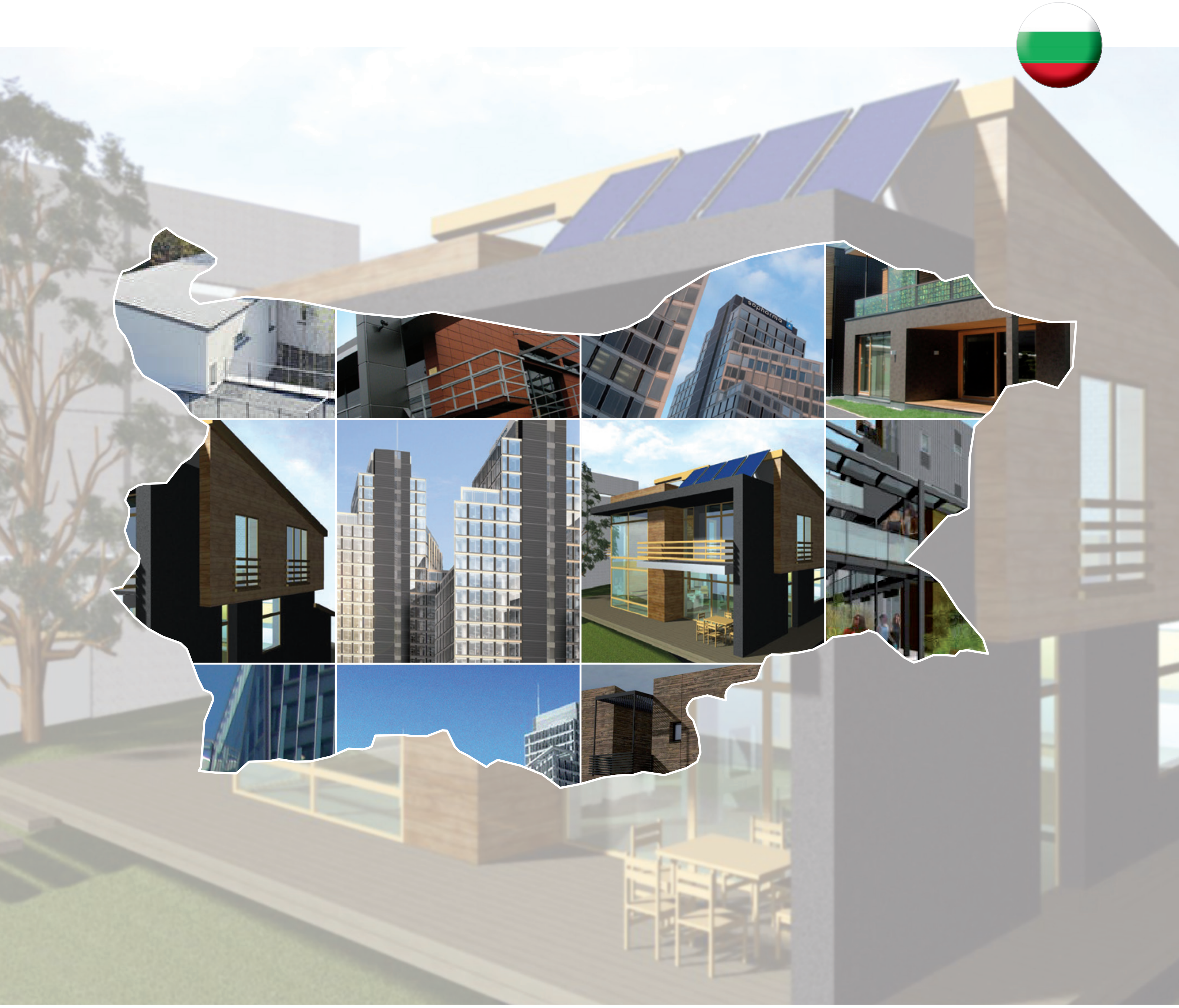
IMPLEMENTING NEARLY ZERO-ENERGY BUILDINGS (nZEB) IN BULGARIA -

TOWARDS A DEFINITION AND ROADMAP



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

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

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1. SETTING THE STAGE

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

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

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

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

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

2. 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 the 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 the energy demand/need, renewable energy share and associated carbon emissions of the building (Tables 1 and 2).

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

Policy	Technical	Beyond EPBD
Meeting the EU's 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 heating, domestic hot water, space cooling and lighting (the latter only for non-residential buildings). It should also include 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 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 as well as 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 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 CO_2 emissions.

Corollary of First nZEB Principle: Threshold for energy demand	Corollary of Second nZEB Principle: Threshold for renewable energy share	Corollary of Third nZEB Principle: Threshold for 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 minimum share of renewable energy demand should be defined.
Implementation approach		
For the definition of such a threshold, it could be recommended to gradually increase the minimum requirements in a certain corridor, which could be defined in the following way: • The upper limit (least ambitious) can be defined by the energy demand/need of the building as derived through application of the cost-optimal methodology (Article 5 of the recast EPBD). • The lower limit (most ambitious) of the corridor is set by the best technology that is 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 CO_2 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 the 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 including even 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 such 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" and evaluates through indicative simulations whether these principles hold true for the situation in Bulgaria.

The objective is to offer an independent and research-based opinion proactively supporting national efforts to draw up an affordable yet ambitious definition and an implementation roadmap for nearly Zero-Energy Buildings (nZEBs) in Bulgaria.

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

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

Detached single family houses and multi-family blocks of flats represent almost 90% of the residential building stock in Bulgaria and around 97% of the net floor area in residential sector.

Residential buildings together with office buildings represent more than 80% of the overall net floor area of the Bulgarian buildings. Therefore, we consider single family, multi-family and office buildings as being representative for the building stock and consequently we selected them for the nZEB analysis.

With these three reference buildings we undertook several simulations using variants of improved thermal insulation and equipment for heating, cooling, ventilation and hot water. To improve the CO_2 balance and the renewable energy share of the building, we considered photovoltaic compensation. These simulations were evaluated for compliance with the nZEB principles, as elaborated in the BPIE study. Moreover, the economic and financial implications of each variant were analysed in order to determine the most suitable and affordable solutions under the country's specific circumstances. Finally, the selected optimal solutions were extrapolated at national level to determine the direct and indirect benefits and impacts. Aside from 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 Bulgaria.

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 Bulgarian buildings, policies and market prices, the definition and selection of reference buildings and the revision of the final study were made by EnEffect, as national consultant.

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

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

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

4. OVERVIEW OF THE BULGARIAN BUILDING SECTOR

The Bulgarian 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 investment;
- 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 total floor area of the building sector in Bulgaria in 2010 was about 262 M m^2, where 212 M m^2 of floor area was in the residential sector and 50 M m^2 was in the non-residential building sector (Table 4).

Traditionally, the majority of the housing building stock in Bulgaria has always been privately owned. In the last two decades many publicly owned residential buildings were split and the share of private residential buildings reached 97%, however the means for maintenance were not guaranteed, there was no state commitment nor was there any substantial subsidy for the refurbishment market. National level of private ownership currently stands at 97%.

In Bulgaria there are around 1.773 M detached single family houses (SFH), around 66% of them being located in rural area. About 96% of the 70 000 multi-family buildings (MFH, block of flats) are located in urban area. Detached single family houses and multi-family blocks of flats represent almost 90% of the residential building stock in Bulgaria and around 97% of the net floor area in the residential sector (figure 2).

The total housing stock in Bulgaria comprises about 3.7 M dwellings, with the average dwelling size of around 60 m^2. Around 68% of the dwellings were built after World War Two and during the communist regime, when energy prices were very low and priority was given to minimizing the initial investments, thus leading to a low quality architecture and insulation. Around 22% of the residential buildings were made with external walls from prefabricated elements with a very poor thermal insulation[4][5].

