:

- Detached single-family houses (SFH)
- Multi-family houses (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 have 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 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[3].

The building simulations were undertaken with the TRNSYS software tool[4]. The economic analysis was performed by using the Ecofys analytical tool Built Environment Analysis Model (BEAM2)[5].

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

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

[4] 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/

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

4. OVERVIEW OF THE ROMANIAN BUILDING SECTOR

The Romanian building sector was analysed as follows:

- Building stock size and new building rates
- Typical shapes of new buildings and current practice
- Current building regulations for new buildings
- Current market situation for investments
- Current support schemes for new buildings
- Current market situation for district heating
- Current market prices for energy efficient technologies

The main findings of this in-depth evaluation are presented in the following sub-chapters.

4.1. BUILDING STOCK SIZE AND NEW BUILDING RATES

The housing stock in Romania consists of approximately 8.2 million dwellings in some 5.1 million buildings. In the urban area, the majority of dwellings (72%) are found in blocks of flats, in contrast to rural areas, where the majority (94.5%) are individual dwellings. Individual single-family buildings represent around 98% of the Romanian residential buildings stock. There are around 81 000 blocks of flats, mainly concentrated in urban areas, representing around 2% of the building stock but accounting for 37% of Romanian dwellings (around 3.18 million apartments). According to the preliminary results of the 2011 Census, the total number of buildings in Romania is about 5.3 million, whereas 5.1 million are residential buildings and 0.2 million are non-residential buildings (Table 4).

Approx. 53% of residential buildings are built before 1970 and more than 90% before 1989 (in terms of m^2), having an energy performance level between 150-400kWh/m^2. Heating energy represents around 55% of the overall energy use in apartments and up to 80% in individual houses. The buildings built before 1990 have poor energy performance at around 180-400kWh/m^2/yr. This is the result of more than 50 years of government policies focusing on constructing a maximum of dwellings with minimal investment. The objective was to keep pace with the migration of the population from rural to urban areas during the industrialisation period. In the meantime, building operating costs and specifically energy bills, increased considerably.

A particularity of Romania (and some other Eastern European countries) is the high rate of ownership in the residential sector, with more than 97% of the residential dwellings being privately owned and mostly inhabited by the owners. This is explained by the fact that after 1989 residential dwellings (mainly state property until then) were either sold by the state to the inhabitants or, by retrocession, returned to the pre-communist property owners.

According to floor area, the most prevalent building type in the residential sector is the rural detached single-family house with 43%, followed by the urban multi-family building with 34% (Figure 2). In the non-residential building sector, the most prevalent building type in the existing non-residential sector is the retail building with 31%, followed by educational buildings with 29%, health buildings with 16% and offices with 13 % (Figure 3). Existing retail buildings encompass a range of this type of building, from retail in mixed used buildings to supermarkets or large malls. On the other hand, the dynamic development of the office buildings sector is reflected by the evolution of the commercial office building stock over the last 5-7 years, justifying the attention which should be paid to this category of building.

Figure 2: Distribution of residential floor area by building type and urbanisation

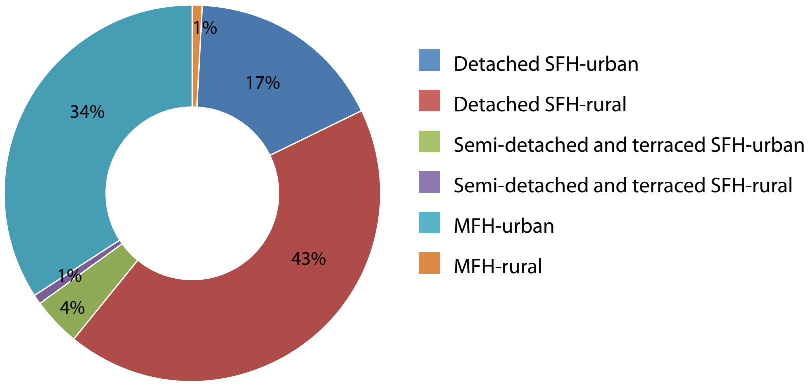
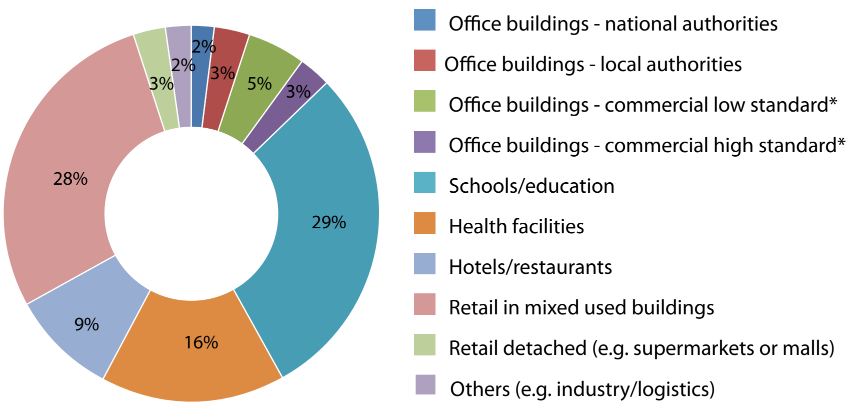


Figure 3: Distribution of non-residential floor area by building type



*) Low standard means low concern for internal comfort and simple HVAC systems (e.g. natural ventilation). High standard means high internal comfort (no overheating), typically achieved by central HVAC-systems.

New construction rates are generally higher in the non-residential sector. Data about new construction per building type category is hard to find. In the residential sector the average new construction rate is about 0.64%[6]. It is not possible to give precise new construction rates per sub-types of buildings. Therefore we can only indicate trends and refer to the average construction rate within the building sector (below or above average). This indication might be misleading, since the rate depends on the denominator, e.g. there might be many houses built in the rural area but the rate may appear below average because the building stock of this type is huge. However, we consider this being the best approximation possible at this stage and acceptable in the context of this study.

For the non-residential sector, the situation is worse; there is no reliable data for each building category. The estimated construction rates for the non-residential sector were very high over the last decade and for certain sub-types even well above 10%/year. This construction rate seems credible if we consider the strong impetus in the service sector in Romania and the lack of existing office buildings. However this

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[6] Based on data from Romanian National Statistics Institute 2005-2011, www.insse.ro

high construction rate cannot last for too many years and will very likely not continue until 2019 when the nZEB requirement should be in place. Market research indicates that floor space of commercial offices almost doubled from 2005 to 2011; however the new high construction rate has been slowing down since 2009 and reached 2.5% in 2011 (Table 4).

Table 4: Development of floor area of commercial office buildings since 2005[7]

Year	2005	2006	2007	2008	2009	2010	2011
Useful area (mill. m^2)	2.5	2.8	3.2	4.1	4.4	4.6	4.7
New built rate (%)	-	12	14	28	7	5	2.5

Therefore we can assume that the construction rates are similar to those of other Central and Eastern European countries (Poland and Hungary), i.e. a new construction rate between 1.5 – 2.5% for the overall non-residential sector and a rate of on average 5% from 2009 to 2011 for office buildings only. For the other categories there is no data available and we indicate the new construction rate to be above or below average as in the case of residential buildings (Table 5).

Table 5: Number of buildings in Romania

Building type		Region	Number of buildings (1000)	Floor area (million m^2)	New construction rate (%)
Residential buildings	Detached single-family houses	Urban	1 189.2	97	Above average
		Rural	3 660.9	237	Below average
	Semi-detached and terraced single-family houses	Urban	112.0	20	Above average
		Rural	54.9	6.3	Below average
	Multi-family buildings	Urban	80.9	191	Below average
		Rural	5.1	5.3	Below average
	Other buildings that cannot be assigned to above categories	Urban	6.3	1.1	Below average
		Rural	8.6	0.5	Below average
	Total		**5 118**	**559**	**0.6**
Non-residential buildings	Commercial and public office		19.1	7.8	Much above average
	Retail		133.5	18.3	Above average
	Hotels & restaurants		5.0	5.2	Above average
	Health facilities		51.3	9.3	Below average
	Educational facilities		8.1	17.4	Below average
	Total		**217.1**	**59.4**	**1.5-2.5***

* Assumption based on the Romanian National Institute of Statistics and authors' best estimation.

[7] Colliers International: Romania Real Estate Review (2011). Market research reports from Romania Colliers International, Bucharest, Romania, 2011 Available at: www.colliers.com/country/romania/

It is worth mentioning that big differences appear between the figures from the 2002 Census and the preliminary data from the 2011 Census. For instance, while Romania's population decreased by more than 2 million inhabitants (with slightly more than 19 million registered inhabitants), there are around 132 million m^2 more in the residential sector (558.8 million m^2 in 2012 compared to 426.5 in 2002) which represents a 31% increase. This can be partially explained on one hand by the general trend towards larger dwellings. (In the past, the average living floor area per inhabitant was around 55m^2.) On the other hand, the data from the 2011 Census is only preliminary.

There is a strong need to improve the reliability of the existing data by improving the data collection process. Data collection should be undertaken more systematically (including an inventory of non-residential buildings) and lead to the integration of all existing data (using different registers and authorities) in one national building database.

4.2. CURRENT REGULATIONS AND PRACTICE FOR NEW BUILDINGS

4.2.1. Energy performance and specific component requirements

In Romania, building code requirements only exist for newly constructed buildings. In terms of minimum energy performance requirements, there are none, neither for newbuild nor renovations. However, the Romanian building code contains prescriptive/element-based criteria for thermal insulation and an overall thermal coefficient (G-value). The global heat transfer coefficient, G (W/m^3K), of the heated volume, is an overall minimum requirement and varies as a function of number of levels of the building and external area per volume ratio (A/V)[8].

For residential buildings the maximum heat demand (per total heated volume) varies from 15 kWh/m^3/year to 37.5 kWh/m^3/year depending on the external area per volume ratio (A/V)[9]. The maximum indicated heat demand does not take into account system efficiencies.

Regarding the energy certification system, classes in EPC are from A (the most efficient) to G (the most energy consuming). Class A in the energy performance certificate (EPC) ranges from 125 kWh/m^2yr (heating, domestic hot water -DHW- and lighting) to 150 kWh/m^2yr (all energy uses). EPC covers heating, cooling, ventilation, DHW and lighting (these are the "utilities", i.e. energy uses). For a building which has no cooling system and no mechanical ventilation system, the energy use class A is below 125 kWh/m^2/yr[10]. These values are not actually imposed as a minimum requirement for new buildings since there is no requirement for final and primary energy in Romania.

According to official evaluations[11], the vast majority of buildings in Romania are in the range of "C" to "D"-classes on an energy certificate level. There are justified concerns that this standard assessment could be too optimistic and that in reality most buildings could be closer to an "E"-standard.

Apart from maximum heat demand there are also specific component requirements in Romanian building codes. These requirements are not connected to EPCs, being based on two separate calculation methods. The building code requirements obviously influence the overall energy performance of a building. Therefore, if a building achieves a good G-value it is mostly expected that the energy demand for heating will be low, and consequently the energy performance will be good. When considering summer conditions, the correlation may not be the same. To obtain a building permit, house builders must prove that the maximum U-value and G-value for the building are respected. The EPC is mandatory at the commissioning phase, but there are no specific requirements such as a maximum energy use or minimum energy class. So, it is theoretically possible to construct an even more energy efficient building

8 BPIE: Europe's Buildings under the Microscope. BPIE, Brussel, Belgium, 2011. Available:at www.bpie.eu

9 The values are from official documents and could be transformed in kWh/m^2, by multiplying by the average height of a floor (between 2.5 to 3m).

10 See more details in EPBD-CA country report (http://www.epbd-ca.org/Medias/Pdf/country_reports_14-04-2011/Romania.pdf)

11 Training for rebuilding Europe (2012a). Building stock data for 13 EU Countries. An Intelligent Energy Europe project, Brussels, Belgium. http://trainrebuild.eu/wp-content/uploads/2011/07/Guidance-Document-for-Trainers.pdf

if desired, but this remains voluntary and depends on costs and energy education. Table 6 gives an overview of these requirements.

Table 6: Specific building code requirements and typical values for new buildings (in W/m²K)

	Walls	Roof	Floor	Windows	Global requirement
Residential (requirement)	0.56 W/m²K	0.20 W/m²K	0.35 W/m²K (floors above unheated basement 0.22 W/m²K (floors, no basement) 0.21 W/m²K (floors of heated basements)	1.30 W/m²K	Global thermal transmittance coefficient, G (W/m³K).
Residential (typical building)	0.56 W/m²K	0.20 W/m²K	0.22 W/m²K	1.30 W/m²K	
Office building (requirement)	Depending on climatic region and thermal inertia, U=0.56…0.67 W/m²K	Depending on climatic region, U=0.22…0.29 W/m²K	Depending on climatic region and thermal inertia, U=0.34…0.50 W/m²K	2.0 W/m²K	Global thermal transmittance coefficient, G (W/m³K).
Office building (typical building)	0.60 W/m²K	0.25 W/m²K	0.35 W/m²K	1.30 W/m²K	

4.2.2. Renewable energy share in new buildings

The building code in Romania doesn't specify any requirements for using renewable energy and DHW in buildings.

4.2.3. Actual practice in construction

4.2.3.1. Enforcement

Building requirements (including minimum thermal performance of building components and global indicator G[12]) are controlled at the stage of construction authorisation (building permit). In principle, the requirements are respected in the design documentation. Otherwise the construction project does not pass the authorisation process. However, in practice, the execution of the work is not always undertaken according to the design and can depend on the budget reduction by the investor. In addition the poor execution of details/joints (thermal bridges) can lead to a reduction of the global thermal resistance of the building envelope and usually result in values which do not respect the minimum thermal requirement.

4.2.3.2. Penalties for non-compliance

If a construction is built without a permit or infringes its permit, the control authorities may order the demolition of those elements which are not compliant with the permit or were built without a permit. In

[12] G is the global heat transfer coefficient (including transmission and ventilation and calculated under design conditions), by division of the total volume of the building

such cases, the construction works can be suspended. In this case, the administrative fine to be paid by the investor is up to approximately €2 300 euro in addition to indemnities for the damage caused.

4.2.3.3. Body responsible for compliance in construction

The main responsible body for compliance control in construction is the State Inspectorate in Constructions (SIC), a public institution with a legal personality, subordinated to the Ministry of Regional Development and Tourism (MDRT). SIC has a control function over the execution of works. The actual inspection for compliance, after issuing the building permit and authorisation of works, is done by either:

- construction inspectors employed by SIC;
- site inspectors/project supervisors (subject to authorisation by SIC) employed by the beneficiary/ building owner;
- technical inspectors (subject to authorisation by MDRT) employed by the contractor.

Compliance with the energy performance regulation is required during the authorisation phase of construction works. During the final commissioning phase, the realisation of an Energy Performance Certificate (EPC) is required. With the exception of apartments in a block of flats, the EPC also displays the energy performance indicator for a reference (national) building (the same geometry as the actual building, but with the minimum thermal requirements fulfilled). This would be equivalent to the energy performance of the same building respecting the minimum energy performance requirements at component level; however the indicated value is purely informative. No additional checks are made in order to verify compliance.

In conclusion, the necessary tools are essentially ready to be used, but there is no mandatory control mechanism established in the current regulation.

There is no reliable data on the compliance/non-compliance levels in Romania (no official data possible). SIC inspectors (special licensed technicians or engineers) usually only control public buildings and large constructions, although it is theoretically mandatory for all buildings. There are only random controls of residential constructions. Thus the level of penalties or fines (e.g. 1.5% for 2011) is not conclusive.

4.2.3.4. Renewable energy and current practice for new buildings

The use of renewable energy technologies in buildings is not a usual practice yet. The main driver for the installation of renewable energy technology in buildings is the "Casa Verde" (Green House) Programme, coordinated by the Environment Fund Administration, which applies to residential and public buildings (for details, see the sub-chapter below on support schemes).

In the non-residential sector, some best practice pilot projects exist, such as for example the solar heating plant in Giurgiu (300m^2 of solar panels installed on two residential blocks to supply hot water to 80 flats), also for three schools, for two sports halls in Giurgiu, for a solar amphitheatre in Targoviste[13], for ICPE experimental stations[14] (as well as the recently opened Solar Park with the first BIPV application in Romania[15]) and for geothermal heat pumps[16]. However; despite the fact that some examples exist, the use of renewable energy technologies in buildings is not current practice in Romania.

Even if the market can offer adequate technology, neither clear mandatory actions, nor provisions stimulating the increase of renewable energy use in buildings exist. The legal act to transpose the EPBD recast (2010/31/EU) is currently in the pipeline (approved by the Government and sent to the Romanian Parliament to be discussed and adopted). It foresees that a feasibility study concerning the

[13] For details see http://solar.valahia.ro/index.html
[14] For details see http://www.icpe.ro/ro/p/1_6_statii_experimentale
[15] For details see http://www.icpe.ro/ro/p/lans_parc_icpe_ro
[16] For details see http://www.geoexchange.ro/Capacitati_Geoexchange_operationale_in_Romania.pdf
[17] Colliers International: Romania Real Estate Review (2011). Market research reports from Romania Colliers International, Bucharest, Romania, 2011

potential use of renewable energy in the designed building has to be provided for each new building at the authorising stage. However, without any incentives for the owner, there is no guarantee that the proposed technologies will be actually applied.

Overall, the most popular technologies are solar thermal systems. Solar electric and heat pumps are also used but their market share is still very small (below 1%).

4.2.4. Workforce education and training for new technologies

There is no fully coherent system in place to ensure the qualification of the building workforce relating to energy efficient technologies or renewable energy systems. The National Qualification Framework is being adapted to align with the European Qualifications Framework (EQF). The occupational standards need to be developed for energy efficiency and renewable energy (RES) skills. All these aspects are tackled by the BUILD UP Skills Romania (ROBUST) project as part of Intelligent Energy Europe (IEE) BUILD UP Skills initiative (under implementation also in the other EU countries). The project aims to develop a national qualification roadmap including continuing education and training of the workforce in the building sector. It shall be endorsed by all relevant stakeholders. The main gaps identified until now (the final identification of the gaps and barriers in the Status Quo Report that was published in August 2012) are mainly of qualitative nature and relate to the increasing need for technology application and the general reduction of the qualified workforce. For renewable energy systems (RES) installers, the certification system or equivalent qualification schemes shall be set-up by the end of 2012 (as mandatory action according to the Renewable Energy Directive, 2009/27/EC).

4.2.5. Current market situation for investments

The sectors with the highest newbuild rates are the retail market (shopping centres and retail parks, with most dynamic being the food and Do-It-Yourself markets), industrial parks (including logistic parks) and offices. All these sectors revealed increased new construction rates up to 2008 , but which declined drastically in 2009 and 2010 (e.g. office market from 26% in 2005 to 47% in 2008 and to 7% in 2010; newbuild rate for class A offices over 3 000m^2 was 24% on average 2006-2010). All other building categories have an average newbuild rate of 10% per year over the last five years (reduced for the last two years).

New construction rates in the residential sector rose from 0.4% in 2005 to 0.8% in 2008 and 0.6% in 2010. There are no statistical data per building type (e.g. SFH, MFH). However, from the annual balance of the dwellings stock (including demolitions and destination changes), the rate for individual buildings can be estimated as being twice the rate for collective buildings.

For the future, the economy is expected to recover after the financial crisis and thereby stimulate a recovery of the construction sector.

The driving factors are the recovery of domestic demand and retail sales, the recovery of existing developers and the arrival of new ones, local authorities increasing investments in infrastructure projects, central authorities supporting the implementation of energy efficiency and RES systems and enforced and clearly established energy requirements for new buildings.

For residential buildings the main investors are from the private sector (90% of the dwellings finalised over the last six years). The same is true for non-residential buildings (>98%). Here big companies have consolidated their operations into single properties (mostly financial institutions, medical and IT&C segments), shopping centres, malls and DIY, retail parks etc.

4.2.6. Low-energy buildings: Additional costs of investments and payback

In general, the additional costs of an energy optimised building are covered by the potential energy cost savings for usual practice rehabilitation (e.g. thermal refurbishment of existing blocks of flats).

However; the situation is not the same for energy upgrading to passive house or very low energy building standards, as well as for the implementation of RES systems. The main reasons are the price of energy, which is still partially subsidised for the population, together with the lack of financial incentives through the state (facilities, stimulation) for the implementation of RES systems.

4.3. CURRENT SUPPORT SCHEMES FOR NEW BUILDINGS

To reduce energy consumption in buildings and to increase the number of buildings with a reduced consumption of energy, the Romanian government implemented two legislative acts, both focusing exclusively on energy savings in retrofitting / upgrading residential buildings.

The first act (Government Emergency Order No 18/2009) has the goal of promoting the increase in the energy performance of multi-family blocks of flats built between 1950 and 1990. The funds for the execution of the intervention works shall be ensured as follows: 50% from the State budget, 30% from funds provided under the local budgets and/or from other legally established sources, and 20% from the owners' association, which is intended for repairs, and/or from other legally-established sources. In order to be eligible for funding, the set of improvements should ensure a decrease in specific annual heating consumption below 100 kWh/square meter of useful area.

The second act (Government Emergency Order No 69/2010) is on the thermal rehabilitation of residential buildings with funds from bank loans, granted under a government guarantee. This act should ensure the non-discriminatory access of owners' associations and natural persons acting as owners of single-family residential buildings to bank loans granted under a government guarantee and having a subsidised interest rate for the thermal rehabilitation of buildings. The value of the loan may account for up to 90% of the value of the works to be executed, limited to €1 850/room for residential blocks and €7 400/room for individual residences. Local public administration authorities are allowed to contribute up to 30% in the expenses incurred by the thermal rehabilitation of residential buildings[18].

The Regional state aid scheme on the use of renewable energy resources and the National Environment Fund programme for RES development are support instruments for RES-Heating projects[19].

An additional support mechanism is the so called **CASA VERDE (Green House) program,** favouring the implementation of renewable energy systems for heating and hot water in buildings. The program was announced in 2008, modified and postponed several time since then. For residential buildings the non-reimbursable grant is limited to €1 390 for solar thermal systems and biomass (solid), and to €1 850 for heat pumps. The budget allocated for this programme was: €94.4 million in 2009, €26.1 million in 2010 and €23.6 million in 2011. "Casa Verde" became operational and significant in summer 2010. The program provides capital grants for individuals or public buildings for RES heating and hot water systems replacing conventional heating systems[20]. There are periodical calls with a specific budget. In 2010, 15 605 requests were received (small systems / households) accounting for €22.4 million, but only 8 819 were accepted and finally €1.9 million were actually paid for only 1 340 requests. In addition to this, 126 projects have been approved in 2010 (submitted in 2009) for administrative units (local councils, schools, hospitals) with a total approved budget of €25.7 million (no implementation data available). In 2011, 14 223 requests were approved (including the ones from 2010 which were not analysed in 2010) for a total amount of €19.7 million. The actual amount paid in 2011 and 2012 is not known (officially). Currently (May 2012), there are no accepted funding requests; the requests already registered are being analysed for approval.

[18] Romania report under article 10(2) of the Directive 2010/31/EU of existing and proposed measures and instruments which promote the objectives of the EPBD, available here: http://ec.europa.eu/energy/efficiency/buildings/implementation_en.htm10

[19] E. Teckenburg, M.R., T. Winkel, Ecofys,, M. Ragwitz, S.S., Fruanhofer ISI, G. Resch, C.P., S. Busch, EEG,,I. Konstantinaviciute, L.e.i. (2011). Renewable energy policy country profiles. Ecofys, Fraunhofer, Energy Economics Group, LEI. Available at: www.reshaping-res-policy.eu

[20] The Ministry of Environment and the national Environment Fund manage the instrument. Details are given on: http://www.mmediu.ro/casa_verde.htm and http://www.afm.ro/program_casa_verde-pf.php
The instrument was introduced by the Ministry Order no.1339/2008. The instrument guide, approved by the Order no. 950/17 June 2010, is available at http://www.afm.ro/main/info_stuf/casa_verde/ordinul_950_17.06.2010_aprobare_ghid_casa_verde.pdf

There are no additional instruments to promote RES-H on the regional/local level. There are no RES support schemes specifically related to district heating, small scale heating or industrial applications.

High potential technologies in terms of market deployment and growth rates are the biomass technologies based on agricultural waste, forestry waste and biogas both in CHP and District Heating (DH) plants but even more in the individual non-grid connected heat sector. Nowadays, only biomass in the individual, non-grid connected heat sector is partly exploited, mainly in the form of log wood and mostly used in inefficient rural stoves. A switch towards more efficient residential heating systems and to DH systems supplied by modern boilers or CHP units is expected[21].

4.4. CURRENT MARKET SITUATION FOR DISTRICT HEATING

A specificity of the Romanian building stock is the rather high number of buildings connected to district heating (DH) networks. District heating is widespread in big cities (also in some smaller ones), the heat being generated also in CHP, but most of them are old and inefficient (some of them have been rehabilitated over the past two decades). The district heating network should significantly be improved. While the number of dwellings connected to the DH decreased in recent years, around 1.5 million dwellings still are connected. They represent mostly apartments (approx. 18.36% of Romanian dwellings) and around half of the dwellings in multi-family buildings[22].

The main problem with DH systems is the continuous price increase which is beyond households' affordability limit which is recognised as 10% of the available household budget. The main findings from the study about challenges and opportunities for district heating systems in Romania are[23]:

- Current DH systems are not efficient, with an improvement potential of around 30%;
- Annual energy costs for a dwelling may be between 20-40% lower in case of an efficient DH systems (compared to individual gas heating systems);
- At the moment, DH systems are very carbon intensive due to the low utilisation of renewables and waste. Therefore it is important to exploit the local potential for alternative, less polluting and cheaper fuels;
- The need for around €5 billion of investments by 2020 in order to keep pace with the EU agreements and 2020 targets and to update the systems (around €500 mill./yr investments as comparing to the actual €30 mill./yr);
- There are now high subsidies for heat energy from DH systems of up to 40% of the costs, which represents a high budgetary effort of around €500 mill./yr;
- There is a need to gradually reduce the subsidies from 2012 onwards and finally phase out the subsidies and to liberalise the energy prices for heating as agreed with the EU and IMF.

There are some efficient and even renewable DH systems in Romania. In those cities where renewable energy is used by exploiting the local potential, the prices are lower than in the others where gas and oil is the only energy carrier. Giurgiu, Beius, Huedin are examples of isolated cases using renewable energies. In addition to these cities, Oltenita city (around 25 000 inhabitants) is another good example. Briefly, they installed some distributed thermal plants with high efficiency in production and distribution (for both heating and DHW), plus additional pilot solar thermal collectors and a pellet boiler in one of the plants. The real price for Gcal is 299 lei, which is lower than that in most of the Romanian cities and at the same time is less driven by gas prices due to renewable energies[24].

[21] E. Teckenburg, M.R., T. Winkel, Ecofys,, M. Ragwitz, S.S., Fruanhofer ISI,, G. Resch, C.P., S. Busch, EEG,,I. Konstantinaviciute, L.e.i. (2011). Renewable energy policy country profiles. Ecofys, Fraunhofer, Energy Economics Group, LEI. Available at: www.reshaping-res-policy.eu

[22] PWC Romania: Provocari si Oportunitati pentru sistemul de furnizare centralizata a energiei termice din Romania, June 2011, available here: http://www.pwc.com/ro/en/publications/assets/assets_2011/Provocari_Oportunitati_Energie_Termica.pdf

[23] Idem previous footnote

[24] Money.ro (2011). Ca în Japonia: Un oraş din România e încălzit cu calculatorul . Money.ro, Bucharest, Romania. In Romanian Available at: http://www.pwc.com/ro/en/publications/assets/assets_2011/Provocari_Oportunitati_Energie_Termica.pdf

5. SIMULATION OF nZEB OPTIONS ACCORDING TO LOCAL CONDITIONS

5.1. DEFINITION OF REFERENCE BUILDINGS

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:

- Detached single-family houses (SFH)
- Multi-family houses (MFH)
- 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 fewer 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.

5.1.1. Reference building N°1: Single-family house (SFH)

The first reference building for Romania is an individual detached house on two floors, in accordance with the identified current practice in construction. It is a building with a comparably simple architecture with a sloped roof facing the South. The conditioned space on the ground floor and first floor is heated to 20°C. The basement (garage and boiler room) and the roof level are assumed to not be heated. The sketches of the reference SFH are in Annex 1 of the study.

The general heating system is a central gas boiler heating system with radiators. The Domestic Hot Water (DHW) system uses a 250 litre tank and is connected to the heating boiler. There is no mechanical ventilation system, i.e. only natural ventilation by windows is performed. As for the general cooling system, a split system exists. There is no solar thermal system and no PV system installed on the roof. The main building characteristics are summarised in the following table.

Table 7: Characteristics of reference Romanian single-family house (specified equivalent U-values consider also thermal cold bridges)

Parameter	Value/Description
Number of conditioned floors	2
Net floor area	99.7 m^2
Room height	2.5 m
U-walls	0.56 W/(m^2K)
U-roof	0.35 W/(m^2K)
U-floor	0.52 W/(m^2K)
U-windows, frame fraction	1.30 W/(m^2K); 30%
Window fraction (window/wall-ratio)	12% (no windows on North facade)
Shading	None
Air tightness	Moderate
Thermal bridges	Yes
Heating system	Gas boiler (set point: 20°C), Heating efficiency: 0.9
DHW system	Same as for heating, DHW efficiency: 0.9
Ventilation system	Natural/window ventilation (0.5 1/h)
Cooling system	Split system (set point: 26°C), SEER[25]: 2.75
Internal gains[26]	5 W/m^2
Installed lighting power[27]	18 W/m^2
Automatic lighting control	No

5.1.2. Reference building N°2: Multi-family house (MFH)

The second reference building is a multi-family house on six floors, in accordance with the identified current practice in construction. The roof is flat and the conditioned space over the six floors is heated to 20°C. The two basements (partially garage) are assumed to be not heated. The sketches of the reference MFH are included in Annex 1 of the study.

The general heating system is a central gas boiler heating system with radiators. The Domestic Hot Water (DHW) system uses a 2 400 litre tank and is connected to the heating boiler. There is no mechanical ventilation system, i.e. only natural ventilation by windows is performed. As for the general cooling system, a split system exists in each apartment. There are no solar thermal systems and no PV system installed on the roof. The main building characteristics are summarised in the following table.

[25] 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.
[26] This value is to be understood as the maximum value.
[27] This value is to be understood as a maximum value. For the hourly demand individual schedules for every zone have been considered. The maximum value of those schedules is 13 % occuring at the evening hours.

Table 8: Characteristics of reference Romanian multi-family house (specified equivalent U-values consider also thermal cold bridges)

Parameter	Value/Description
Number of conditioned floors	6
Net floor area	2 870 m^2
Room height	2.73 m
U-walls	0.6 W/(m^2K)
U-roof	0.24 W/(m^2K)
U-floor	0.60 W/(m^2K)
U-windows, frame fraction	1.30 W/(m^2K), 30%
Window fraction (window/wall-ratio)	23%
Shading	None
Air tightness	Moderate
Thermal bridges	Yes
Heating system	Gas boiler (set point: 20°C), Heating efficiency: 0.9
DHW system	Same as for heating, DHW efficiency: 0.9
Ventilation system	Natural/window ventilation (0.5 1/h)
Cooling system	Split system (set point: 26°C), SEER: 2.75
Internal gains[28]	5 W/m^2
Installed lighting power[29]	18 W/m^2
Automatic lighting control	No

5.1.3. Reference building N°3: Office building

The third reference building is an office building on the 3 to 5 floors, with a high amount of glazing area (55% window fraction), as identified in accordance with the current practice in construction. The roof is flat and the conditioned space is heated to 20°C. The basement (garage) is assumed to be not heated. The sketches of the reference office building are included in Annex 1 of the study.

Heating and cooling are provided by fan coil units using a central gas boiler as heating source. The Domestic Hot Water (DHW) system uses a 300 litre tank and is connected to the heating boiler. The building has mechanical ventilation without heat recovery. There are no solar thermal systems and no PV system installed on the roof. The main building characteristics are summarized in the following table.

[28] This value is to be understood as a maximum value.
[29] These values are to be understood as the maximum value. For the hourly demand individual schedules for every zone have been considered. The maximum value of those schedules is 13 % occuring at the evening hours.

Table 9: Characteristics of reference Romanian office building (specified equivalent U-values consider also thermal cold bridges)

Parameter	Value/Description
Number of conditioned floors	3-5
Net floor area	2 817 m^2
Room height	3.30 m
U-walls	0.61 W/(m^2K)
U-roof	0.33 W/(m^2K)
U-floor	0.64 W/(m^2K)
U-windows, frame fraction	1.30 W/(m^2K), 15%
Window fraction (window/wall-ratio)	55% (East side without glazing)
Shading	None
Air tightness	Moderate
Thermal bridges	Yes
Heating system	Gas boiler, fan coils (set point: 20°C), Heating efficiency: 0.9
DHW system	Same as for heating, DHW efficiency: 0.9
Ventilation system	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
	Conference rooms: 2.72 1/h
	Other rooms: 0.46 1/h
Cooling system	Central chiller, fan coils, (set point: 26°C), SEER: 2.7
Internal gains[30]	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
	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[31]	10 W/m^2
Automatic lighting control	No

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

5.2. DEFINITION OF NZEB OPTIONS, BASIC ASSUMPTIONS AND SIMULATION APPROACH

5.2.1. nZEB solutions for single-family house (SFH)

For all variants – for comparison reasons – the geometry of the reference buildings has not been changed, even they are not optimum for a very low-energy building. The reference building identified by the country expert had the cellar with the sub terrain garage as part of the heated areas. However, this was assumed to be unheated with insulation at the cellar ceiling (0.52 W/m²K). Table 10 shows the variants considered for simulations with TRNSYS.