The specific energy consumption per heated area is higher in Bulgaria than in Western European countries, mostly due to the very low quality insulation, which leads to a de facto energy poverty status and many people are not able to pay for heating their homes to the normal comfort level. It is very common that over the winter people are used to heating only one room of their home and spend most of the time there in order to keep the energy expenditure within the affordable budget.

[4]TrainRebuild: *Guidance Document for Trainers, Intelligent Energy Europe, Brusse*l, Belgium, 2012. Available at: http://trainrebuild.eu/wp-content/uploads/2011/07/Guidance-Document-for-Trainers.pdf

[5]*TrainRebuild: Training for Public Authority Civil Servants, Intelligent Energy Europe, Brussel*, Belgium, 2012. Available at:http://trainrebuild.eu/wp-content/uploads/2011/07/Draft-Toolkit-for-Local-Authorities.pdf

Between 1996 and 2004, the energy efficiency of households improved by only 4% compared to the 1990 baseline. A particular aspect in Bulgaria is the extensive use of firewood as the most common heating solution in single family homes from rural area[6].

The new construction rates are calculated based on the available statistics for the years 2009 and 2010. New construction rates are generally higher in the non-residential than in the residential sector. In the residential sector the average new construction rate is of about 0.9%. The average new construction rate in the non-residential sector is 2.8%, where restaurants and hotels have the highest new construction rate with 10%, followed by retail buildings with 6.9% and office buildings with 0.8%. Due to the demographic decline in Bulgaria (since 1985 the Bulgarian population has decreased by 1.5 M), few new educational and health facilities are build.

The most prevalent building type in the residential sector is the urban multi-family building with 41% and the rural single family house with 32% (figure 2). Figure 3 illustrates the distribution of the non-residential building stock in Bulgaria according to the floor area. In the non-residential sector, the most prevalent building is the office building with 37%, followed by educational buildings with 22% and retail buildings with 19%.

[6]Idem 4 and 5

Table 4: Number of buildings in Bulgaria and new construction rates[7]

Building type		Region	Number of buildings (1000)	Floor area (million m²)	New construction rate (%)
Residential Buldings	Detached single family houses	urban	600	48	1.1
		rural	1 173	68	1.1
	Multi-family buildings	urban	67	88	0.8
		rural	2.7	1.3	0
	Other buildings that cannot be assigned to above categories	urban	94	4.1	0.9
		rural	117	2.9	0.9
	Total		**2 053**	**212**	**0.9**
Non-residential buildings	Commercial and public office		No data	20.4	0.8
	Retail		No data	10.2	6.9
	Hotels & restaurants		3.2	5.5	10
	Health facilities		2.3	2.1	0
	Educational facilities		7.7	12.1	0
	Industrial facilities		No data	2.07	0
	Other facilities		3.3	3.2*	0
	Total		**16.5**	**50**	**2.8**

*total floor area (no data on net floor area available)

[7]Data collected from Bulgarian National Statistical Institute (NSI), Sustainable Energy Development Agency and based onEnEffect estimation.

Figure 2: Distribution of residential floor area by building type

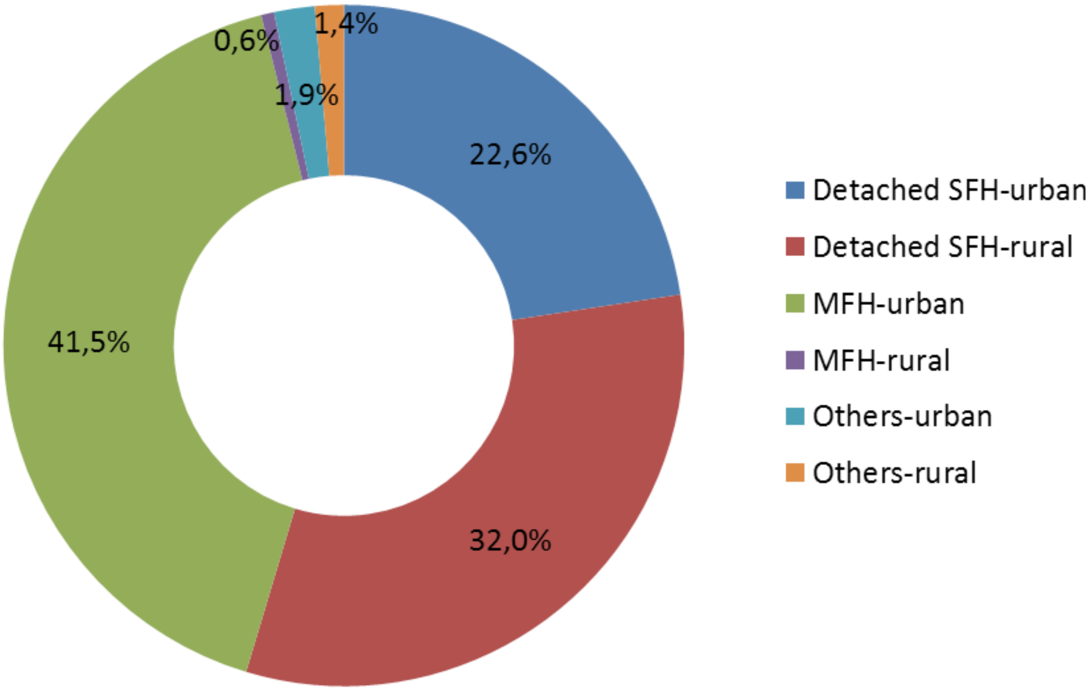
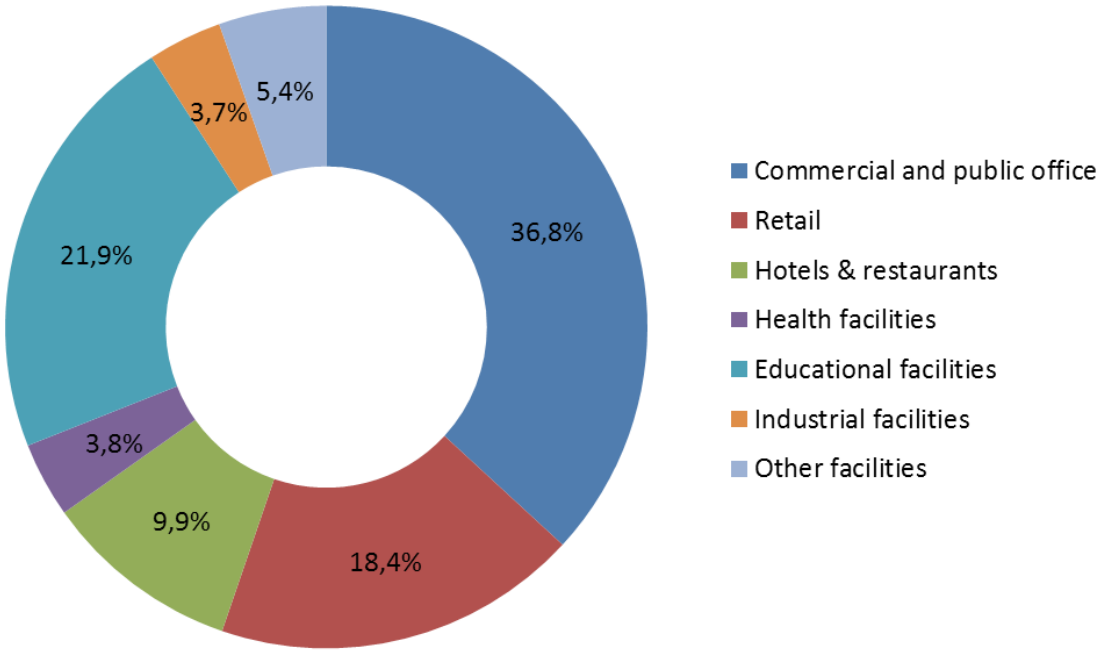


Figure 3: Distribution of non-residential floor area by building type



4.2. CURRENT BUILDING REGULATIONS FOR NEW BUILDINGS

4.2.1. Energy performance and specific component requirements

In Bulgaria there are no energy performance requirements in building norms, but there are minimum U-values requirements for specific building components (table 5), indicated by the building norms in force from 2004 and last time amended in 2009[8].

Table 5: Specific component requirements in Bulgaria

Maximum U-values for:	Walls	Roof	Floor	Windows
Single family buildings	0.35	0.28	0.4	1.7
Multi-family buildings	0.35	0.28	0.4	1.7
Office buildings	0.35	0.28	0.4	1.7
Other non-residential buildings	0.35	0.28	0.4	1.7

Any new building must have a technical certificate, the energy certificate being a part of it. For receiving the energy certificate, it is necessary to calculate the energy performance of the building (in kWh/m^2/yr) as well as to determine the energy class it belongs to. The energy performance for new buildings is calculated based on the referent U-values prescribed by the law.

The energy certificate shows whether that the new building refers to class A or class B. All new buildings are at least in energy class B, because the minimum threshold of energy class B is set by the minimum requirements from the existing regulations in place at the moment of evaluation (table 6). In other words, if the U-value requirements from Table 5 are fulfilled, than the building is in class B, if the energy performance of the building is more than two times better than the one resulted from the norms, then the building goes into energy class A.

In some cases the U-value for one building component can be out of range, but if the final energy performance is lower than the EP calculated with the U-values required by norms (table 5), then the energy certificate is issued.

[8]Bulgarian Ministy of Regional Development and Public Works (2009). *Ordinance No 7 of 15.12.2004 for energy efficiency, heat conservation, and energy savings in buildings.* Amend 2009

Table 6: Energy classes for buildings in Bulgaria [9]

Limits	Energy Efficiency Class	Explanation
EP ≤ 0.5*EPmax,r	A	High Energy Efficiency
0.5*EPmax,r< EP ≤ EPmax,r	B	
EPmax,r< EP ≤ 0.5*(EPmax,r + EPmax,s)	C	
0.5*(EPmax,r + EPmax,s) < EP ≤ EPmax,s	D	
EPmax,s< EP ≤ 1.25*EPmax,s	E	
1.25*EPmax,s< EP ≤ 1.5*EPmax,s	F	
1.5*EPmax,s< EP	G	High Energy Consumption

Where:

EP – Energy performance characteristic (kWh/m^2/yr) with the U-values of the building.
EPmax,r – Energy performance characteristic (kWh/m^2/yr) of the building calculated with the last issued U-values norms (i.e. the existing norms in accordance with the current legislation at the moment of the estimations).
EPmax,s – Energy performance characteristic (kWh/m^2/yr) of the building calculated with the U-values norms active in the moment of building commissioning.

Requirements concerning the efficiency and the exhaust gases of boilers (Table 7) are also prescribed by the law.

Table 7: Requirements for efficiency and the exhaust gasses of boilers[10]

Fuel	O_2	Roof	Floor	Windows
Natural gas – conventional boiler	2 – 4	120 – 160	< 100	> 92
Natural gas – condensing	2 – 4	ϴgn,w,r5 – 20*	< 100	*
Light Fuel Oil - conventional	3 - 5	140 – 180	< 50	> 90

* Depends on the temperature of the returned water ($\Theta_{gn,w,r}$) and the heat capacity.

[9]Ministry of Economy, Energy and Tourism and Bulgarian Ministy of Regional Development and Public Works (2009). *Ordinance RD-16-1058*

[10]*Bulgarian Ministry of Economy, Energy and Tourism (2009). Ordinance RD-16-932.*

4.2.2. Renewable energy share in new buildings

There are currently no building obligations that require the use of renewable energy for heating, cooling and DHW. As requested by the EPBD, the Bulgarian Energy Efficiency Act for Buildings stipulates that every project for new construction of buildings or reconstruction of old buildings over 1000 m^2 should consider the potential use of renewable energy generation. Moreover, the current renewable energy law in Bulgaria (last updated on 17.07.2012) foresees simplification of the procedures in implementation of small wind turbines and small PVs in private properties. A new renewable energy law is currently under elaboration, but it is not certain whether it will comprise requirements for renewable energy integration in buildings[11].

According to Energy Act, Energy Distribution Companies are obliged to buy only electricity produced by RES. The price of electricity produced by RES is approved annually by the State Energy and Water Regulation Commission and is calculated to make investment in these technologies profitable.

4.2.3. Actual practice in construction, enforcement and compliance

Renewable technologies are frequently used in office buildings. The most popular technology is air to air heat pump. The most common RES for new detached and semi-detached houses are solar panels for DHW and biomass boilers for heating.

In Bulgaria there are no specific penalties concerning energy performance of buildings, but in case the building parameters do not correspond to the legal requirements, the building will not receive the necessary energy certificate and, consequently, it will not be able to be occupied or used. The responsible body for compliance in construction is the National Construction Control Agency that approves companies with temporary certificates, updated every 3 or 5 years.

The compliance levels can only be estimated on the basis of the report on the activities of the Direction for National Building Control for the last three years. Table 8 gives an overview of the total permissions for the use of new constructions and the share of prohibitions. However, thesefigures reflect all kinds of constructions in Bulgaria including buildings, roads, bridges, etc.

Table 8: Permissions and prohibitions of all kinds of construction activities in Bulgaria[12]

		2009	2010	2011
Prohibition of construction process	%	4%	4%	3%
Prohibition for construction	%	7%	8%	22%
Prohibited access to the construction area	%	3%	1%	3%
Total permissions for use of new constructions	No.	5 445	4 768	5 038

[11] Bulgarian Sustainable Energy Development Agency (2012). *Law on Energy from Renewable Sources*

[12] Direction for National Building Control of Bulgaria. *2009, 2010 and 2011 Reports for the activities of the Direction for National Building Control Direction.* Available at: http://www.dnsk.mrrb.government.bg/UI/Home.aspx?0ZKDwUgLUJrV873wh%2bYm8mjyJNAG8eYD

According to EnEffect opinion, the compliance level for buildings is higher than 90% as the build control starts simultaneously with the construction activities. While the required investments before construction start-up are significant (purchase of land, documentation, permissions, design etc.), it is the investors' interest to comply with the technical requirements, to complete the building and to sell the apartments or rent the offices in the building.

The construction supervision guarantees that the building is in accordance with all issued standards. This starts at the same time as the construction activities and lasts until the final permission for use is granted. The construction supervisor is liable for[13] :

- Construction start in accordance with the Bulgarian legislation;
- Completeness and proper preparation of documents and reports during construction;
- Execution of the works in accordance with the approved investment projects and the requirements of Art. 169, paragraph 1 and 2 from the Spatial Planning Law;
- Compliance with the conditions of health and safety during construction;
- Preventing damage to third persons and property due to construction;
- Suitability of the construction for issuing the final permission for use.
- Assessment of the accessibility of the building by persons with disabilities.
- Assessment for energy efficiency.

As the supervision starts with the approval of the documentation and lasts until the permission is granted, the investor and the constructor are advised by the supervisor and no violations are tolerated.