Table 10: 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 U-Roof: 0.35 W/m².K U-Floor: 0.52 W/m².K	1.3 W/m².K	0%	No	Reference
V1	U-Wall: 0.15 W/m².K U-Roof: 0.12 W/m².K 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 U-Roof: 0.12 W/m².K 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 U-Roof: 0.12 W/m².K 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 U-Roof: 0.10 W/m².K U-Floor: 0.36 W/m².K	0.80 W/m².K	90%	No	Passive house standard[32]
V5	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.36 W/m².K	0.80 W/m².K	90%	Yes	Passive house standard + 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[33]
3. Ground collector brine heat pump
4. Gas condensing boiler

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

[33] V1 and V2 will be considered to have a low temperature floor heating system to get a better system efficiency

5.2.2. 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 11 shows the variants simulated with TRNSYS.

Table 11: 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/m².K U-Roof: 0.24 W/m².K U-Floor: 0.60 W/m².K	1.3 W/m².K	0%	No	Reference
V1	U-Wall: 0.20 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.40 W/m².K	1.0 W/m².K	0%	No	Improved building shell
V2	U-Wall: 0.60 W/m².K U-Roof: 0.24 W/m².K U-Floor: 0.60 W/m².K	1.3 W/m².K	80%	No	Mech. ventilation with heat recovery
V3	U-Wall: 0.20 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.40 W/m².K	1.0 W/m².K	80%	No	Improved building shell + mech. ventilation with heat recovery
V4	U-Wall: 0.20 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.40 W/m².K	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 four base variants the following four heating source options have been considered:

1. Wood pellet boiler
2. Air source heat pump[34]
3. Ground collector brine heat pump
4. Gas condensing boiler
5. District heating

5.2.3. nZEB solutions for office buildings

Similarly, for office buildings simulation, the geometry of the reference was kept, even if it is not an optimum for an nZEB. Table 12 shows the variants simulated with TRNSYS.

[34] V1 and V2 will be considered to have a low temperature floor heating system to get a better system efficiency

Table 12: 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/m².K U-Roof: 0.33 W/m².K U-Floor: 0.64 W/m².K	1.3 W/m².K	0%	None	55%	Manual control	No	Reference
V1	U-Wall: 0.61 W/m².K U-Roof: 0.33 W/m².K U-Floor: 0.64 W/m².K	1.3 W/m².K	80%	None	55%	Manual control	No	Mech. ventilation with heat recovery
V2	U-Wall: 0.15 W/m².K U-Roof: 0.12 W/m².K U-Floor: 0.23 W/m².K	1.0 W/m².K	80%	Automatic	55%	Manual control	No	Mech. ventilation with heat recovery + improved building shell + external shading
V3	U-Wall: 0.15 W/m².K U-Roof: 0.12 W/m².K U-Floor: 0.23 W/m².K	1.0 W/m².K	80%	Automatic	36%	Manual control	No	Mech. ventilation with heat recovery + improved building shell + external shading + reduced window share
V4	U-Wall: 0.15 W/m².K U-Roof: 0.12 W/m².K U-Floor: 0.23 W/m².K	1.0 W/m².K	80%	Automatic	36%	Automatic controlled lighting	No	Mech. ventilation with heat recovery + improved building shell + external shading + reduced window share + automatic lighting control
V5	U-Wall: 0.15 W/m².K U-Roof: 0.12 W/m².K U-Floor: 0.23 W/m².K	1.0 W/m².K	80%	Automatic	36%	Automatic controlled lighting	Yes	Mech. ventilation with heat recovery + improved building shell + external shading + reduced window share + automatic lighting control + 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

5.2.4. General assumptions of the calculations

For calculating the impact of different supply options in the building's overall energy and CO_2 balances, the following general assumptions have been considered:

Table 13: Assumed CO_2-emissions, primary-energy-factors and shares of renewable energy of the considered energy carriers

Parameter	Unit	Off-site, grid electricity	District Heating[35]	Natural gas	Wood pellets	On-site electricity[36]
CO_2 factor[37]	[kg/kWh]	0.252	0.141	0.202	0.0	-0.252
Renewable share[38]	[%]	35	50	0	100	100
Primary energy factor[39]	[-]	2.0	0.9	1.1	0.2	-2.0

For grid electricity the projected EU-27 average values (for detailed description see footnotes) have been chosen in consideration that local building sector targets should not be influenced by local power sector efficiency and thereby ensure consistency with the overall EU targets. However, the thresholds that will be recommended to be implemented in Romania according to the roadmap (see Chapter 8) will take into account actual Romanian primary energy and CO_2 emission factors (which are at the moment 2.8 and 0.171kgCO_2/m^2/yr respectively). It should be noted that, due to future decarbonisation of electricity production systems, the primary energy factors will decrease. Therefore, this anticipated improvements of primary energy and CO_2 factors will be reflected in tighter thresholds for CO_2 in the proposed nZEB definitions.

The Romanian market currently does not offer 100% renewable electricity products, which could increase the number of possible nZEB solutions.

The local specific energy production of PV systems per kWp was assumed to be 1 150 kWh/kWp[40].

Assumed necessary heating capacities for reference buildings are in Table 14.

[35] The district heating was assumed to be supplied by 40% wood, 10% solar thermal and 50% gas. The distribution losses were assumed to be 40%.
[36] For the purpose of this simulation only photovoltaic (PV) is considered.
[37] For the calculation the EU-27 average was applied. For the CO_2 emissions factors of electricity average values for the years 2011 to 2040 were assumed, taking into account a constant decrease towards -90% by 2050 (according to the power-sector reduction target).
[38] The shares of renewable energy are calculated as "2011 to 2040"- average values, based on the renewable energy projections of the Energy Environment Agency and the ECN for the EU-27.
[39] The primary energy factor for electricity was calculated as "2011 to 2040"- average value, based on the renewable energy projections of the Energy Environment Agency and the ECN for the EU-27. The remaining primary energy factors were calculated using EPB calculation methodology (MC001-2006).
[40] Joint Research Centre - European Commission (2012). Web Page: Photovoltaic Geographical Information System - Interactive Maps. Available: at : http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php

Table 14: Installed heating capacity of the heating systems for Romania

Variant	SFH [kW]	MFH [kW]	OFFICE [kW]
V0	10.8	153	333
V1 A	5.8	133	171
V1 B	5.8	133	171
V1 C	5.8	133	171
V1 D	5.8	133	171
V1 E	5.8	133	171
V2 A	5.8	99	117
V2 B	5.8	99	117
V2 C	5.8	99	117
V2 D	5.8	99	117
V2 E	5.8	99	117
V3 A	4.1	80	100
V3 B	4.1	80	100
V3 C	4.1	80	100
V3 D	4.1	80	100
V3 E	4.1	80	100
V4 A	3.3	80	100
V4 B	3.3	80	100
V4 C	3.3	80	100
V4 D	3.3	80	100
V4 E	3.3	80	100
V5 A	3.3	-	100
V5 B	3.3	-	100
V5 C	3.3	-	100
V5 D	3.3	-	100
V5 E	3.3	-	100

5.2.5. Simulation Approach

The results of the simulations of the predefined solutions are analysed in comparison with the nZEB principles defined in Chapter 2.

The following parameters are considered and calculated:

- Specific final energy demand detailed by building services (i.e. heating, domestic hot water, cooling, ventilation and auxiliary energy)
- Specific primary energy demand
- Share of renewable energies
- Specific CO_2 emissions

In addition to the above-mentioned assumptions, for all solutions a further set of solutions with a rooftop PV system for compensating the remaining CO_2 emissions was assumed. The available roof areas as well as the required areas for solar thermal systems have also been considered; in some cases full compensation cannot be achieved.

The sizes of the building's roof as well as the considered solar-thermal collectors introduce a limitation for the PV compensation in terms of maximum installed capacity such as in the followings: 4.8 kWp for SFH; 43.8 kWp for MFH and 61.6 kWp for office buildings.

Table 15 shows the derived sizes of the rooftop PV systems, which were necessary for reaching a high-degree or even full compensation of building's CO_2 emission.

Table 15: Sizes of the rooftop PV systems, necessary for a compensation of the CO_2-emissions

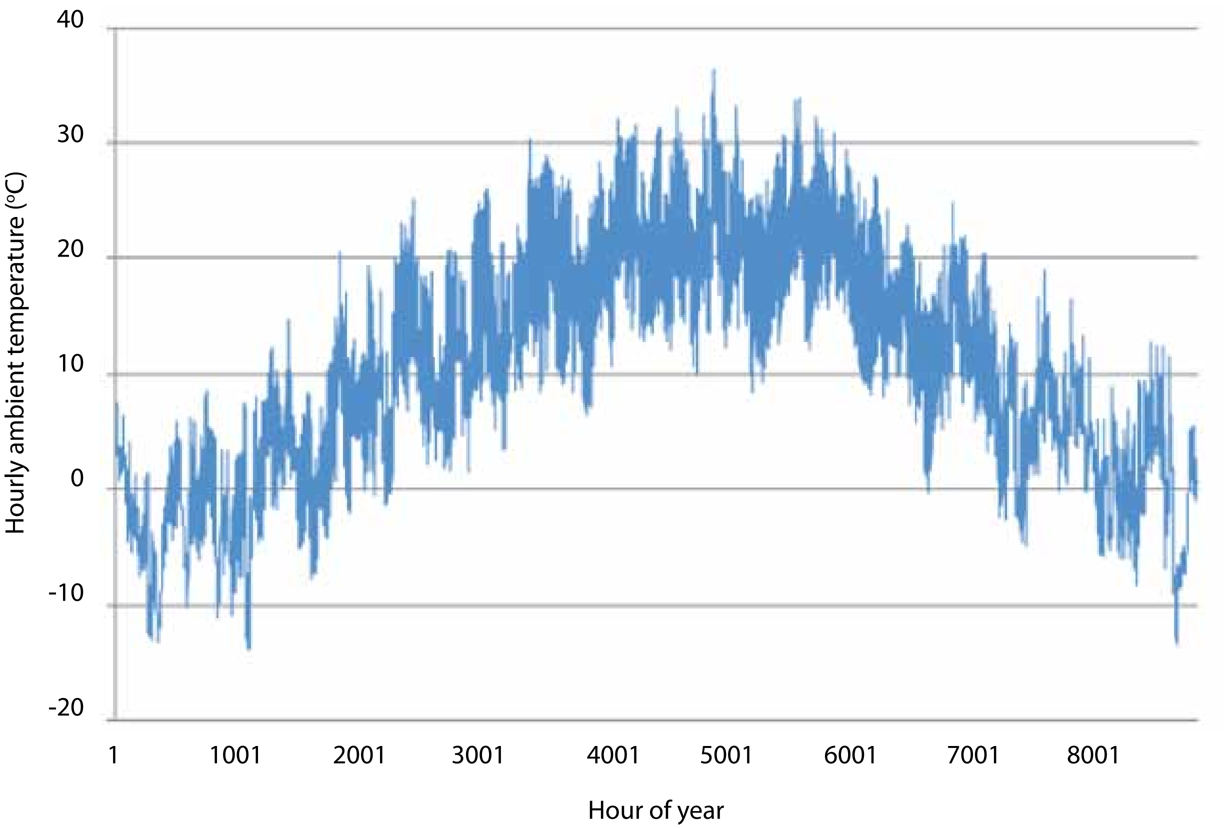
Variant	SFH [kW]	MFH [kW]	OFFICE [kW]
V1 A	2.1	43.8	61.6
V1 B	1.7	43.8	61.6
V1 C	0.6	7.6	61.6
V1 D	4.8	43.8	61.6
V1 E	-	43.8	61.6
V2 A	1.6	43.8	61.6
V2 B	1.2	43.8	61.6
V2 C	0.6	13.2	61.6
V2 D	4.0	43.8	61.6
V2 E	-	43.8	61.6
V3 A	1.6	43.8	61.6
V3 B	1.4	43.8	61.6
V3 C	0.6	14.1	61.6
V3 D	3.8	43.8	61.6
V3 E	-	43.8	61.6
V4 A	1.4	38.8	61.6
V4 B	1.2	38.8	61.6
V4 C	0.6	14.5	61.6
V4 D	2.9	38.8	61.6
V4 E	-	38.8	61.6
V5 A	0.9	-	61.6
V5 B	0.8	-	61.5
V5 C	0.6	-	55.0
V5 D	1.6	-	61.6
V5 E	-	-	61.6

Remark: The electricity produced by PV was calculated as a negative contribution to the specific CO_2 emissions and the specific primary energy demand for the base nZEB system solutions, assuming the CO_2 emission and primary energy factors of conventional grid electricity. Negative values for the CO_2 emissions and the primary energy are possible for those solutions, where the required CO_2 compensation (i.e. for the associated CO_2 emissions of the primary energy consumption of the buildings) is less than the smallest PV system (assumed to be 0.6 kWp). In cases where the rooftop PV system produces more energy than the annual demand (=> plus energy buildings) a renewable energy share above 100% is possible. On the other hand, especially for MFH and office buildings solutions, it is possible that the available roof space doesn't permit full CO_2 compensation. The existence of solar collectors leads to a further reduction of the maximum available roof space for PV.

The internationally known and well proven software tool "TRaNsient SYstems Simulation" (abbreviation: TRNSYS, version 17) has been used to perform the necessary multi-zoned dynamic simulations. Each agreed reference building was split up into several zones (e.g. living room, bedroom, kitchen for SFH) to be able to take into account the differing person density or internal gains in each of the zones.

The climatic conditions forming the basis for the reference building simulations originate from Meteonorm 6.1. The following graph shows the hourly ambient temperatures for the agreed location of Bucharest.

Figure 4: Hourly ambient temperature in Bucharest



5.3. RESULTS OF SIMULATIONS AND ECONOMIC CALCULATIONS

The three predefined reference buildings for SFH, MFH and office buildings were simulated using the above presented assumptions and by considering the defined variants for heating, cooling, ventilation and domestic hot water (DHW) supply. The purpose of this simulation is to determine the buildings' final and primary energy consumption, renewable energy share, CO_2 emissions and therefore to perform the economic analysis and to identify the cost-optimal nZEB solutions.

5.3.1. Final energy demand

Mainly because of its size, the reference single-family house (SFH) has the highest specific energy demand for heating. With most ambitious solutions the specific final energy demand for SFH can be reduced even below 10 kWh/m²*yr.

The multi-family house (MFH) has a higher specific DHW demand and less space on the roof for solar collectors than the SFH. The specific final energy demand for the most ambitious MFH solution is therefore 15 kWh/m²*yr higher than the final energy demand of the SFH.

As the lighting demand has to be considered for the office building and the shares for the cooling and ventilation demands are higher than for the residential buildings, the specific final energy demand for the most ambitious office solution is, at about 25 kWh/m²a, the highest among the three examined building types.

All heat pump solutions lead to a significant reduction of the final energy demand.
Detailed breakdown of final energy consumption in the selected reference buildings are presented in Figure 5 (A-C).

5.3.2. Primary energy demand

The gas boiler solutions for the SFH with the CO_2 compensation leads to a theoretical negative specific primary energy demand. Without CO_2 compensation, the minimal specific primary energy ranges between approximately 15 kWh/m²*yr for the most ambitious SFH solutions and more than 40 kWh/m²a for the most ambitious office building solutions.

For the MFH, even with maximum possible CO_2 compensation, the most ambitious gas boiler solution has a specific primary energy demand of more than 15 kWh/m²*yr.

The reference office building has the highest specific primary energy demand. This is due to the fact that, as already mentioned, during the evaluation of final energy demand, additional lighting and ventilation demand should be considered as well as the comparably high demand for cooling. Without CO_2 compensation, the gas boiler solutions indicate the highest primary energy demands.

Considering the CO_2 compensation, solutions below 10 kWh/m²*yr are achievable for all building types.
The primary energy consumption in the selected reference buildings and in different nZEB variants are presented in Figure 6 (A-C).

Figure 5: final energy demand for SFH, MFH and offices by building services

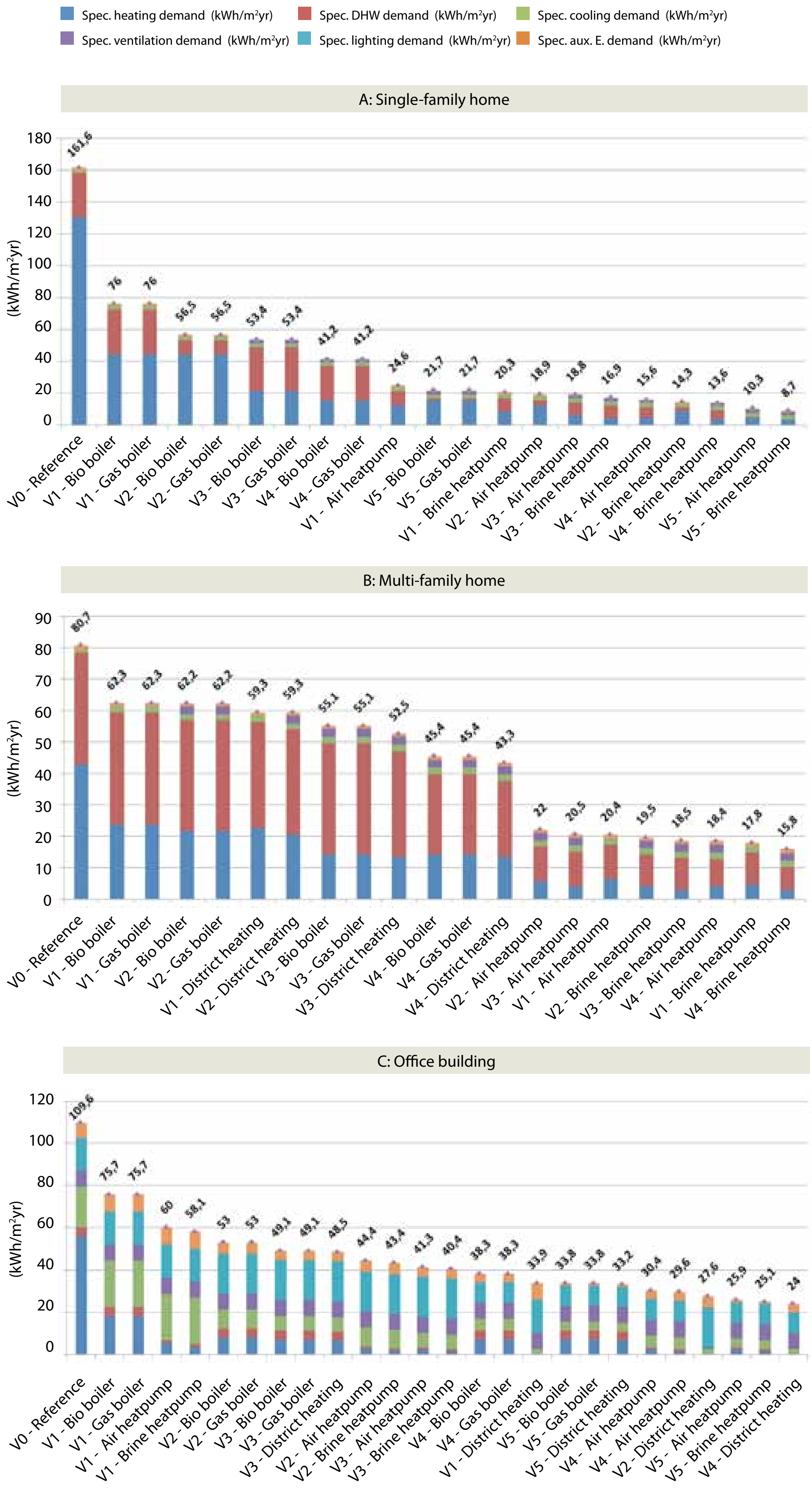
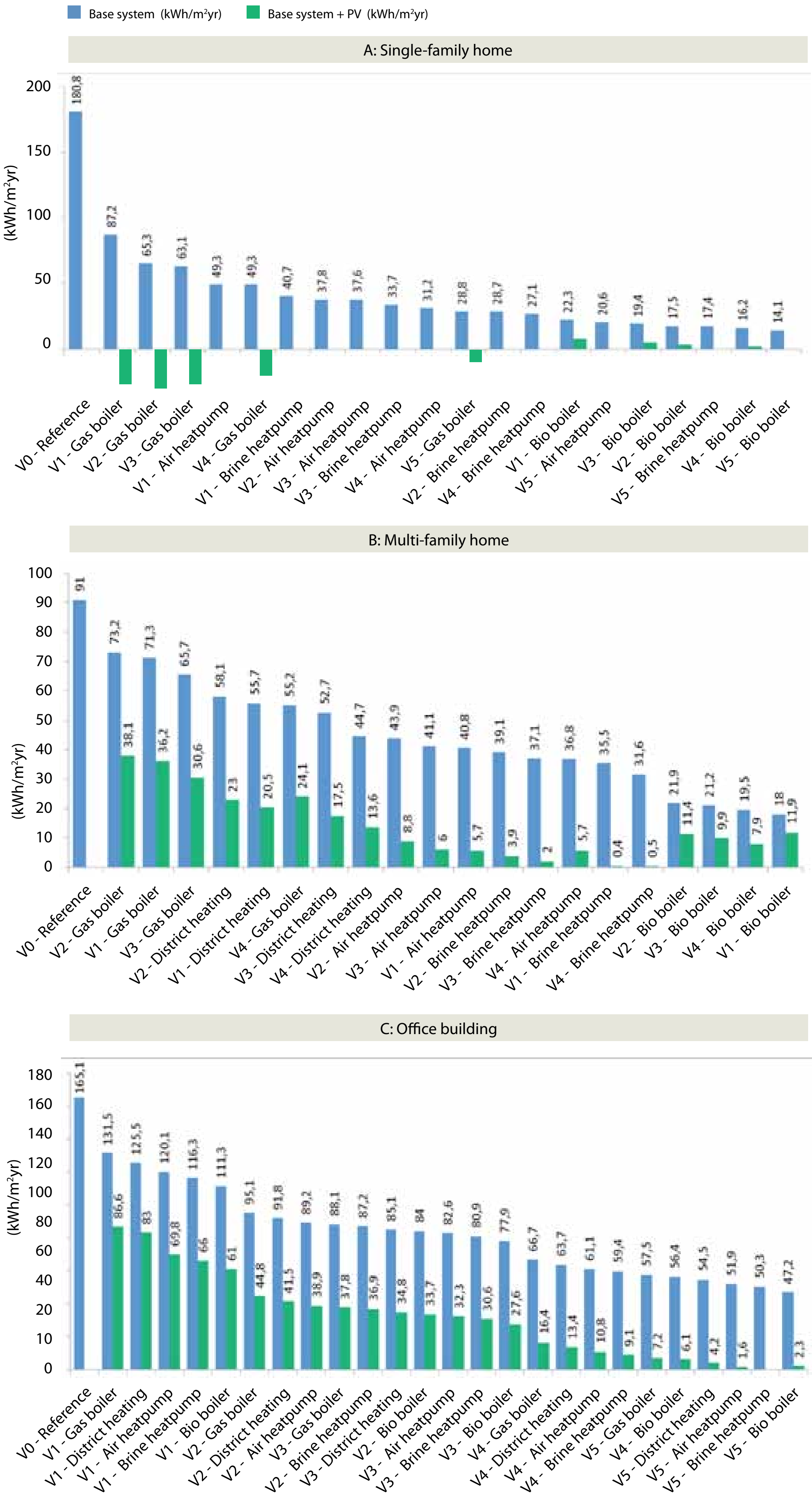


Figure 6: primary energy demand for SFH, MFH and offices



5.3.3. Associated CO_2 emissions energy

For single and multiple family buildings, all bio-boiler solutions are below the 3 kg/m²*yr threshold[41]. The heat-pumps solutions in the most ambitious building insulation variants fulfil the emissions requirement. Almost full CO_2 compensation (zero carbon) by using rooftop PV systems is possible for all SFH variants.

In the case of MFH, the PV compensation moves all the heat-pump solutions and the DH solution (with 50% renewable energy share) below the 3 kg/m²*yr threshold, even in the case of the most ambitious building insulation variant. For the other solutions, the limited roof space of MFH doesn't allow the PV compensation to decrease the building emissions below the threshold.

In the case of the office building, all basic solutions without CO_2 compensation generate specific CO_2 emissions above 3 kg/m²*yr. PV compensation helps achieving the 3 kg/m²*yr requirement for the most ambitious building insulation solutions (V4, V5).

The CO_2 emissions relating to the primary energy consumption in the selected reference buildings and in different nZEB variants are presented in Figure 7 (A-C).

5.3.4. Renewable energy share

The wood pellet boiler solutions indicate the highest share of renewable energies. For the SFH and the MFH solutions, shares between 80% and 100 % were achieved. The share of renewable energies for the wood pellet boiler solutions decreases with reduced heating and DHW demand, because the relative influence of the electricity demand e.g. for the auxiliary energy and the ventilation increases.

The share of renewable energies for the best base office solutions (without CO_2 compensation) range between 50% and 60%, due to significant electricity demands for lighting, cooling and ventilation.

District heating solutions (DH with 50% renewable energy share) lead to renewable energy shares of 50% for MFH and 40% in the case of office buildings.

Apart from most of the gas boiler, district heat solutions and V1 of the office building, nearly all solutions with CO_2 compensation reach a share of 90%.

The renewable energy share in the selected reference buildings and in different nZEB variants are presented in Figure 8 (A-C).

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[41] 3 kgCO_2/m²*yr had been identified as being the upper limit of the building emissions (EU average) for keeping the building sector in line with 2050 decarbonisation goals. More information in BPIE (2011) "Principles for nearly Zero-Energy Buildings - Paving the way for effective implementation of policy requirements". Available at www.bpie.eu

Figure 7: Associated CO_2 emissions for SFH, MFH and offices

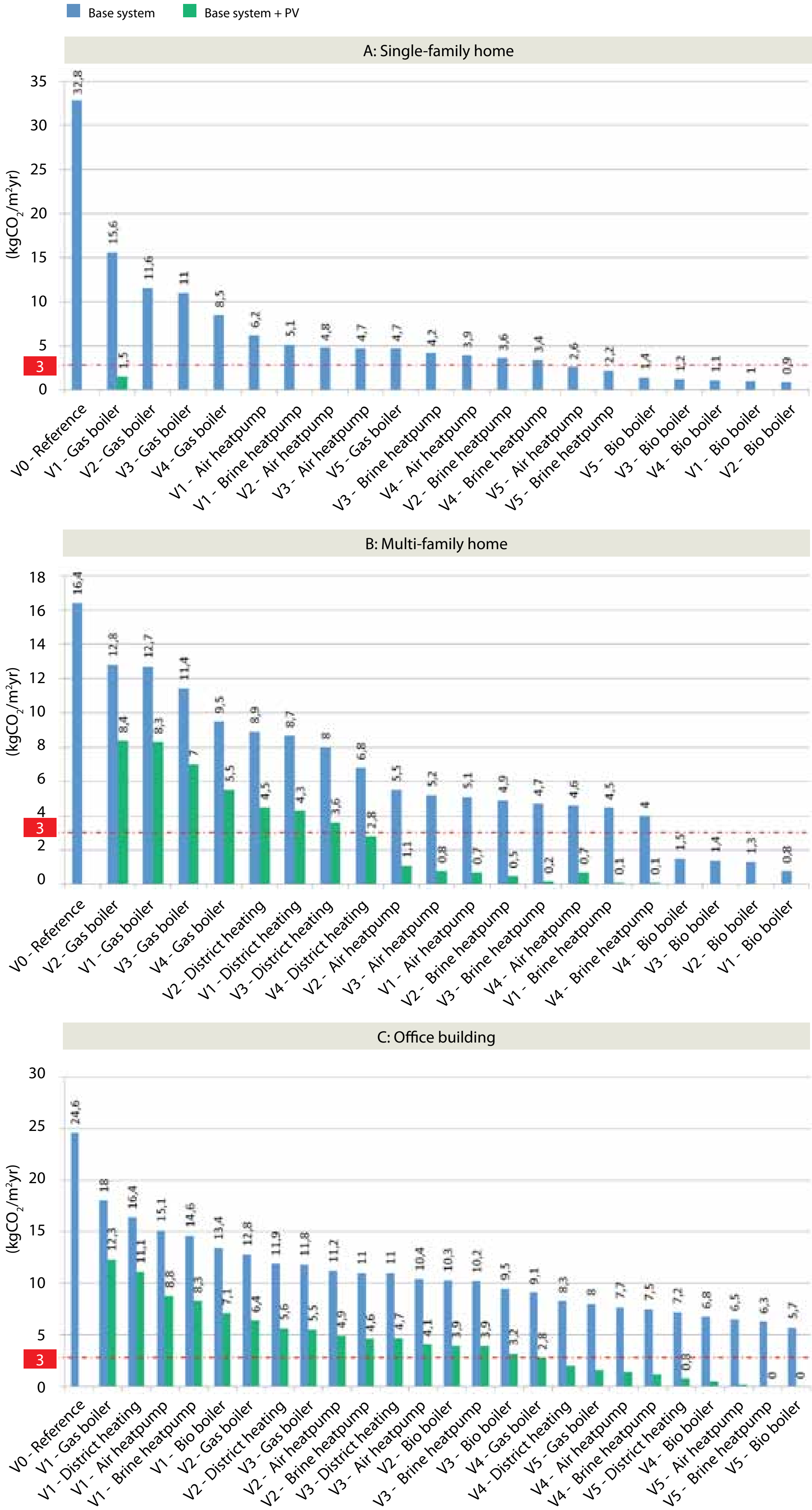
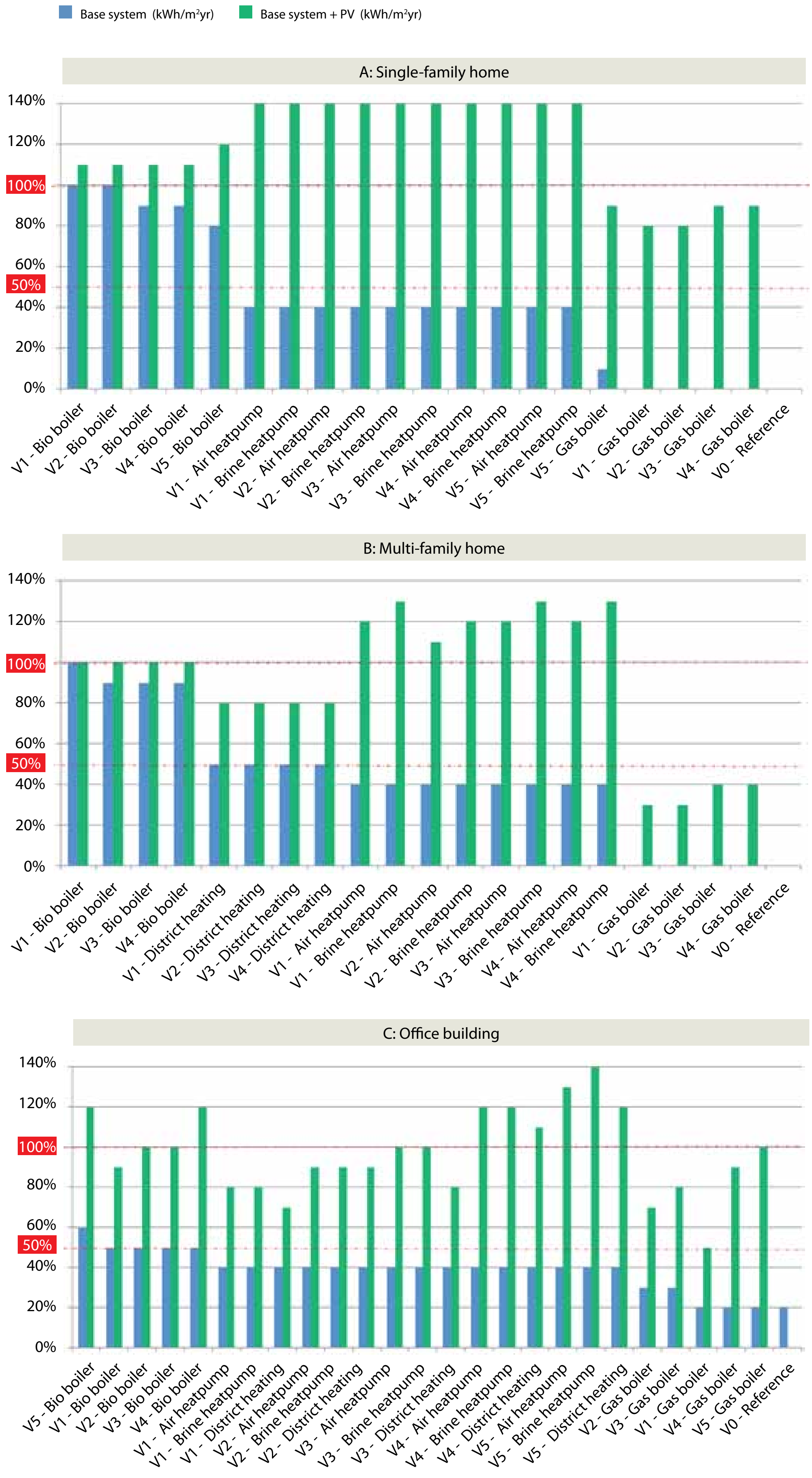


Figure 8: Renewable energy share for SFH, MFH and offices



6. FINANCIAL ANALYSIS OF THE nZEB SOLUTIONS

The financial impacts for single-family, multi-family and office buildings have been calculated by assuming the extra investment costs and related cost savings (mainly reflecting energy savings) of nZEB solutions as compared to the reference buildings according to the current standard.

6.1. BASIC ASSUMPTIONS

The following tables present the assumed energy prices as the basis for estimating the financial impact for private households and offices. These prices are averages, considering a period of 30 years with an anticipated high increase in energy prices over the period 2011-2020 (when a price liberalisation is foreseen) and an average annual price increase rate of 1.5% afterwards (2021-2040).

All calculations for Romania were based on an interest rate of 8% as it is currently the case in Romania.