4.3. WORKFORCE EDUCATION AND TRAINING IN NEW TECHNOLOGIES

Workforce education and training in new energy efficient and renewable technology is vital for further implementation of nearly zero-energy buildings. At the moment an education and training strategy within the IEE Build-UP Skills Bulgaria project[14] , implemented by EnEffect Consult, Bulgarian Construction Chamber and National Agency for Vocational Education and Training is under elaboration.

In the Status Quo Report of the project, it is mentioned that no shortage of workers is anticipated for traditional professional activities such as concrete-worker, reinforcement worker, mason, carpenter, plumber, electrician, roofer, installer of window frames, thermal insulation installer, water-proofing installer or shuttering-worker. However, due to natural reasons (retirement, job shift etc.), by 2020 it is assumed that there will be a need for training around 20% new workers, whenever possible, preferentially, young people from socially vulnerable strata of the population. Moreover, due to the stable penetration of low-energy solutions in the mainstream construction practice, it is additionally supposed that nearly all workers would be engaged (although at different levels) in continuing vocational training activities dedicated to the so called "green skills", either on-site or through specialized training programs.

The report noted that the situation is different in the field of renewable energy equipment for energy supply in buildings where there is a clear shortage of installers in each of the studied systems (i.e. small biomass-fired boilers, photovoltaic and solar thermal systems, geothermal systems and heat pumps, mini wind turbines). Therefore, there is a strong need for new specialized training schemes that have to be developed and introduced in the training system at the same rate or even exceeding the expected market penetration growth of above specified systems.

In addition, the Status Quo report identified, for the coming years, a strong need of well-trained trainers in civil engineering professions and practical classes. The situation is aggravated by the fact that nowadays in Bulgaria the teaching profession is unattractive for young graduates and a significant number of teachers will retire over the next years. The estimation from the Status Quo report indicates that by 2020 there will be a needed of at least 1000 additional trainers, able to teach theory and practical skills for all classic construction works, energy efficiency and renewable energy.

[13]Territorial Regulation Act – Art. 168 (1)

[14]Build Up Skills Bulgaria (2012). Available at: http://www.buildupskillsbg.com/

The Sustainable Energy Development Agency (SEDA) is in charge of a public register for entities carrying out energy efficiency audits and the certification of buildings. Entities are accredited by the Agency against a fee according to Ordinance RD-16-348 in force since 14 April 2009[15].

The examination material and the evaluation are standard for the whole country and are prepared by accredited high schools in coordination with the executive director of the SEDA and are approved by the Ministry of Economy, Energy and Tourism. At the end of the training course the assessors have to pass a two-part exam, an individual test and to elaborate an individual project. The final exam is conducted by an examination commission which consists of professors from the Technical University and a representative of the SEDA.

According to the Build-Up Skills project, the scheme for training and accreditation of energy auditors is well developed and operating well. At the moment there are available guidelines and software for energy audits for buildings, issuing of certificates, measurements etc. Moreover, there is a list of independent, accredited certifiers available at national level, with more than four hundred companies certified for making energy audits in buildings.

4.4. CURRENT MARKET SITUATION FOR INVESTMENTS

In the last seven years the number of new-built multi-family houses is over 60% of the total number, and the total floor area is about 50% of the new-built area. The migration of population from rural areas to cities (with a peak in 2008 due to a high economic growth) required more and more multi-family houses to satisfy the market. The grown population of the big towns in Bulgaria lead to the need for new commercial and working places. Therefore, over the last years, in city areas, new retail and office buildings were constructed at a higher rate than other non-residential buildings. However, as the market is already flooded by free flats and offices, these sectors will probably reduce their growth rates in the near future. The experts' forecasts indicate for the future an increased build rates for detached houses, semi-detached houses and luxury residential buildings, mostly located in the suburbs of big Bulgarian cities. The future development of the construction sector in Bulgaria seems to be strongly influenced by the future economic situation in the EU.

4.4.1. Main investors in buildings sector

Main investors in the most dynamic sector, multi-family houses, are the end-users (future private owners), about 92% of them being Bulgarian citizens. The size of the purchased apartments depends on the monthly income of the family. The highest rate of newly bought properties is for two-room apartments with the floor area of about 55 - 60 m^2. Over the last 3-4 years, the investors' preference was to buy new homes from their savings or by using small loans from banks, due to higher interest rates in Bulgaria, compared to the average in the EU.

The additional investments of an energy optimized building are estimated as being reasonable and will be covered by the potential energy costs savings (for the whole life cycle of the building), but only if every building is examined separately and specific investments are suggested. Subsidies and tax reduction for execution of such projects would additionally improve the financial parameters of investment. This will also stimulate the implementation of various types of energy efficiency measures.

[15]Ministry of Energy and Economy of Bulgaria (2009). Ordinance RD-16-348.

4.5. CURRENT SUPPORT SCHEMES FOR NEW BUILDINGS

Currently, in Bulgaria, there are several support schemes and programmes addressing energy efficiency and renewable energy heating in buildings such as in the followings:

- Operative program "Regional development";
- Sub-Program "Introduction of Energy Saving Technologies and Renewable Energy Sources" ;
- SEDA Grants program;
- International fund "Kozloduy";
- •The first and the (announced) second EBRD credit lines.

However, all support schemes are targeted only on existing buildings and there is no scheme for new buildings. There is no scheme to specifically support energy efficiency and renewable energy in new buildings. There is a programme for the development of rural areas which supports the construction of new family hotels and guest houses, but the incentive is given without a specific condition for implementing energy efficiency or renewable energy measures.

4.5.1. The European Bank for Reconstruction and Development credit lines

The credit line of the EBRD ('BEERECL') runs quite successfully in supporting RES-Heating (as well as RES-Electricity and energy efficiency) projects, on a large, industrial scale and for households/SMEs (energy efficiency, only RES-H&C).

To support Bulgarian households to reduce their energy consumption, the European Commission, the EBRD, and the Bulgarian Energy Efficiency Agency have developed a € 40 M Residential Energy Efficiency Credit (REECL) Facility[16] providing dedicated credit lines to Bulgarian banks for offering loans to owners and Home Owners Associations for specific energy efficiency measures including: double-glazing windows, wall, floor, and roof insulation, efficient biomass stoves and boilers, solar water heaters, efficient gas boilers, heat pump systems, building-integrated photovoltaic systems, heat-exchanger stations and building installations, gasification installations, and balanced mechanical ventilation systems with heat recovery.

Later on, the credit line was reinforced by adding an additional € 14 M in grant financing is earmarked in support of project development and incentive grants paid to REECL borrowers. Therefore borrowers will benefit from up to a 35% incentive towards the cost of the energy saving projects subject to the terms and conditions of the REECL. This additional financing grant comes from the Kozloduy International Decommissioning Support Fund (KIDSF), set up in 2000 with contributions from the European Commission, EU member countries and Switzerland. KIDSF financially supports the early decommissioning of units 1-4 of Kozloduy Nuclear Power Plant. KIDSF also supports energy sector initiatives associated with the decommissioning effort, such as improving energy efficiency in Bulgaria. The REECL loans and incentive grants are available to REECL borrowers until 31 July 2014. It is anticipated that the total number of energy efficiency home improvement projects to be financed under the REECL facility will be in the range of 50000.

Overall, the new financing scheme will distribute € 40 M over 4 years. The first financing scheme had a budget of € 50 M of which almost € 15 M had been used for the grants and project management costs. The website of REECL indicated that about 30 000 home improvements have been funded through the credit line during the first stage of the programme[17].