Table 16: Assumed energy prices for private households and offices/industry (average 2011-2040)

Assumed energy prices for private households (average 2011-2040)			
	Energy price average	Yearly price increase 2011 to 2020	Yearly price increase 2021 to 2040
Gas [€/kWh]	0.044	6.0 %	1.5 %
Conventional electricity [€/kWh]	0.154	5.5 %	1.5 %
Feed-in electricity [€/kWh]	0.154	5.5 %	1.5 %
District heat (50% RES) [€/kWh]	0.023	6.0 %	1.5 %
Wood pellets [€/kWh]	0.054	1.5 %	1.5 %
Assumed energy prices for offices/industry (average 2011-2040)			
	Energy price average	**Yearly price increase 2011 to 2020**	**Yearly price increase 2021 to 2040**
Gas [€/kWh]	0.046	6.0 %	1.5 %
Conventional electricity [€/kWh]	0.198	5.5 %	1.5 %
Feed-in electricity [€/kWh]	0.198	5.5 %	1.5 %
District heat (50% RES) [€/kWh]	0.023	6.0 %	1.5 %
Wood pellets [€/kWh]	0.054	1.5 %	1.5 %

The assumed investment costs as identified on the Romanian market today are described in the following tables. Obviously, investment costs are dependent on specific market circumstances, contract negotiations, sales volumes etc. and might differ substantially at the level of individual projects. This study doesn't take into account the potential price decrease for new technologies. However, this is very probably going to happen after a certain level of market upscale. Consequently, additional costs for new technologies may decrease by 2019/2020 (when the move to nZEB is required) if proper policies are prepared and implemented.

Table 17: Assumed additional* investment costs of building components for Romania (local experts, own investigations)

Component	SFH	MFH	Office	Unit
Additional costs triple glazing	15	15	15	€/m² glazing
Additional costs PH windows	187	-	-	€/m² glazing
Additional costs automatic external shading	-	-	65	€/m² shading
Additional costs heat recovery	21	26	-	€/(m³/h)
Additional costs improved heat recovery	31.5	-	11	€/(m³/h)
Additional costs air tight construction	289	537	537	€
Additional costs automatic lighting control	-	-	7.5	€/m²
Additional costs floor heating	11	11	-	€/m²
Additional costs 1 cm roof insulation	0.51	0.51	0.51	€/m²
Additional costs 1 cm wall insulation	0.47	0.47	0.47	€/m²
Additional costs 1 cm floor insulation	1.13	1.13	1.13	€/m²
Additional costs high efficient cooling system	-	-	909	€/kW
Spec. costs PV system	2 400	1 700	1 700	€/kWp
Spec. costs solar hot water system	1 098	735	-	€/m² collector

*) compare to the reference variants

Table 18: Assumed investment costs of heating system for Romania (source: local experts, own investigations)

Heating system incl. exhaust system [prices €]	SFH (4…9 kW)	MFH (80…130 kW)	OFFICE (100…170 kW)
Gas boiler [€]	3 510	6 970 – 16 690	13 750 – 20 000
Air heat pump [€]	4 280 – 7 360	53 810 – 90 150	67 420 – 115 700
Brine heat pump [€]	8 090 – 13 920	61 940 – 103 770	77 610 – 133 180
Pellet boiler [€]	9 280	19 100 – 37 000	34 930 – 53 070

Table 19: Assumed subsidies for SFH (as they are in CASA VERDE programme)

Technology	Subsidy
Heat pump system	€1 850
Solar thermal system	€1 390
Wood pellet boiler	€1 390

6.2. FINANCIAL ANALYSIS OF THE nZEB SOLUTIONS

The results of cost simulations are presented in Figures 9 and 10. Figure 9 considers only the basic options without the PV compensation; Figure 10 considers the PV compensation (that reduces the building's CO_2 emissions as much as possible to zero within the space limitation of the roof). The graphs show the specific annualised costs (on m^2 of net floor area) over a period of 30 years, which is the usual time period over which a new building doesn't need major interventions and hence additional investments.

The simulation of annualised costs in Figure 9 indicates that the most economic solutions of the MFHs and the office buildings are the district heat solutions. Besides the gas boiler, the second most economic heating system for the SFH is the air/water heat pump. The most economic solutions for the SFH and the MFH (which indicate specific CO_2 emissions below 3 $kgCO_2/m^2/yr$) are those with wood pellet boilers. The lowest annualized costs compared to the reference buildings are at around €7.7 /m^2/yr for the SFH and €1.6/m^2/yr for the MFH.

At the moment there are no specific feed in tariffs for renewable energy in Romania. Therefore, for the nZEB solutions which integrate PV compensation, the feed in tariff (for PV) is assumed to be the same size as the electricity price. For this reason and also due to higher electricity prices for the industry, PV systems (compensating CO_2 emissions) are only economically feasible for the office building.

Three office building solutions with district heating are at comparable annualised cost level to the reference building. Out of these, the most economic nZEB solution with CO_2 emissions below 3 $kgCO_2/m^2/yr$ is the V4-District heating.

The most economic MFH solutions are those with CO_2 emissions below 3 $kgCO_2/m^2/yr$ and PV compensation; the same is true for V4 with district heating. This solution indicates annualised additional costs of €1.7/m^2/yr compared to the reference MFH.

Except for the gas boiler solutions at the SFH, the air heat-pump solution V3 with PV compensation is the most economic solution (additional cost at about €3.6/m^2/yr). It fulfils the CO_2 threshold with emissions slightly above 3 $kgCO_2/m^2/yr$ without PV compensation and below 3 $kgCO_2/m^2/yr$ when PV compensation is considered.

Figure 9: Annualised costs of nZEB solutions without CO_2 compensation

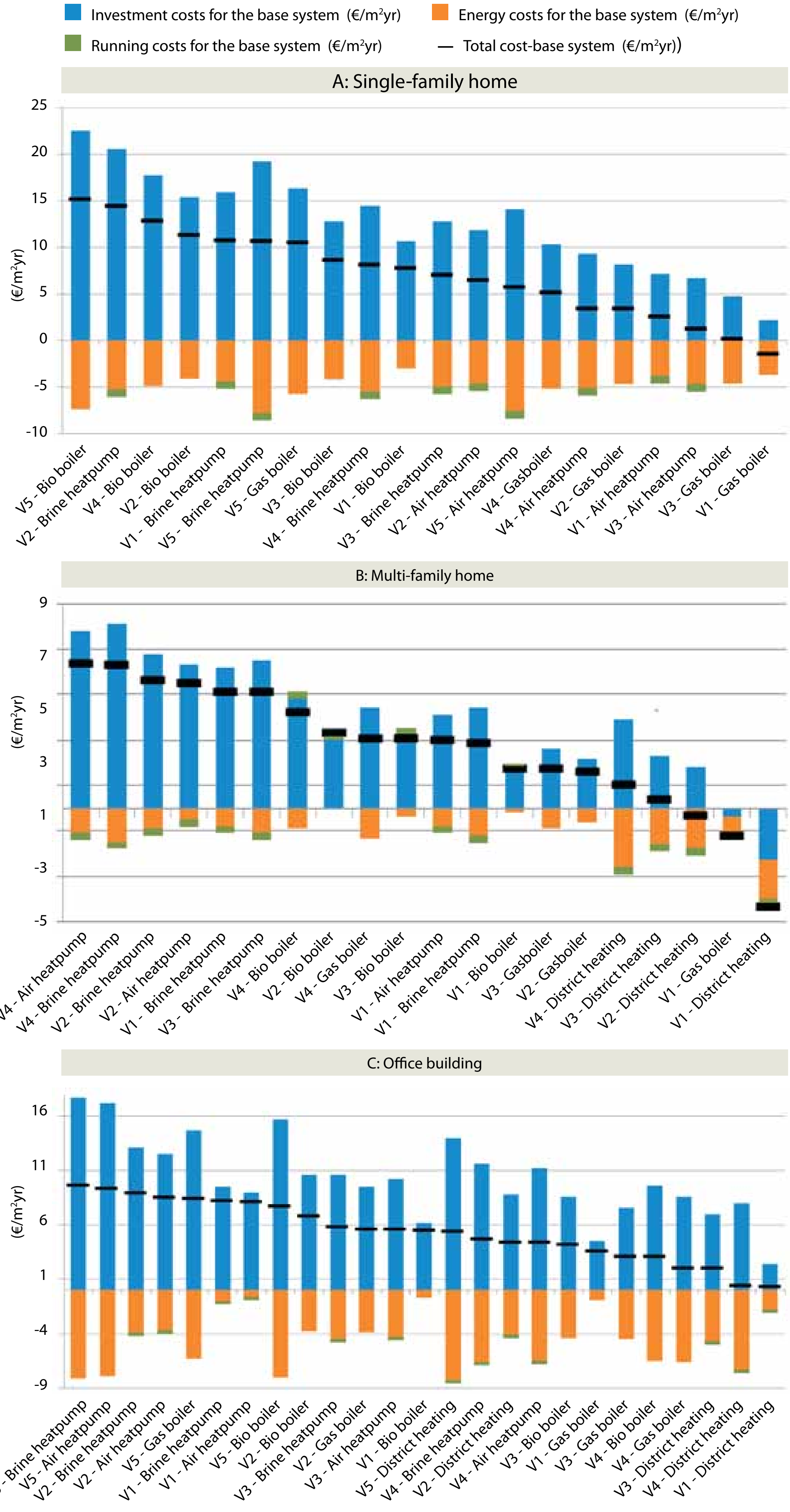
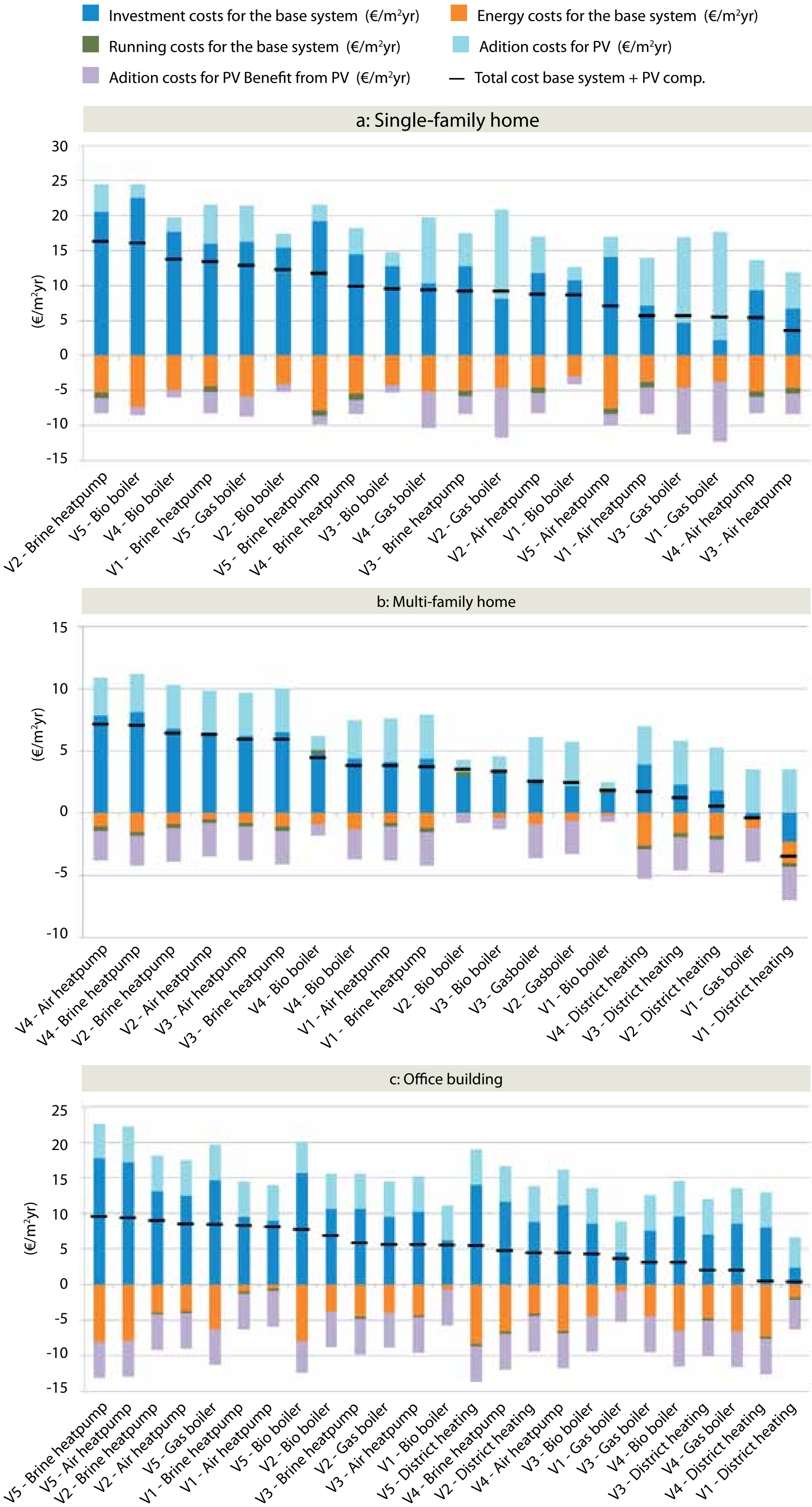


Figure 10: Annualised costs of nZEB solutions with CO_2 compensation



6.3. SUMMARY OF RESULTS

The simulations demonstrate clearly that nZEB solutions in Romania are achievable, even without major changes to the common building shapes.

For full CO_2 compensation and a high share of renewable energy, rooftop PV is sufficient for most of the residential building solutions.

When it comes to office buildings, both the building height (5 levels) and the lighting demand make it more difficult to achieve full CO_2 compensation. But an improvement in the building's geometry will consistently diminish the additional costs.

Without PV compensation, all examined solutions which fulfil the nZEB principles have positive annualised specific additional costs under the given circumstances. Very low energy prices and the actual high interest rate of 8% prevent a return on investment for most of the considered options.

Without favourable feed in tariffs, this is also valid for the rooftop PV for SFHs and MFHs. Due to the higher electricity prices for industrial customers, PV compensation for office buildings is economically feasible.

The annualised specific additional costs for solutions that fulfil the nZEB principles as defined in the previous BPIE study range from around €3.6/m^2/yr (V3 with air heat-pump and rooftop PV) to around €16/m^2/yr.

For MFH, the most economic solution that fulfils the nZEB principles (i.e. V4 with district heating and PV and all pellet boiler solutions without PV compensation) has annualised specific additional costs between €1.5-4.5/m^2/yr.

The most economic office building solution that fulfils nZEB principles has almost no annualised additional costs (i.e. V4 with district heating and maximum roof coverage of PV). Full CO_2 compensation for the office building is only achievable when, on top of V4 package, the cooling system is improved (see solution V5 with brine heat-pump). For this solution the annualised cost rises to about €8/m^2/yr.

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

In this chapter the calculations made for reference buildings will be compared to purchasing power in Romania to make some statements about market affordability.

The simulation results for each solution are shown in tables 20-22. 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, domestic hot water. For office buildings, this includes additionally lighting energy consumption. The colour code used for different nZEB options is in line with the nZEB principles defined in the previous BPIE study[42].

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

Table 20: 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	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 21: Overview of the results for the multi-family 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	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	24.1	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 22: 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	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: The compensation of 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 contributes to 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 e.g. 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). All solutions are with PV compensation and the variations of the most suitable technologies and facade qualities are considered. Table 23 presents these suggestions.

Table 23: Overview of the (cost-) optimal variants and the additional costs in per m² and in percentage of the full costs

Building type	Variant	Brief Description	Heating system	Additional annualized costs (Base year 2010) [€/m²yr]	Additional annualised costs comparing with average reference actual price[43] [%]
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 coo ling: efficient high temperature concrete activation	Bio pellet	7.7	12.3%

[43] 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 increase annualized total costs for new buildings between 2.8 to 11.7% compared to actual market prices for new buildings in this category. The related cost increase is dependent on the building shell, heating system and the type of building. For offices, the increase in annualized total costs ranges from about 0.5 to12.3%.

District heat solutions for multifamily houses turned out to be above the CO_2 emission target of 3 $kgCO_2/m^2/yr$ if the renewable energy share of future district heating is not well above 50% (as assumed in this evaluation). For most of the analysed solutions this renewable energy share is not sufficient to bring down the CO_2 emissions to or below the required 3 $kgCO_2/m^2/yr$. The reason is the low efficiency of district heating systems (assumed here at 40%) and the insufficient share of renewable energies. According to a recent study about Romanian district heating systems[44] , there are some good practices for green district heating (DH). It is presented as a good economic option. DH in Romania with a high share of renewable energy may be a key point for the heating strategy in the future. It is a very valuable option in the context of increasing the energy performance of buildings (including the nZEB).

As suggested in the BPIE study presenting nZEB principles[45], 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 20-22 and taking into consideration the additional costs and results for basic variants without PV compensation, the following levels are proposed to be considered as nZEB definitions for Romania (Table 24).

Table 24: Proposed nZEB definitions for Romania

Building type	Minimum requirements	Year		
		2016	2019	2020
Single-family buildings	Primary energy [$kWh/m^2/yr$]	100		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$]	<10		<3-7
Multi-family buildings	Primary energy [$kWh/m^2/yr$]	70		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$]	<10		<3-7
Office buildings	Primary energy [$kWh/m^2/yr$]	100		40-60
	Renewable share [%]	>20		>40
	CO_2 emissions [$kgCO_2/m^2/yr$]	<13		<5-8
Public office buildings	Primary energy [$kWh/m^2/yr$]	100	40-60	
	Renewable share [%]	>20	>50	
	CO_2 emissions [$kgCO_2/m^2/yr$]	<13	<5	

The above-suggested thresholds for an nZEB definition in Romania are relatively ambitious but yet affordable as several options have additional specific annualised costs below €5 /m^2/yr.