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[16]Residential Energy Efficiency Credit Line Facility. More information available here: www.reecl.org

[17]Eva Teckenburg, M.R., Thomas Winkel, Ecofys,, Mario Ragwitz, S.S., Fruanhofer ISI,, Gustav Resch, C.P., Sebastian Busch, EEG,,Inga Konstantinaviciute, L.e.i. (2011). *Renewable energy policy country profiles*. Ecofys, Fraunhofer, Energy Economics Group, LEI. Available at: www.reshaping-res-policy.eu

4.5.2. Other support schemes for energy efficiency in existing buildings

In Bulgaria there are several support schemes, mainly financed by EU Structural Funds and from the International fund 'Kozloduy', such as in the following:

- The Priority Line "Sustainable and Integral Urban Development" of the Operative program "Regional development" offers 100% grant support to public authorities for reconstruction of buildings including energy efficiency measures in buildings of the following sectors: education, health care, social services and culture.
- The Priority Line "Sustainable and Integral Urban Development" of the Operative program "Regional development" offers 50% grant support to public authorities and to building owners associations for reconstruction including energy efficiency measures in multi-family buildings.
- The "Kozloduy" international fund offers 100% grants for energy efficiency projects in municipal and state owned buildings.
- The Sub-Programme "Introduction of Energy Saving Technologies and Renewable Energy Sources" of Priority Line "Increasing efficiency of enterprises and promoting supportive business environment" of the Operative program "Competitiveness" offers between 35% and 50% grants to SMEs for implementation of energy efficiency projects, including energy efficiency in buildings.

4.5.3. Other general support schemes

In addition to previous support schemes addressing directly energy efficiency and renewable energy in buildings, there are other financing programmes that can potentially cover buildings activities such as in the following:

- The Bulgarian Energy Efficiency and Renewable Energy Credit Line - 15% grant for projects including: Investments in new hydro power or run-of-the-river with installed capacity less than 10 MW (investments in second hand hydro power or rehabilitation of existing sites are not eligible); Investment in new and second hand wind turbines with installed capacity of less than 5 MW; Biomass investments with installed capacity of less than 5 MW electric output (for biomass heat only boilers with a thermal input higher than 10MWth, the EBRD will confirm eligibility based on an outline of the investment prepared and submitted by us outlining the origin of fuel supply and establishing if an Environmental Impact Assessment is needed for the project); Solar thermal; Geothermal; Biogas.
- Measures 311 and 312 of the Program for Development of the Rural Regions offers grants up to 80%, but not more than 200 000 EUR for renewable energy project in rural regions.
- The Sub-Programme "Introduction of Energy Saving Technologies and Renewable Energy Sources" of Priority Line "Increasing efficiency of enterprises and promoting supportive business environment" of the Operative program "Competitiveness" offers between 35% and 50% grants to SMEs for implementation of renewable energy projects.
- The Sub-Programme "Introduction of Energy Saving Technologies and Renewable Energy Sources" of Priority Line "Increasing efficiency of enterprises and promoting supportive business environment" of the Operative program "Competitiveness" offers 50% grants to Large enterprises for implementation of renewable energy projects.
- The SEDA Grants program offers from 60 to 85% grants for implementation of renewable energy projects in SMEs.

Moreover, there is potentially € 40 M available from the regional development funds (2007-2013) which can be used for enhancing the energy performance of buildings. Unfortunately, in practice these incentives are not translated into an increase in refurbishment projects, since pilots still dominate the market. Recently the parliament has adopted new laws on housing that might facilitate these investments[18] .

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[18]TrainRebuild (2012a). *Guidance Document for Trainers*. Available at: http://trainrebuild.eu/wp-content/uploads/2011/07/Guidance-Document-for-Trainers.pdf

5. DEFINITION OF nZEB OPTIONS AND SOLUTIONS

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 Bulgaria, which differs in many respects from the overall EU situation, as presented in the general European study "Principles for nearly Zero-Energy Buildings".

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

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

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

The SFH is by far the dominant building type in Bulgaria and within this category the detached SFH has the highest share in the residential sector (55% of net floor area). It is appropriate to note that part of those buildings are not inhabited or only temporarily inhabited as "second houses" on the weekends during the summer. The second largest amount of floor space was indicated for urban MFH (i.e. 42% of the net floor area in residential sector). In the non-residential buildings sector, office buildings are by far the dominant building type, followed by educational, retail and healthcare buildings.

The retail buildings sector is characterised by a high diversity of subtypes and the definition of many reference buildings would be necessary to produce an accurate picture. In addition, there is a very low dynamic of constructing new educational and healthcare buildings. Public administration buildings, included in the office buildings category, receive a particular attention from the EPBD which indicates that public administration buildings should play a leading role and adopt more timely and ambitious nZEB requirements. Based on this, we chose office buildings to be the third relevant reference building category for this study.

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

The first reference building is an individual detached house on two floors. The building has a double pitched roof. The conditioned space at the ground floor and the first floor are heated to 20°C. The cellar is assumed to be unheated. The sketches of the reference SFH are in Annex 1 of the study.

The general heating system is a solid fuel boiler, fired with wood, connected to radiators. As the minimum comfort conditions in winter (20 °C) can only be insured by an automatic controlled system, a wood pellet boiler was assumed, although most of the wood heating systems in single family houses are manually fired. For the domestic hot water production the most common two solutions were considered by their estimated share of occurrence. The first domestic hot water (DHW) system uses a 150 litre tank and is connected to the heating boiler (share: 40%). The second system consists of a direct electric heater (share 60%).

There is no mechanical ventilation system, only natural ventilation by windows. 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 summarized in the following table.

Table 9: Main characteristics of reference Bulgarian single family house (specified equivalent U-values consider also thermal cold bridges)

Parameter	Value/Description
Number of conditioned floors	2
Net floor area	127 m^2
Room height	2.65 m
U-walls	0.34 W/(m^2K)
U-roof	0.27 W/(m^2K)
U-floor	0.55 W/(m^2K)
U-windows, frame fraction	1.70 W/(m^2K); 21%
Window fraction (window/ wall-ratio)	13% (only 5% on North and West facades)
Shading	None
Air tightness	Moderate
Thermal bridges	Yes
Heating system	Wood boiler (set point: 20°C) Heating efficiency: 0.82
DHW system	Combination of wood boiler and electric heater DHW efficiency: 0.93 (40% Wood = 0.82 60% electric heater = 1.00)
Specific DHW demand	15.8 kWh/(m^2a)
Ventilation system	Natural/window ventilation (0.35 1/h)
Cooling system	Split system (set point: 26°C) SEER: 3.2
Internal gains[19]	13.5 W/m^2
Installed lighting power [20]	11.7 W/m^2

[19]This value is to be understood as a maximum value. For more accurate evaluation of internal gains due to persons and equipment, there are detailed time schedules considering the number of persons and equipment existing at a certain moment in a certain zone of the building.

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

5.1.2. Reference Building N°2: Multi-family houses (MFH)

The second reference building is a multi-family house, which has 6 levels. The roof is flat and the conditioned space over the 6 floors is heated to 20°C. The two basements (partially garage) are assumed to be not heated. The following figures show the facade views and one floor plan with the zone classification.

The general heating energy is provided by a district heating system with radiators. The Domestic Hot Water (DHW) system uses a 2400 litre tank and is connected to the heating boiler.

There is no mechanical ventilation system and only natural ventilation by windows is considered. Furthermore no cooling systems are installed. There are no solar thermal systems and no PV system installed on the roof. The main building characteristics are summarized in the following table.