[44] 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.
[45] BPIE (2011b). Principles for nearly Zero-Energy Buildings - Paving the way for effective implementation of policy requirements. Buildings Performance Institute Europe (BPIE). Available at: www.bpie.eu

However, these thresholds are significantly less ambitious than in other Western European countries, which are aiming to reach by 2020 climate neutral, fossil fuel free or even energy positive new buildings[46]. Thinking long term, it is necessary to ensure that the building concept is 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, by creating new activities and jobs and by contributing to a better quality of life.

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.

7.1. AFFORDABILITY OF IDENTIFIED nZEB SOLUTIONS

In 2011 in Romania, the monthly average income after taxation is about €488 per household, from which all living expenses have to be covered i.e. food, energy, transport etc. After deducting all necessary living expenditures, there remains on average €55 per household available for other expenditures.

The calculated cost-optimal variants have additional monthly investment costs ranging between €26-79/month/household in the case of a single-family building and €9-34/month/household in the case of a multi-family building. While most of the variants (with the exception of the variant 3c. bio pellet for the single-family house) are theoretically in the range of the average household's available budget of €55, they cannot be considered being 'affordable'.

Our analysis did not take into account however the expected economic and household income growth by 2021. If the cost of the technologies decreases, nZEB would become economically more feasible. This being said, it is difficult to predict the evolution of the Romanian market, which could be fostered by introducing specific policies and support measures.

On the other hand, the annualised additional costs for the nZEB residential solutions (with an increase of 3.5% to 9.6%) cannot be considered 'unaffordable'. Moreover, the simulation of nZEB solutions from this study were made on reference buildings defined according to the actual practice in construction. By using improved geometries as well as better integration techniques the additional costs may be lowered. There are two possible alternatives that could be considered. A first option is to allow for a higher benchmark regarding the CO2 emissions for nZEB in Romania. The maximum limit of 3kgCO2/m2/yr was identified as the EU average, necessary for reaching the 2050 decarbonisation goals (i.e. 80-90% reduction of CO2 emissions from the buildings sector by 2050). The consequence of allowing for a higher

[46] 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.

benchmark would be that other EU countries need to compensate this with more ambitious standards leading to maximum emissions significantly below 3 kg CO2/m2/yr. Indeed, this is a political discussion about how to share the burden in context of the EU emission reduction targets. Another alternative would be for the Romanian government or the EU to provide higher financial support (e.g. in the form of subsidies) to allow for the implementation of the standards required to reach nZEB levels.

7.2. 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. There is a higher quality of life 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). Concerning the noise protection, the thick and well-insulated structures provide effective sound insulation.
- Ambient benefits arise through reduced energy demand that minimises wider environmental impacts of energy extraction, production and supply.
- There are environmental benefits from improving local air quality.
- Social benefits derive from 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 result from 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[47].

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 25 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.

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

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[48]. Consequently, it is very likely to have a much higher job creation potential than estimated in this study.

Table 25: 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[49]	1 390-2 203 full-time employees

Table 26 shows a detailed overview of the possible contribution of each variant in the residential and the non-residential sector.

Table 26: 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 costs per m^2 [€/m^2yr]	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

[48] 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).

[49] 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'.

8. 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 for communication. They managed to raise awareness for 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 together with a simple but effective monitoring and control mechanism is important.
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[50]. Overlap of supporting financial instruments should be avoided .

8.1. BUILDING CODES

The first condition is the reinforcement of current building codes by a gradual increase of the energy performance requirements as well as their systematic enforcement and compliance controls. The upcoming legislation transposing the EPBD at national level will make sure that energy performance requirements become introduced in building codes. It is also required by the EPBD to relate energy performance requirements to primary energy consumption, in order to have a more accurate picture of the energy quality and of the related CO_2 emissions. This also means that the first measure to be implemented is to reduce as much as possible the energy demand/need of buildings.

In addition, EPBD requires supplying the remaining energy demand/need of the building by onsite and nearly renewable energy, likely to be generated onsite or nearby. This is in line with the actual practices

[50] 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

in implementing very low-energy buildings such as the Passive House standard which imposes a limit of 15kWh/m²/yr for the energy demand for heating, mainly because this is the maximum energy need that can be cover by a heat pump. Nearly Zero-Energy Buildings cannot be evaluated and implemented as a sum of their building components and equipment. Very low-energy buildings should be designed based on a holistic approach in order to minimise the gap between estimated and real energy performance and the overall investments and operation costs of the building. It is recommended to introduce a renewable energy share requirement in the building codes. This is in line with Article 13 from the RES Directive. Implementing nZEBs will positively contribute to both the implementation of buildings and renewable energy policies and thereby help achieve the EU climate and energy targets.

Due to their energy consumption, buildings are responsible for a major share of CO_2 emissions. In its policies for reducing carbon emissions the EU introduced a 20% binding target by 2020 and the ambitious goal of reducing them by 80-90% by 2050. While the carbon emissions of buildings and their respective energy demand will be reduced and the renewable energy use increased, it is recommended to introduce an additional requirement in building codes (even indicative at the beginning) concerning related CO_2 emissions.

For instance in Ireland minimum requirements have been established for both energy consumption and CO_2 emissions. In the UK, buildings performance requirements only refer to CO_2 emissions. According to the EU EPBD, energy performance certificates have to indicate both energy demand and CO_2 emissions of a building. Therefore, introducing a CO_2 threshold for CO_2 emissions of buildings will ensure not only coherence and integration of climate, energy and buildings requirements, but also secure the sustainable development of building sector.

The following table shows the actual status of regulations on building codes for new buildings in Romania and the necessary steps towards the nearly Zero-Energy Buildings levels.

Table 27: Further steps for improving building codes in Romania

State of art	1. Romania has building code requirements only for new buildings and no whole building energy performance-based requirements for new buildings and renovations. 2. Romania has prescriptive/ element-based criteria for thermal insulation and an overall heat transfer coefficient G-value. The global thermal transmittance coefficient, G (W/m³K), of the heated volume, is an overall minimum requirement (for heating only) and varies as a function of the number of levels of the building and external area per volume ratio (A/V).
Gaps in the implementation	1. No specific requirements for primary energy use or CO_2 emissions
What can be improved to achieve the implementation of nZEBs?	1. To secure the path to nZEB in the future, the regulation should be changed. The changes should affect the structure of the regulation and its ambition level. 2. The structure should be adapted, including minimum requirements in primary and primary energy use / CO_2 emissions and the use of renewable energy. 3. The ambition level of the obligations should be tightened.
Intermediate steps	1. Tighten ambition level of obligations: - Tighten requirements for building envelope - Tighten max. final and primary energy use 2. Change structure of regulation: - Introduce minimum energy performance requirements in final / primary energy use and at least indicative requirements for CO_2 emissions - Introduce minimum requirements for renewable energy share or compulsory use of RES equipment

8.2. ENERGY PERFORMANCE CERTIFICATION

In Romania, the energy performance certificate has been compulsory for new buildings since 2007. The certificate was not mandatory for change of ownership and the renting of old buildings. Energy certificates are not necessarily placed on public buildings but are issued for renovated collective buildings and placed at the Owner Associations Office. From 2011 energy certificates are mandatory whenever a flat or house is sold or rented, thus creating an awareness raising wave that could be used to push for a stronger refurbishment and a new nearly zero-energy construction programme.

Anticipating improvements in building codes, energy certificates should be prepared for the upcoming market uptake of very low-energy buildings. The energy scales from the energy certificates should be adapted accordingly in order to cope with the anticipated lower energy consumption of nZEB and to have sufficient steps within 0-100kWh/m^2/yr.

With rising requirements on building energy certification and expert capacity, implementation issues may appear. A solution for avoiding these problems is to upscale programmes for training building certifiers and auditors in a timely fashion and to permanently improve their skills and capabilities.

While some of the measures listed below are already in place in Romania, it is good to remember that to achieve a well-functioning system, it is recommended that all of the following criteria[51] are fulfilled:

1. Existence of a well-structured network of independent energy auditors
2. Mandatory training
3. Limited validity of the professional status of the Energy Certification Assessors (ECA) to a certain period and subject to renewal (e.g. every 5 years)
4. Effective monitoring and control of ECA activities
5. Central database for certificates managed at national level
6. Linkage of capacity building programs with information campaigns and other soft tools

8.3. RAISING AWARENESS AND INFORMATION

At the local level, municipalities and their associations such as the Romanian Federation of Local Authorities or Romanian Association of Towns should inform local market actors by:

- Encouraging cooperation between members at several levels;
- Organizing programmes that can facilitate learning, exchange of experience and networking;
- Providing professional training;
- Exchanging best practice experience.

There is still a significant need for awareness-raising for energy efficiency in buildings in Romania. It is recommended that all new instruments be accompanied by awareness-raising campaigns.

Moreover, communication between national and local levels has to be improved to achieve an effective correlation between National Action Plans (for energy efficiency, renewable energy and buildings) and local strategies and, where available, Sustainable Energy Action Plans.

[51] Intelligent Energy Europe (2010). Comparison of building certification and energy auditor training in Europe.

Nevertheless, it is equally important to strengthen the existing information and control capacities by reinforcing their responsibilities and by developing new ones. Therefore, it is necessary to create one-stop-shops at the level of local authorities and energy agencies able to offer guidance and competent advice to building owners and stakeholders on how to properly implement the buildings requirements in a cost-effective way and using all existing financial support instruments.

8.4. FINANCIAL SUPPORT AND CAPACITY BUILDING

New regulations should always be accompanied by financial support schemes, capacity building programmes and awareness-raising campaigns.

For a successful implementation of nZEBs after 2020, the interaction of different policy instruments has to be considered. A financial scheme should be embedded in the regulation framework (as for example the Energy Saving Ordinance - EnEV in Germany) and be accompanied by a broad information campaign creating awareness amongst building owners. In particular, financial support should be considered for single-family buildings, where the financial effort appears to be higher than for the other two building types.

To maximise the benefits and to contribute to behavioural change of the society, policy-makers must avoid short term solutions, and concentrate on predictable long-term programmes.

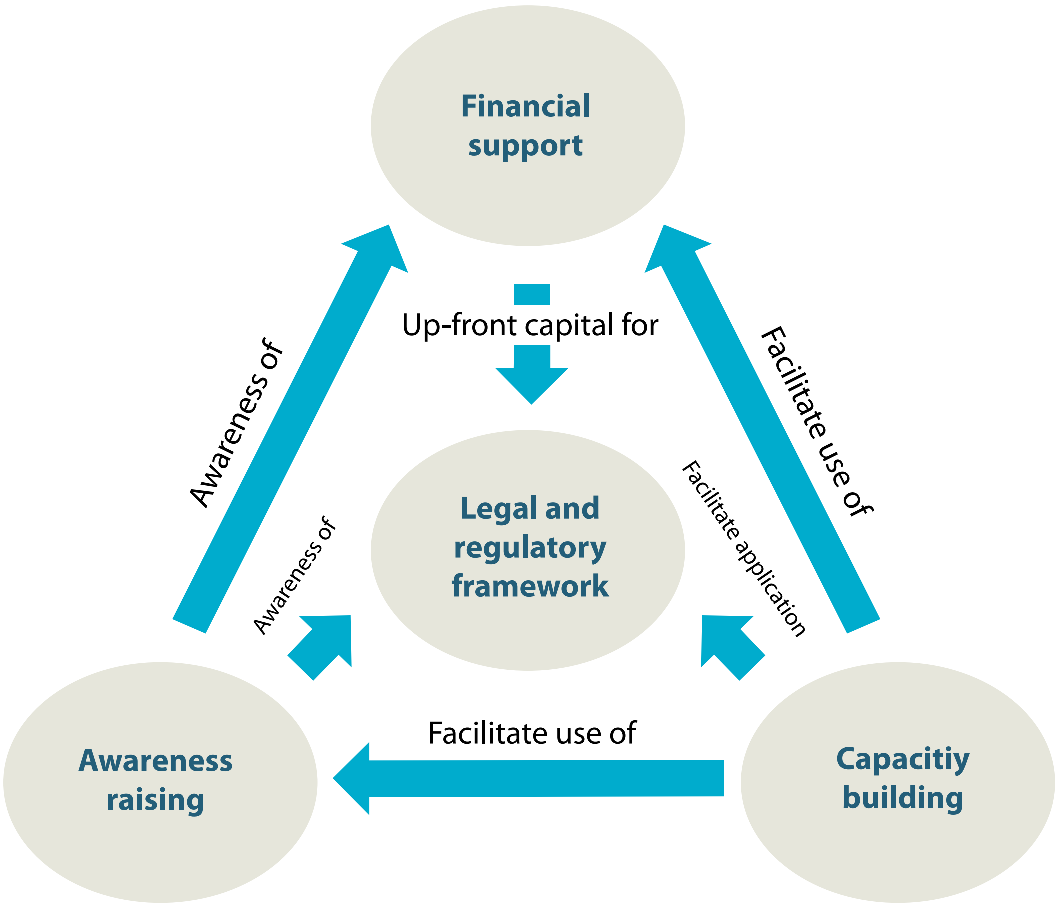
The existing market barriers for improving the energy performance of buildings should be identified and eliminated in order to allow a smooth implementation for low-energy buildings.

In the process of elaborating new policies, the first step to be made is a gap analysis addressing:

- energy efficiency and renewable energy measures and technologies to support policies,
- existing barriers to be overcom,
- effective types of economic instruments,
- the required level of economic support,
- auxiliary financing instruments needed to make financing work.

Financial schemes have the objective of fostering market development and aim for long term impact, beyond the lifetime of the specific support measure. To ensure the effectiveness of the different instruments to be introduced on the market (see Figure 11 on page 58), a careful analysis is required to better understand their interaction.

Figure 11: Interaction of different policy instruments



Based on existing best practices, there are a few recommendations to be taken into account when introducing or expanding existing financial schemes:

1. An in-depth analysis of financial gaps should be realised to determine cost-optimal energy efficient measures and supporting renewable technologies.

2. Financial schemes are key for the successful implementation of nZEBs. Grants and preferential loans are the most prevalent forms of instrument and, based on data, are also the most successful and cost-effective ones. The financial support should be carefully assessed in order to avoid too high or too low incentive levels. They can either slow-down the market uptake (by making it strongly dependent on incentives) or not stimulate the market uptake properly by not giving the right compensation for additional costs. For loans, there appears to be a correlation between take up and interest rate levels, i.e. when the interest rates fall, the applications increase. A low interest rate works as an incentive as it is perceived as the most important factor. An example is the Thermo Modernisation Fund in Poland[52].

[52] 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

3. In order to reduce the financing gap, all available options such as the Green Investment Schemes built by selling the surplus of CO_2 allocations under ETS schemes, financing schemes of International Financial Institutions, dedicated lines from European Investment Banks should be considered , but mainly the Structural Funds.
4. The results of a study carried out by the Baltic Energy Efficiency Network (BEEN), including 26 different partners from Estonia, Latvia, Lithuania, Poland, Germany, Russia and Belarus revealed that the decisive factor for the success of a loan programme is its affordability; this depends highly on the length of the loan's duration. To implement a successful loan programme it is important to offer long duration loans that make the (monthly) capital costs fit the net disposable income of investors/dwellers. Although the economic feasibility depends on interest rates, it has less influence on the affordability than the loan duration.[53]
5. Complex application and transactional procedures can negatively affect the take up of an instrument. It is necessary to create simply accessed but effective financial instruments, avoiding unnecessary intermediate bodies in the financing chain and unjustified additional costs.

To maximise the benefits of energy efficient and renewable energy supplied buildings, it is necessary to support the development of local supply chain industries and services. Closing the economic cycle in the country itself will multiply the macro-economic benefits. The objective should be to make the biggest proportion of investments at local level. This will lead to the creation of sustainable jobs and additional tax revenues for public budgets. A suggestion on how to improve the existing financial schemes for buildings is proposed in Table 28.