Table 10: Main characteristics of reference Bulgarian multi-family house (specified equivalent u-values consider also thermal cold bridges)

Parameter	Value/Description
Number of conditioned floors	6
Net floor area	2870 m^2
Room height	2.73 m
U-walls	0.64 W/(m^2K)
U-roof	0.30 W/(m^2K)
U-floor	0.55 W/(m^2K)
U-windows, frame fraction	1.70 W/(m^2K), 15%
Window fraction (window/wall-ratio)	23%
Shading	None
Air tightness	Moderate
Thermal bridges	Yes, significant thermal bridges considered
Heating system	District Heating (set point: 20°C) Heating efficiency: 0.99
DHW system	Same as for heating DHW efficiency: 0.99
Specific DHW demand	20.4 kWh/(m^2a)
Ventilation system	Natural/window ventilation (0.5 1/h)
Cooling system	None
Internal gains [21]	20 W/m^2
Installed lighting power [22]	10 W/m^2

[21] This value is to be understood as a maximum value.

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

5.1.3. Reference building N°3: Office building

Concerning the office building, the reference is a 3 level high building, with a high amount of glazing area (50% window fraction). The roof is flat and the conditioned space is heated to 20°C. The basement (garage) is assumed to be not heated. The following figures show the facade views and one floor plan with the zone classification.

Heating and cooling are provided by fan coil units using heat pumps for every thermal zone. The very small Domestic Hot Water (DHW) demand is provided by instant electrical heaters directly in the toilet or kitchen areas.

The mechanical ventilation has a heat recovery rate of 70%. For cooling, a central air cooled compression chiller system with fan coils was assumed. The set point temperature for cooling during the operating times is 24°C.There are no solar thermal systems and no PV system installed on the roof of the reference office. The main building characteristics are summarized in the following table.

Table 11: Main characteristics of reference Bulgarian office building (specified equivalent u-values also considering thermal cold bridges)

Parameter	Value/Description
Number of conditioned floors	3
Net floor area	886 m^2
Room height	3.00 m
U-walls	0.46 W/(m^2K)
U-roof	0.32 W/(m^2K)
U-floor	0.46 W/(m^2K)
U-windows, frame fraction	1.70 W/(m^2K), 15%
Window fraction (window/ wall-ratio)	50%
Shading	Internal blinds, manual control
Air tightness	Moderate
Thermal bridges	Yes
Heating system	Heat pump, fan coils (set point: 20°C) Heating efficiency: 3.3

DHW system	Decentralised direct electric
Specific DHW demand	0.8 kWh/m²a
Ventilation system	Mechanical ventilation 70% heat recovery Ventilation rates (6:00-18:00): Office spaces: 1.36 1/h Conference rooms: 2.72 1/h Other rooms: 0.46 1/h
Cooling system	Compression chillers, fan coils (set point: 24°C) SEER: 3.3
Internal gains [23]	30 W/m²
Installed lighting power [24]	25 W/m²
Automatic lighting control	Only in service area
Person density in office areas (considered as an additional internal load)	0 am – 8 am and 6 pm - 0 am: no persons 8 am – 12 am and 2 pm – 6 pm: 1 person/15 m² 12 am – 2 pm: 1 person/30 m²

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

5.2.1. nZEB solutions for single family houses (SFH)

For all variants – for comparison reasons – the geometry of the reference buildings has not been changed, even though it is far from optimal for an nZEB. Table 12 shows the solutions, which have been examined by dynamic thermal simulations.

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

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

Table 12: Bulgarian SFH, nZEB variants

Variants	U-value Opaque Shell[25]	U-Value Window	Heat Recovery Rate	Solar Collector for DHW	Brief Description
V0	U-Wall: 0.34 W/m².K U-Roof: 0.27 W/m².K U-Floor: 0.55 W/m².K	U-Win-dow: 1.7 W/m².K	0%	No	Reference
V1	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.20 W/m².K	U-Win-dow: 1.0 W/m².K	0%	No	Improved building shell
V2	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.20 W/m².K	U-Win-dow: 1.0 W/m².K	0%	Yes	Improved building shell + solar collectors
V3	U-Wall: 0.12 W/m².K U-Roof: 0.10 W/m².K U-Floor: 0.20 W/m².K	U-Win-dow: 1.0 W/m².K	80%	No	Improved building shell + mech. ventilation with heat recovery
V4	U-Wall: 0.10 W/m².K U-Roof: 0.09 W/m².K U-Floor: 0.20 W/m².K	U-Win-dow: 0.80 W/m².K	92%	No	Nearly passive house standard[26]

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

For each of the four base variants, the following four heating supply options will be considered:

- Air source heat pump[27]
- Ground collector brine heat pump[28]
- Wood pellet boiler
- Gas condensing boiler

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

[26]Passive house standard: major shell improvements, no heat bridges, airtight construction, highly efficient mechanical ventilation (> 90%), useful heating and cooling demand < 15 kWh/m²yr.

[27]Solutions will be considered to have a low temperature floor heating system to get a better system efficiency.

[28] cf. previous footnote.

5.2.2. nZEB solutions for multi-family houses (MFH)

As for the SFH, the geometry of the reference buildings has not been changed, even though it is not optimum for an nZEB. Table 13 shows the variants simulated with TRNSYS.

Table 13: Bulgarian MFH, nZEB variants

Variants	U-value Opaque Shell[29]	U-Value Window	Heat Recovery Rate	Solar Collector for DHW	Brief Description
V0	U-Wall: 0.64 W/m².K U-Roof: 0.30 W/m².K U-Floor: 0.55 W/m².K	U-Win-dow: 1.7 W/m².K	0%	No	Reference
V1	U-Wall: 0.45 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.32 W/m².K	U-Win-dow: 1.0 W/m².K	0%	No	Improved building shell
V2	U-Wall: 0.64 W/m².K U-Roof: 0.30 W/m².K U-Floor: 0.55 W/m².K	U-Win-dow: 1.7 W/m².K	85%	No	Mech. ventilation with heat recovery
V3	U-Wall: 0.45 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.32 W/m².K	U-Win-dow: 1.0 W/m².K	85%	No	Improved building shell + mech. ventilation with heat recovery
V4	U-Wall: 0.45 W/m².K U-Roof: 0.15 W/m².K U-Floor: 0.32 W/m².K	U-Win-dow: 1.0 W/m².K	85%	Yes	Improved building shell + mech. ventilation with heat recovery + solar collectors

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

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

- Air source heat pump
- Ground collector brine heat pump
- Wood pellet boiler
- Gas condensing boiler
- District heating

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

5.2.3. nZEB solutions for Office Building

As for the other reference buildings, the geometry of the reference buildings has not been changed, even though it is not optimum for an nZEB. Table 14 shows the variants simulated with TRNSYS.

Table 14: Bulgarian office building, nZEB variants

Variants	U-value Opaque Shell[30]	U-Value Window/ windows share	Heat Recovery Rate	External shading	Window Share	Light system	Solar collector for DHW	Brief Description
V0	U-Wall: 0.46 W/m².K U-Roof: 0.32 W/m².K U-Floor: 0.46 W/m².K	1.7 W/ m².K, 50% windows share	70%	None	Manual control	No	No	Reference
V1	U-Wall: 0.30 W/m².K U-Roof: 0.25 W/m².K U-Floor: 0.40 W/m².K	1.7 W/ m².K, 50% windows share	70%	Automatic	Manual control	No	No	IImproved building shell + external shading
V2	U-Wall: 0.30 W/m².K U-Roof: 0.25 W/m².K U-Floor: 0.40 W/m².K	1.7 W/ m².K, 50% windows share	70%	Automatic	Automatic	Automatic controlled lighting	No	Improved building shell + external shading + improved lighting
V3	U-Wall: 0.30 W/m².K U-Roof: 0.25 W/m².K U-Floor: 0.40 W/m².K	Controlled lighting	80%	Automatic	50%	Automatic controlled lighting +LEDs	No	Improved building shell + external shading + improved lighting + improved windows + improved heat recovery

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

- Central air/water heat pump
- Central brine/water heat pump
- Central wood pellet boiler
- Central gas condensing boiler
- District heating

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

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 general assumptions from table 15 have been considered.