[53] Boermans, T.,Grözinger, J. (2011). Economic effects of investing in energy efficiency in buildings - the BEAM² Model. Cohesion policy investigating in energy efficiency in buildings. Ecofys. Available: http://ec.europa.eu/regional_policy/conferences/energy2011nov/index_en.cfm

Table 28: Further steps for improving financial support schemes in Romania

State of art	1. RES-Heating projects are supported by the Regional state aid scheme on the use of renewable energy resources and by the National Environment Fund programme for RES development 2. CASA VERDE (Green House) programme. focusing on building heating and hot water systems using RES
Gaps in the implementation of nZEBs	1. No holistic policy package 2. No long term programme for new buildings 3. No specific mechanism to promote RES-H&C. except for the existence of co-financing of some projects within programs such as European Structural Funds or the Environment Fund. 4. The NREAP issued mid 2010 did not sufficiently address biomass utilisation, although the biomass potential is large and biomass for heating is expected to be the main contributor to the 24% renewable energy quota by 2020.
What can be improved to achieve the implementation of nZEBs	1. Create financial/fiscal instruments for EE and RE in new buildings that are embedded in a holistic policy package and which should include regulatory and communication elements. 2. Make energy efficiency measures affordable (remove barriers): - Loans - Grants 3. Facilitate the use of renewable technology by removing existing barriers and by introducing market support schemes (such as feed-in-tariffs) for: - local technology (financial support. knowledge transfer) - technology to be imported (where necessary) from other (EU) countries
Intermediate steps	1. Create an in-depth gap analysis to find out: - which EE measures and supporting RE technologies exist - which barriers exist - which types of instruments are best to overcome barriers - what level of support is needed - which auxiliary instruments are needed to make financing work - how to overcome budget limitations for support programmes

8.5. MARKET UPTAKE

An important condition for achieving a liberalised energy market and the uptake of energy efficient and renewable is to gradually decrease subsidies for energy prices. In the same time it is important to elaborate supports policies to ease the social burden.

Another important condition for a successful transition to nZEB is to support the deployment of new technologies in order to cope with the anticipated increase of demand.

The most popular renewable technologies currently used in new Romanian buildings are solar thermal systems. According to EurObserv'ER[54] renewable energy barometer, the total installed solar-thermal collectors area in 2010 in Romania was approx. 144.000 m^2 with a thermal capacity of around 101MWhth. The Romanian solar thermal industry reported for 2010 a turnover of 20 million Euro and 250 direct and indirect jobs.

Photovoltaic systems (PV) and heat pumps are currently used at a very small scale in buildings (below 1%). The cumulative installed PV power capacity in 2010 was approx. 1.9MWp. out of which 1.3MWp represents grid-connected capacity and 0.6MWp off-grid[55]. 1.3MWp were installed in 2010.This may be a promising sign indicating that the PV market could have a fast uptake in the coming years.

Overall, the use of renewable energy technologies in buildings is not yet a usual practice in Romania. The main driver of installing renewable energy technology in buildings is the support scheme "Casa Verde" (Green House) Programme.

In Romania, 20% of all new buildings have mechanical exhaust ventilation systems[56]. However, information on market penetration of mechanical ventilation exhaust and supply with heat recovery is not available. Overall we must say that there is a general data scarcity concerning the use of insulation materials, efficient windows and pellet boilers.

As a consequence, the apparently little developed markets for efficient and renewable technologies have to be developed significantly in order to prepare for the transition to nZEB. According to Ecofy's estimations, the implementation of nZEB will require a wide market penetration of mechanical ventilation with heat recovery, improved insulation materials and triple glazed windows. Similar market demand is foreseen for heat pumps, pellet boilers and PV systems (Table 29).

[54] EurObserv'ER (2011): The state of renewable energy in Europe. 11th EurObserv'ER Report, available at: http://www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan11.pdf
[55] Idem 52
[56] Litui, A. (2010). Ventilation system types in some EU countries. Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA),. Available: <http://www.rehva.eu/en/496.ventilation-system-types-in-some-eu-countries

Table 29: Comparison of actual market and demand for new technologies

	Insulation materials	Ventilation systems with heat recovery	Triple glazed windows	Heat pumps	Pellet boilers	Solar thermal systems	PV
Actual market status	No data available	Very small	Very small	Very small	Very small	According to demand	Very small
Demand in percentage of new nZEBs	100%	100%	100%	~50%	~50%	>15%	>75 %
Required growth of market	No data	Very high	No data	Very high	No data	normal	Very high

8.6. INTEGRATION OF BUILDING POLICIES INTO WIDER ENERGY, CLIMATE AND LOCAL POLICIES

To minimise the transition burden and costs, it is recommended to harmonise building policies with other complementary local policies, especially with district heating strategies. This study shows that district heating may significantly help lower the costs of nZEB implementation if the renewable energy share is to be increased above 50%. Coherent buildings, renewable and district heating policies may significantly help to boost the development of local supply chain industries, to create additional jobs and to overall improve the living standard and welfare.

8.7. EDUCATION AND TRAINING OF WORKFORCE

The transition to very low energy buildings will be more difficult and costly without any measures for improving the skills of the building sector workforce. The basic education curricula have to be adapted for both 'blue' and 'white' collars involved in the various stages of building planning, design and construction. In addition, long life training schemes should be introduced to keep pace with the new activities, processes and technologies.

At the moment there is no fully coherent system for ensuring the qualification of building workforce targeting energy efficient technologies or renewable energy systems. The BUILD UP Skills Romania (ROBUST) project, part of the Intelligent Energy Europe (IEE) BUILD UP Skills action (30 EU countries), aims at developing a national qualification roadmap, including ongoing education and training for the workforce in the building sector.

The main gaps identified so far[57] are mainly of a qualitative nature and relate to the increasing need for technology application. In general one can observe a growing reduction of the qualified workforce in the construction sector.

For RES installers, certification system or equivalent qualification schemes shall be set-up by the end of 2012 (as mandatory action according to 2009/28/EC Directive). Energy auditors need to undergo training and also need to be accredited by the Ministry of Regional Development and Tourism. The Ministry

[57] The final identification of the gaps and barriers done within the Status Quo report due in summer 2012

will decide on the conditions and procedures for the technical and professional assessment of energy auditors, including the legal framework for carrying out the energy auditing activities and effective independent control system for energy performance certificates and inspection reports.

Currently in Romania there is only one accredited passive house planner, according to the Passive House Institute Darmstadt. To conclude, there is still a significant need for capacity building in Romania.

8.8. COMPLIANCE

To justify public expenditure and to assess impacts and cost-effectiveness of policies a monitoring and evaluation mechanism must be part of new building policies right from the start[58].

Currently there is no reliable information on compliance within the building sector in Romania. Generally, the authorisation process requires that the design documentation should be followed during implementation. However, practice tells us that the execution is not always aligned with the initial design. The reason for this is often an unexpected budget reduction or simply the improper execution of details/joints (thermal bridges) leading to values which may no longer respect the minimum thermal requirements. If a construction is built without a permit or by infringement of such permit, the control authorities may order the demolition of those elements which are not compliant with the permit or were built without one. Then a fine of up to €2 300 has to be paid.

8.9. EXEMPLARY ROLE OF THE PUBLIC SECTOR

The public sector should certainly lead by example also for what concerns the implementation of nZEB in Romania. Leadership could be demonstrated by an early implementation of nZEB (as required by recast EPBD) but also by improving the public procurement rule for very low-energy buildings in both renovation and construction/rent of a newbuild. Ambitious policies for the public sector will make the case for the effectiveness of low-energy buildings, and at the same time decrease the energy costs of public administration. They will offer better working conditions for public sector employees and finally help the construction sector apply new buildings technologies and techniques.

8.10. RTD AND DEMONSTRATION PROJECTS

Research and innovation for energy efficient and renewable technologies should be supported. Investing into research will not only multiply economic benefits at national level, but also increase the competitiveness of national stakeholders at regional and European level.

Last but not the least, it will be necessary to conduct highly visible demonstration projects 'starring' very low energy buildings. There is a need to show case for the effectiveness of new technologies and their affordability.

[58] 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

8.11. A 2020 ROADMAP FOR IMPLEMENTING NZEBS IN ROMANIA

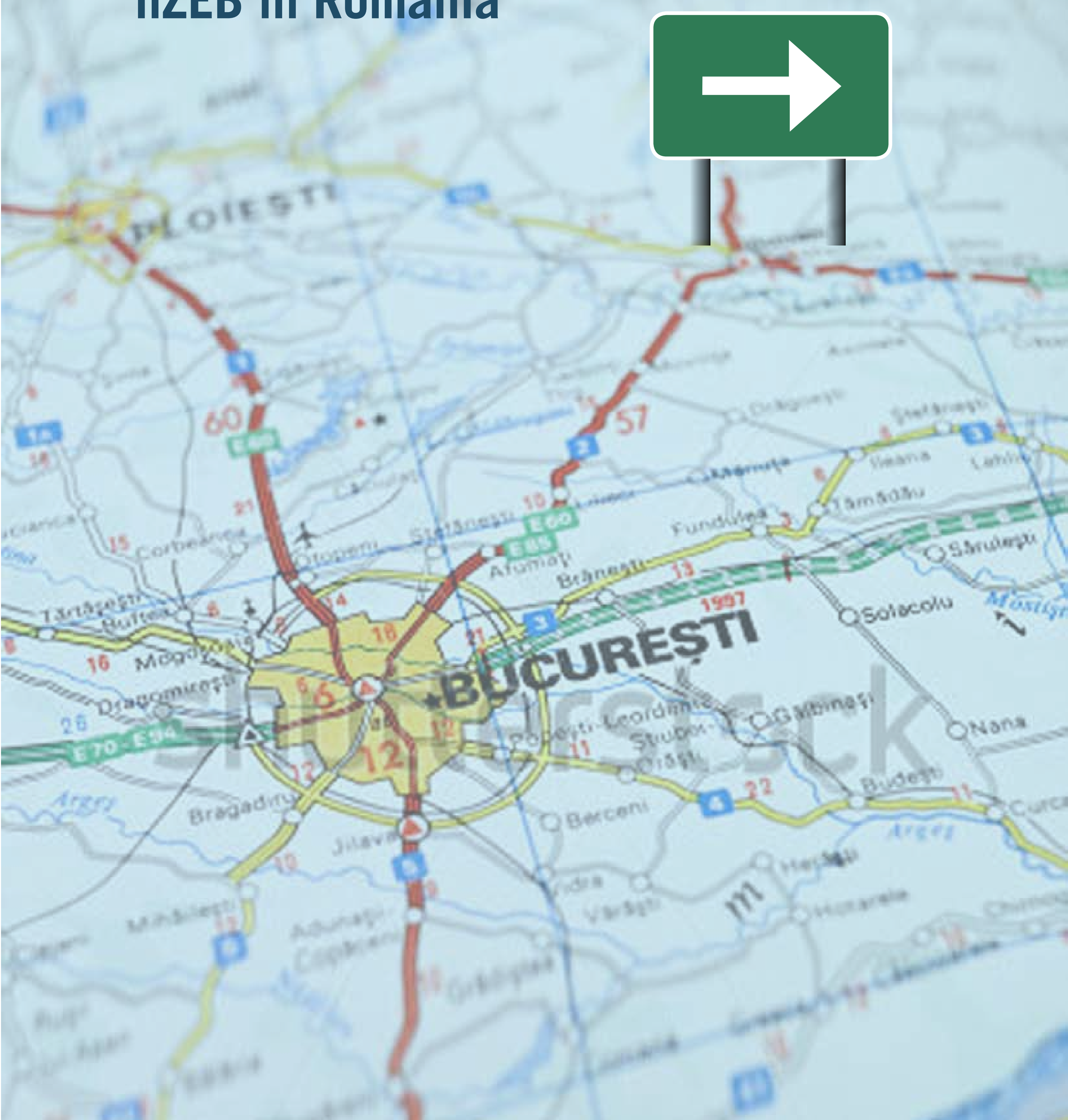
We demonstrate in this report that the additional financial efforts involved in moving towards nearly Zero-Energy Buildings are manageable with appropriate policy measures. By improving the thermal insulation of new buildings and by increasing the share of renewable energy use in a building's energy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

Roadmap 2020 for moving towards nZEB in Romania



ANNEX I

Sketches of defined reference buildings

Reference Building N°1: Single-family house (SFH)

Figure A1: West (left) and South (right) facade views of the Romanian single-family house

Figure A2: Floor plan (ground floor) of the Romanian single-family house

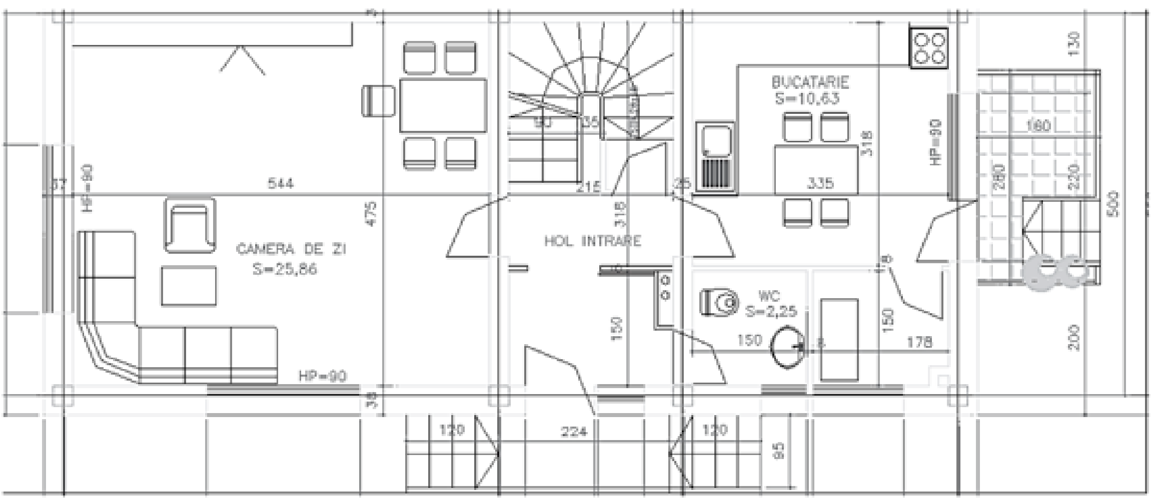


Figure A3: North and South facade view of the Romanian multi-family house

North and South facade

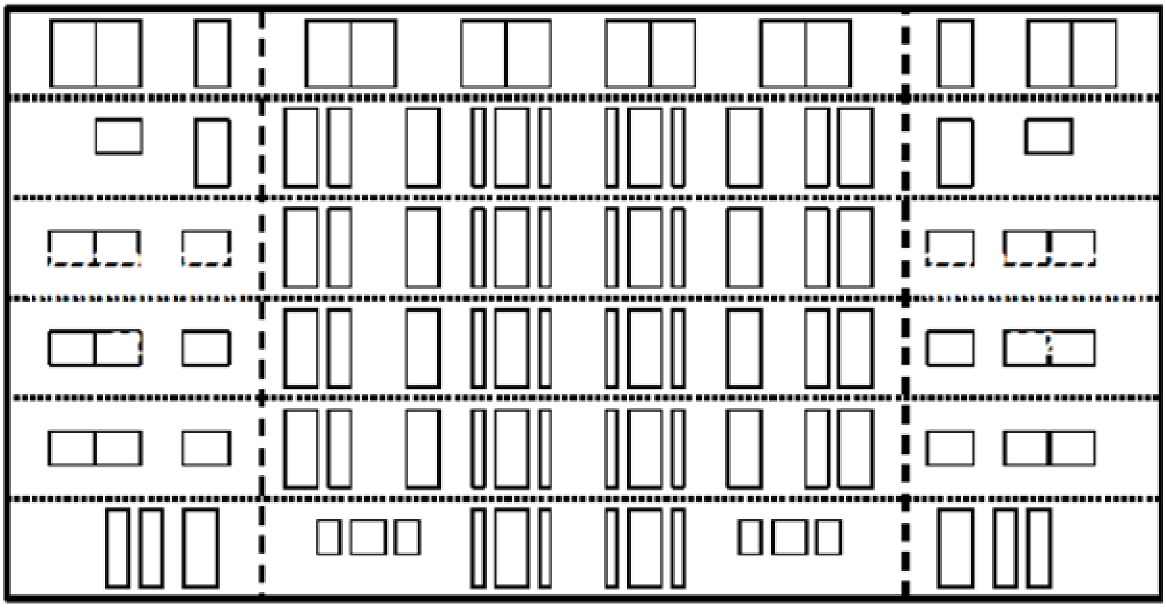


Figure A4: East and West facade view of the Romanian multi-family house

East and West facade

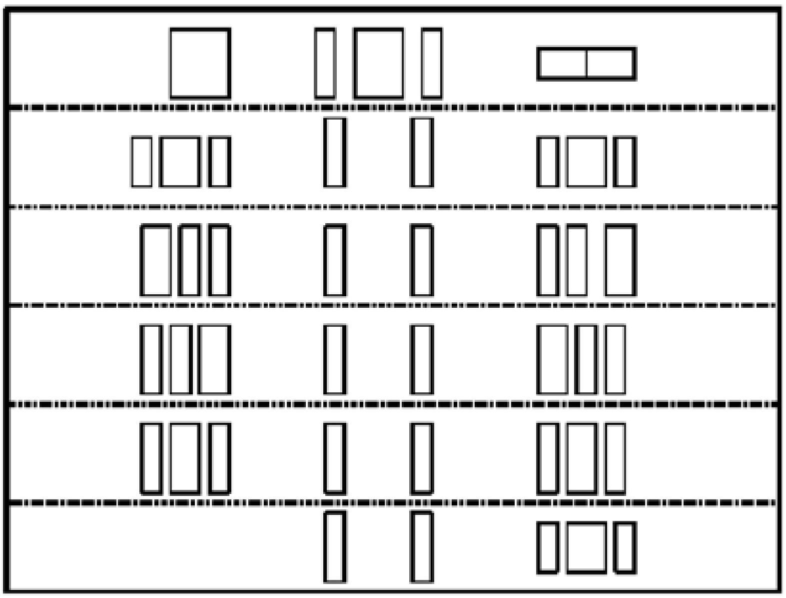


Figure A5: Floor plan (standard floor) with the simulated zones of the Romanian multi-family house

The floor plan shows the five zones which have been simulated for the multi-family house. The central zone with stairs (Z5_STAIRS) and the four apartment areas either with orientation to the North, East, South and West (Z1_N_APART. Z2_E_APART. Z3_S_APART. Z4_W_APART). All zones range over the 6 floors.