Table 15: 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[31]	Natural gas	Wood pellets	On-site electricity[32]
CO_2 factor[33]	[kg/kWh]	0.252	0.68	0.202	0.0	-0.252
Renewable share[34]	[%]	13	0	0	100	100
Primary energy factor[35]	[-]	2.0	1.3	1.1	0.2	-2.0

For the grid electricity the projected EU27 average values (for detailed description see footnotes) have been chosen considering that local building sector targets should not be influenced by local power sector efficiency and, thus, insure consistency to the overall EU targets. However, the thresholds that will be recommended to be implemented in Bulgaria according to the roadmap (see chapter 9) will take into account actual Bulgarian primary energy and CO_2 emission factors (which are at the moment 3.0 and 0.68, respectively 0.8 kg CO_2/kWh). It should be noted that, due to the decarbonisation of electricity production systems in the future, 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 Bulgarian market actually 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 1050 kWh/kWp for Sofia[36] .

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[31]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%.

[32]For the purpose of this simulation only photovoltaic (PV) is considered.

[33]For the calculation the EU-27 average was applied. For the CO2 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).

[34]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.

[35]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).

[36]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

Assumed necessary heating capacities for reference buildings are shown in Table 16.

Table 16: Installed heating capacity of the heating systems for Bulgaria

Variant	SFH [kW]	MFH [kW]	OFFICE [kW]
V0	11.6	165	70
V1 A	6.1	127	65
V1 B	6.1	127	65
V1 C	6.1	127	65
V1 D	6.1	127	65
V1 E	6.1	127	65
V2 A	6.1	109	65
V2 B	6.1	109	65
V2 C	6.1	109	65
V2 D	6.1	109	65
V2 E	6.1	109	65
V3 A	4.6	71	44
V3 B	4.6	71	44

V3 C	4.6	71	44
V3 D	4.6	71	44
V3 E	4.6	71	44
V4 A	3.9	71	-
V4 B	3.9	71	-
V4 C	3.9	71	-
V4 D	3.9	71	-
V4 E	3.9	71	-

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, a further set of solutions with a rooftop PV system for compensating the remaining CO_2 emissions was assumed for all solutions. 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 following: 4kWp for SFH; 43.8 kWp for MFH and 24.2 kWp for office buildings.

Table 17 shows the derived sizes of the rooftop PV systems, which were necessary for reaching a high-degree or even full compensation of a building's CO_2 emissions.

Table 17: Sizes of the rooftop PV systems, necessary for a compensation of the CO_2 emissions

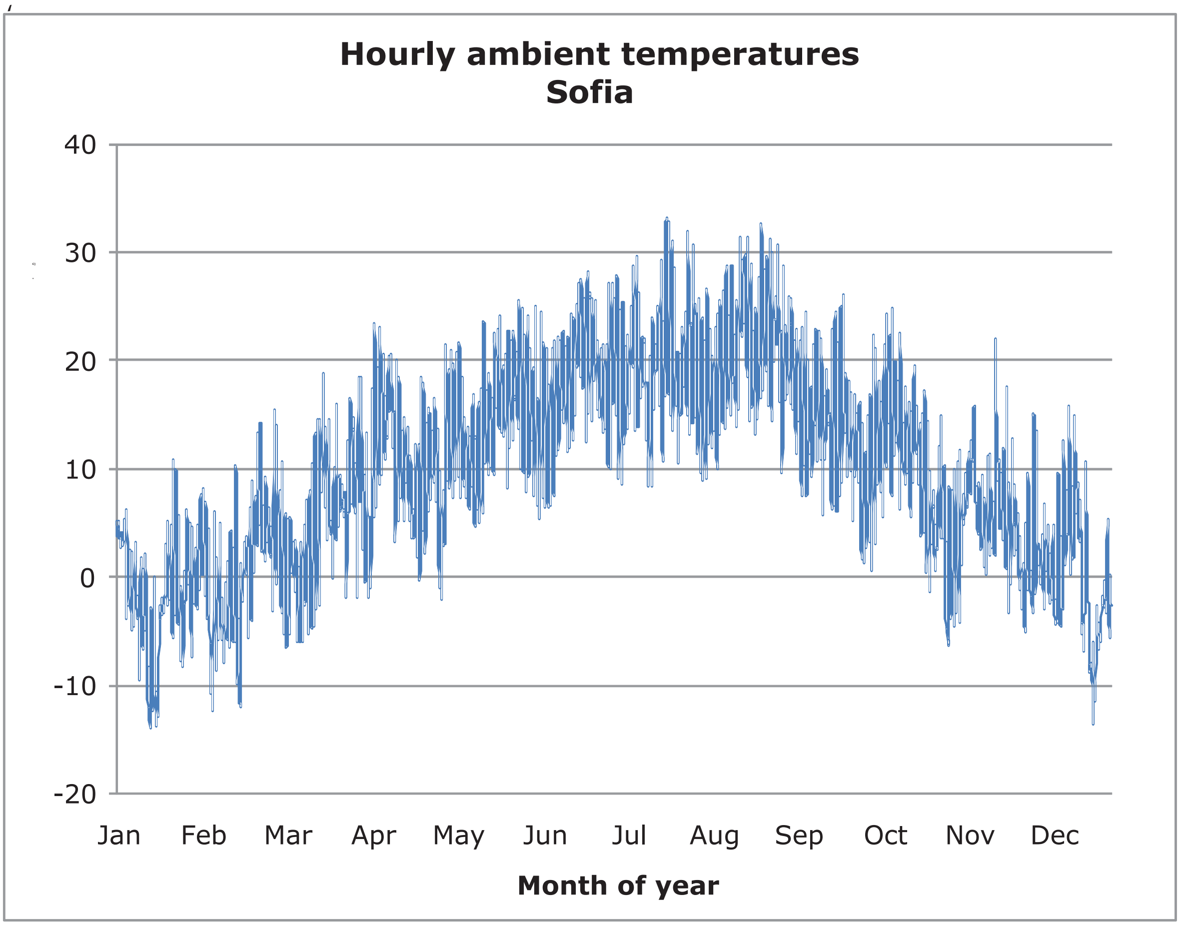
Variant	SFH [kW]	MFH [kW]	OFFICE [kW]
V1 A	3.1	43.8	24.2
V1 B	2.6	43.8	24.2
V1 C	0.6	3.6	24.2
V1 D	4.0	43.8	24.2
V1 E	-	43.8	24.2
V2 A	2.4	43.8	24.2
V2 B	1.8	43.8	24.2
V2 C	0.6	9.9	24.2
V2 D	3.2	43.8	24.2
V2 E	-	43.8	24.2
V3 A	2.5	43.8	24.2
V3 B	2.2	43.8	24.2
V3 C	0.6	9.4	24.2
V3 D	4.0	43.8	24.2
V3 E	-	43.8	24.2
V4 A	1.9	38.8	-
V4 B	1.6	38.7	-
V4 C	0.6	9.9	-
V4 D	4.0	38.8	-
V4 E	-	38.8	-

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 emissions 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 when 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 in basic variant V4 leads to a further reduction of the maximum available roof space for PV.