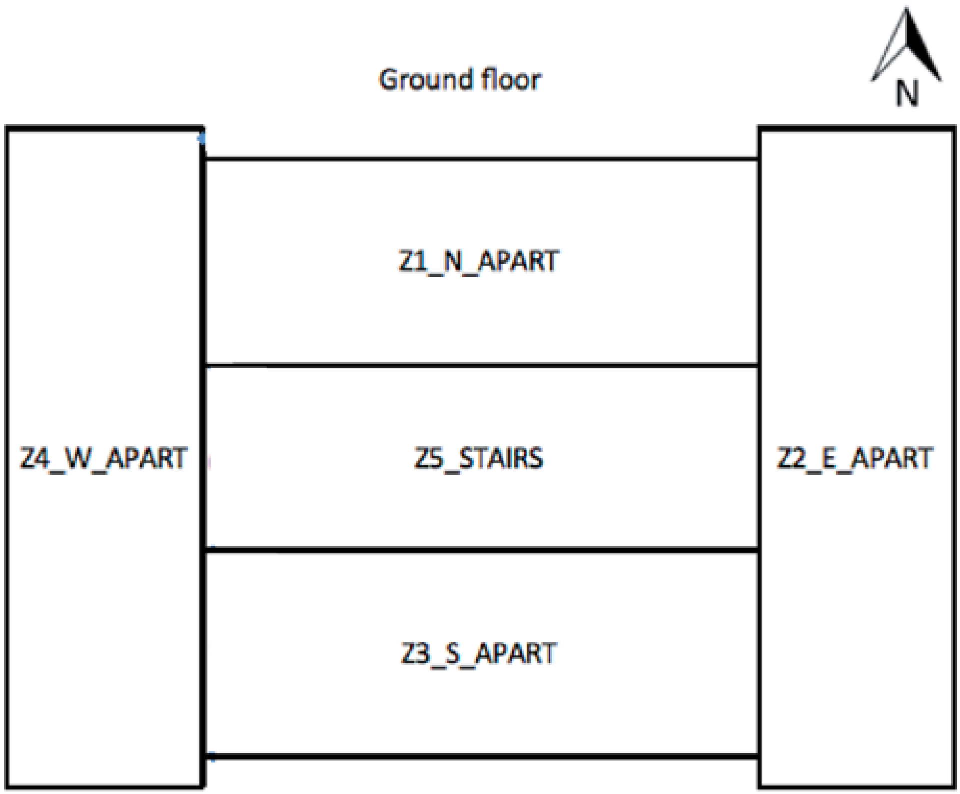


Figure A6: North facade view of the Romanian office building

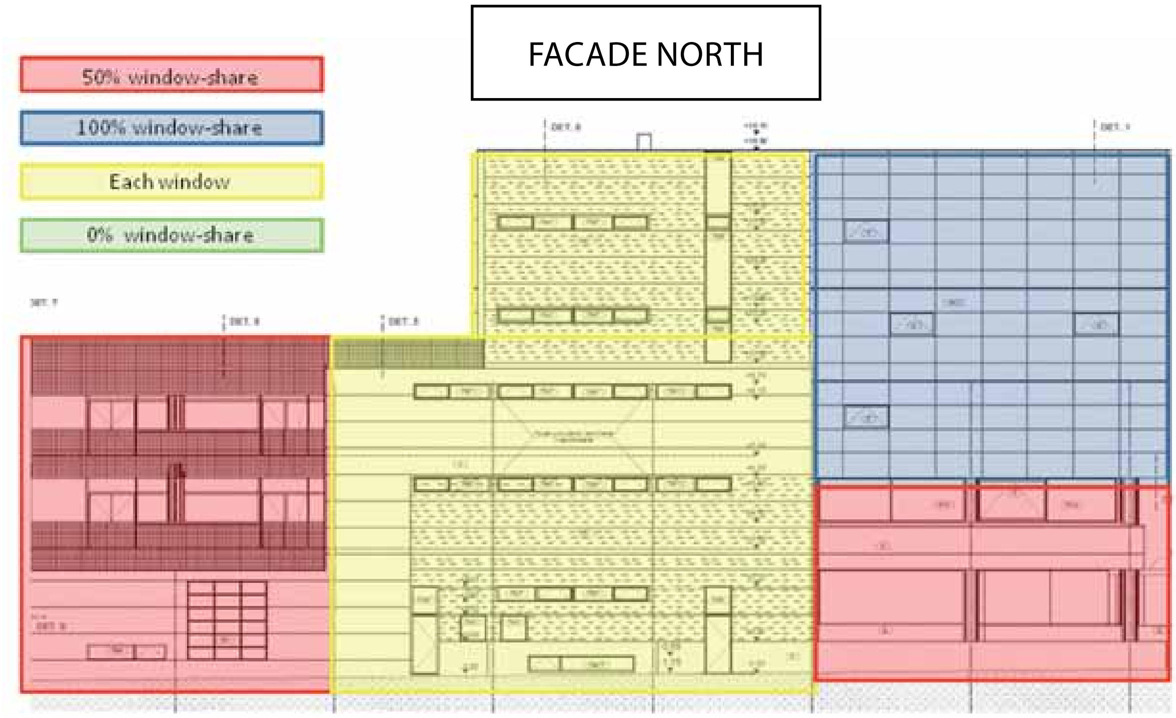


Figure A7: East facade view of the Romanian office building

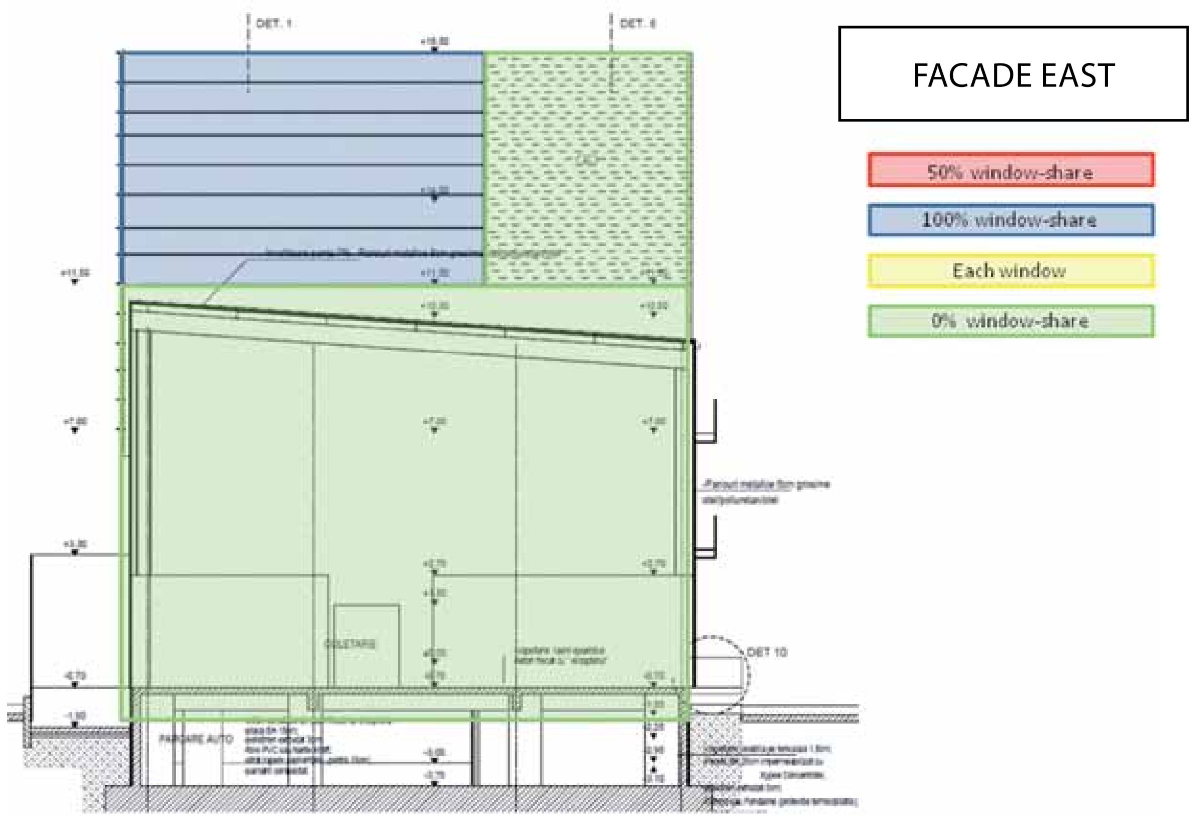


Figure A8: South facade view of the Romanian office building

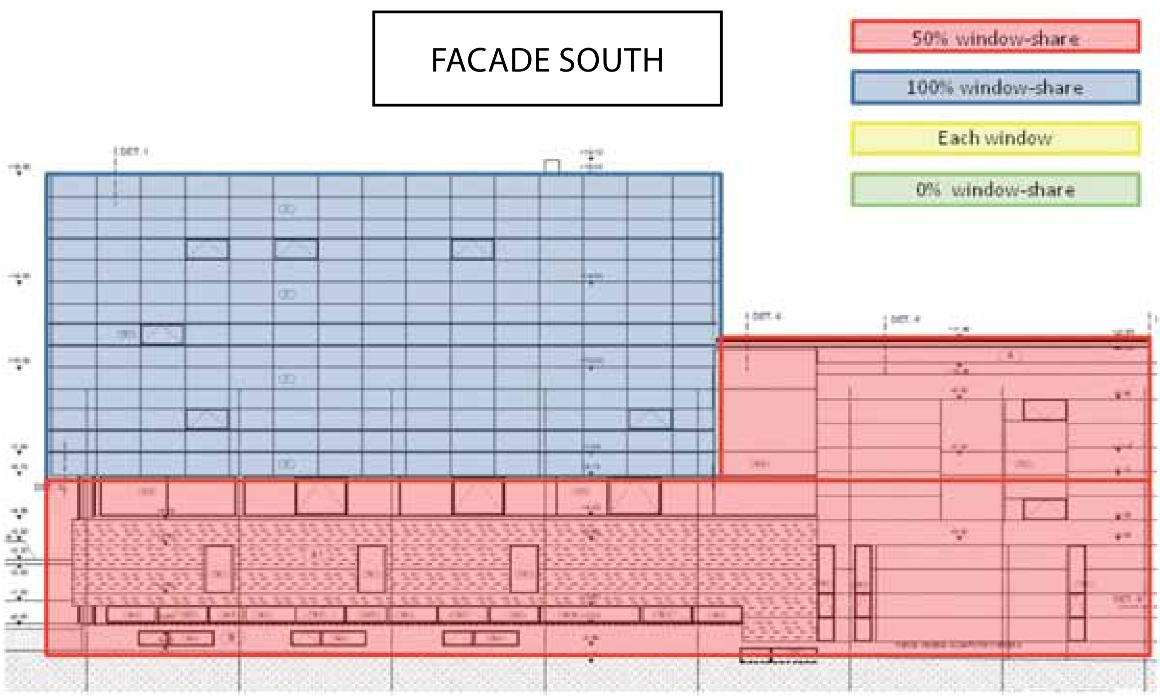


Figure A9: West facade view of the Romanian office building

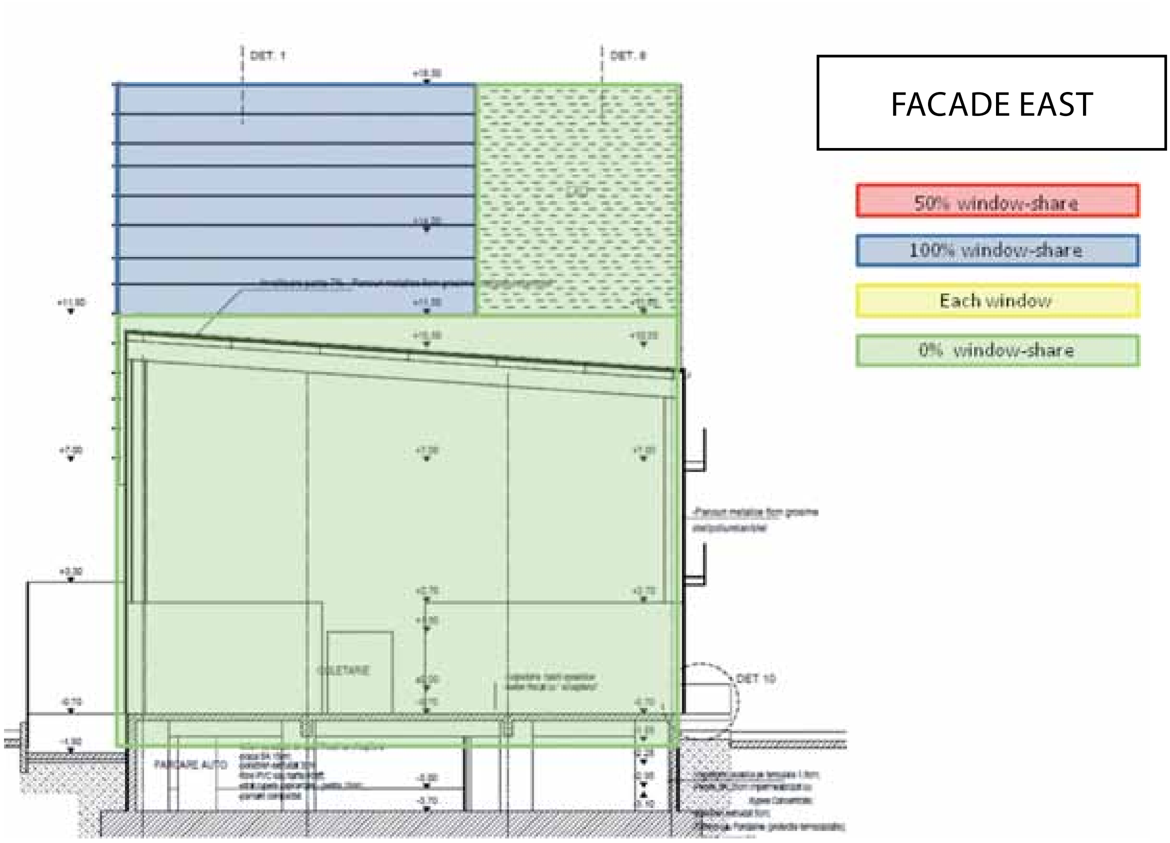
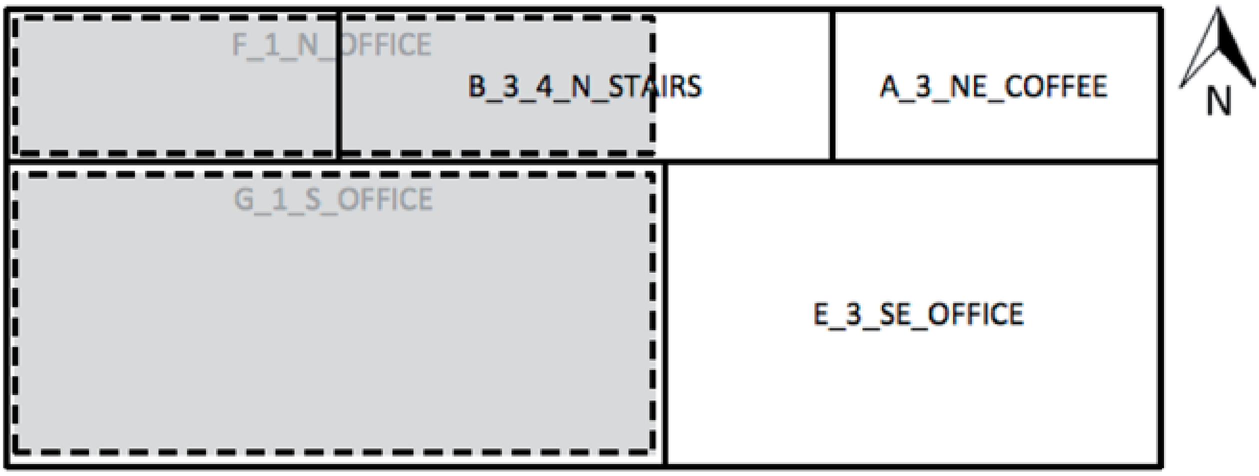


Figure A10: Floor plan with the simulated zones of the Romanian office building

The floor plan shows the seven zones which have been considered for the simulations. Counting from A to G the second part of the name indicates the number of floors enclosed by the zone followed by the orientation and the main usage. That means that the eastern part has got 3 floors with a roof terrace on top and the western part 5 floors with two grey highlighted zones forming the 5th floor with a window share of nearly 100% (F_1_N_OFFICE. G_1_S_OFFICE). The dimensioning has been done in centimetres.



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