The internationally known and well proven software tool "TRaNsientSYstems Simulation" (abbreviation: TRNSYS, version 17) has been used to perform the necessary multi-zoned dynamic simulations. Each agreed reference building was split 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 Sofia.

Figure 4: Hourly ambient temperature in Sofia



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 (disadvantageous shell to heated floor area ratio) the reference of the single family house (SFH) has the highest specific energy demand for heating (about 140 kWh/m²/yr). At the most ambitious solutions the specific final energy demand for SFH can be reduced to about 13.5kWh/m²/yr).

Apart from the demand for heating and cooling – which becomes less important when using heat pumps – the demands for ventilation, cooling and especially lighting are relevant for the final energy demand of an office building. Due to additional consideration of lighting demand and to a higher consumption demands for cooling and ventilation, the specific final energy demand for the most ambitious office building solution is by far the highest among the three examined building types (about 33 kWh/m²/yr).

As expected, the simulation indicates that the heat pump solutions lead to a significant reduction of the final energy demand for all three building types.

A detailed breakdown of the final energy consumption in the selected reference buildings is presented in Figure 5 (A-C).

5.3.2. Primary energy demand

The office reference building has the highest specific primary energy demand. This is due to a higher electricity share and to the additional lighting, ventilation and cooling demand.

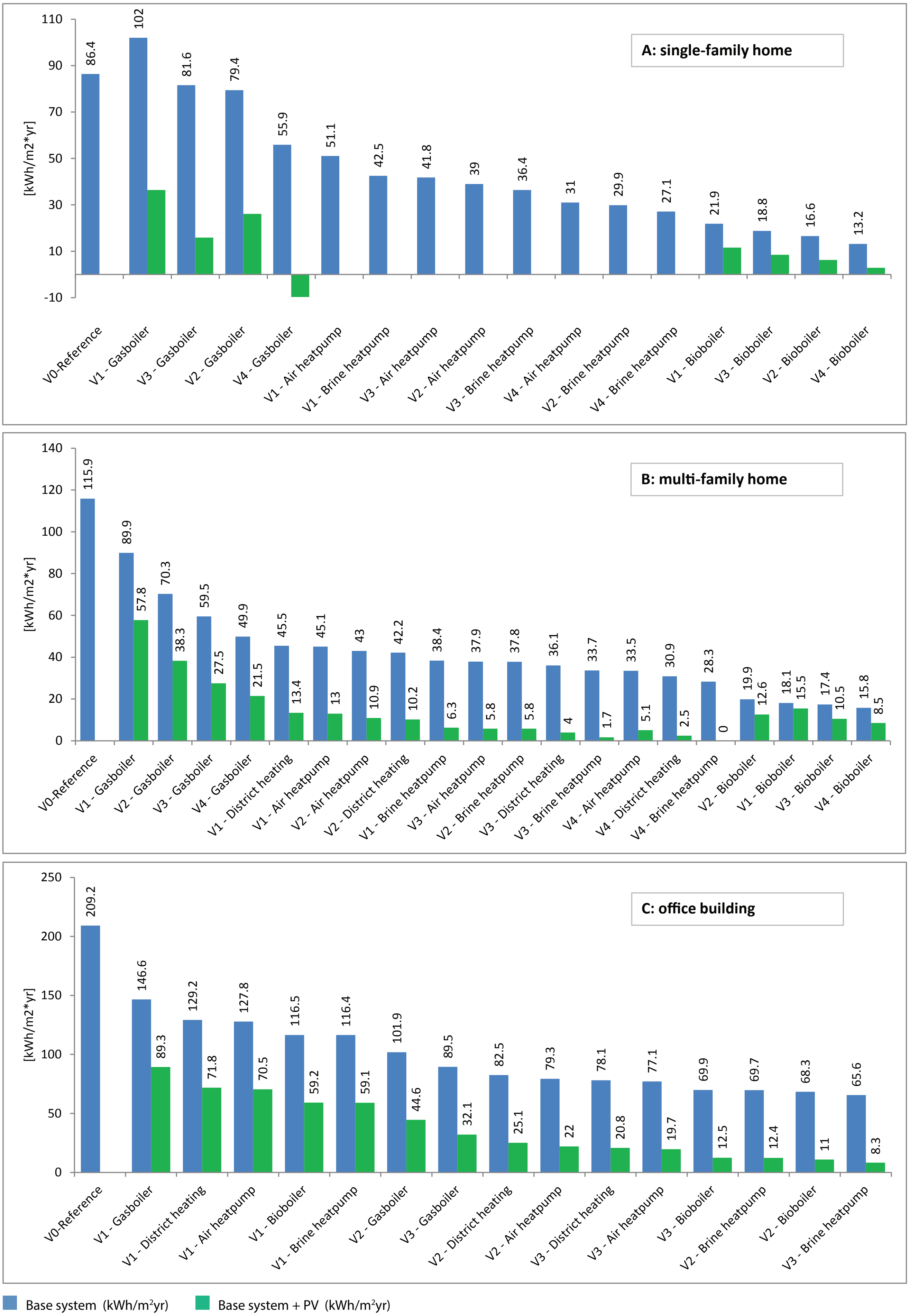
For residential buildings, the gas boiler solutions indicate the highest primary energy demand.

For the MFH and the office building, even with maximum possible CO_2 compensation (i.e. additional rooftop photovoltaic generation), the most ambitious gas boiler solution still has a significant remaining specific primary energy demand. The CO_2 compensation for the most ambitious gas boiler solution of the SFH leads to a theoretical negative specific primary energy demand. Without CO_2 compensation the minimal specific primary energy ranges between approximately 15-17 kWh/m²/yr for the most ambitious SFH and MFH solutions, but remains above 65 kWh/m²/yr for the most ambitious office building solutions. For all building types are achievable primary energy consumptions below below10 kWh/m²/yr with an additional rooftop PV system for CO_2 compensation.

A detailed breakdown of primary energy consumption in the selected reference buildings is 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

The CO_2 emissions associated to primary energy consumption is significantly high for all three reference buildings (between 45-60kg CO_2/ m^2/yr).

For residential buildings, the bio-boiler (wood pellet boiler) solutions in all improved insulation variants reduce the CO_2 emissions to almost zero. For the office building, the CO_2 emissions remain high even in the most advanced nZEB solution considered in the simulation.

For all SFH solutions – apart from the gas variants – a full CO_2 compensation by PV-rooftop systems is possible. For MFH, with the exception of gas boiler variants and the V1 district heating solution, the limited roof space at the MFH allows a CO_2 compensation with rooftop PV system that lead the specific CO_2 emissions below 3 kg/m^2/yr.

For the office building a full CO_2 compensation cannot be achieved, but several heat pumps and bio-boiler solutions in variants supposing the most ambitious improved insulation lead to associated CO_2 emissions below 3 kg/m^2/yr (i.e. variants V2 and V3, with heat pumps and wood pellet boiler).

A detailed breakdown of CO_2 emissions associated to primary energy consumption in the selected reference buildings is presented in Figure 7 (A-C).

5.3.4. Renewable energy share

Without CO_2 compensation the wood pellet boiler solutions indicate the highest share of renewable energies for all building types, i.e. above 90%for residential buildings and at around 40-60% for the office building.

The share of renewable energies for the best office solutions without CO_2 compensation is at about 60%, because of the significant electricity demands for lighting, cooling and ventilation.

The CO_2 compensation by introducing an additional rooftop PV system increases the renewable energy share above 100% for almost all simulated nZEB solutions. The exceptions are the gas boiler and district heat solutions for all three buildings and, additionally for the office building, the least insulated variant, V1.

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

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

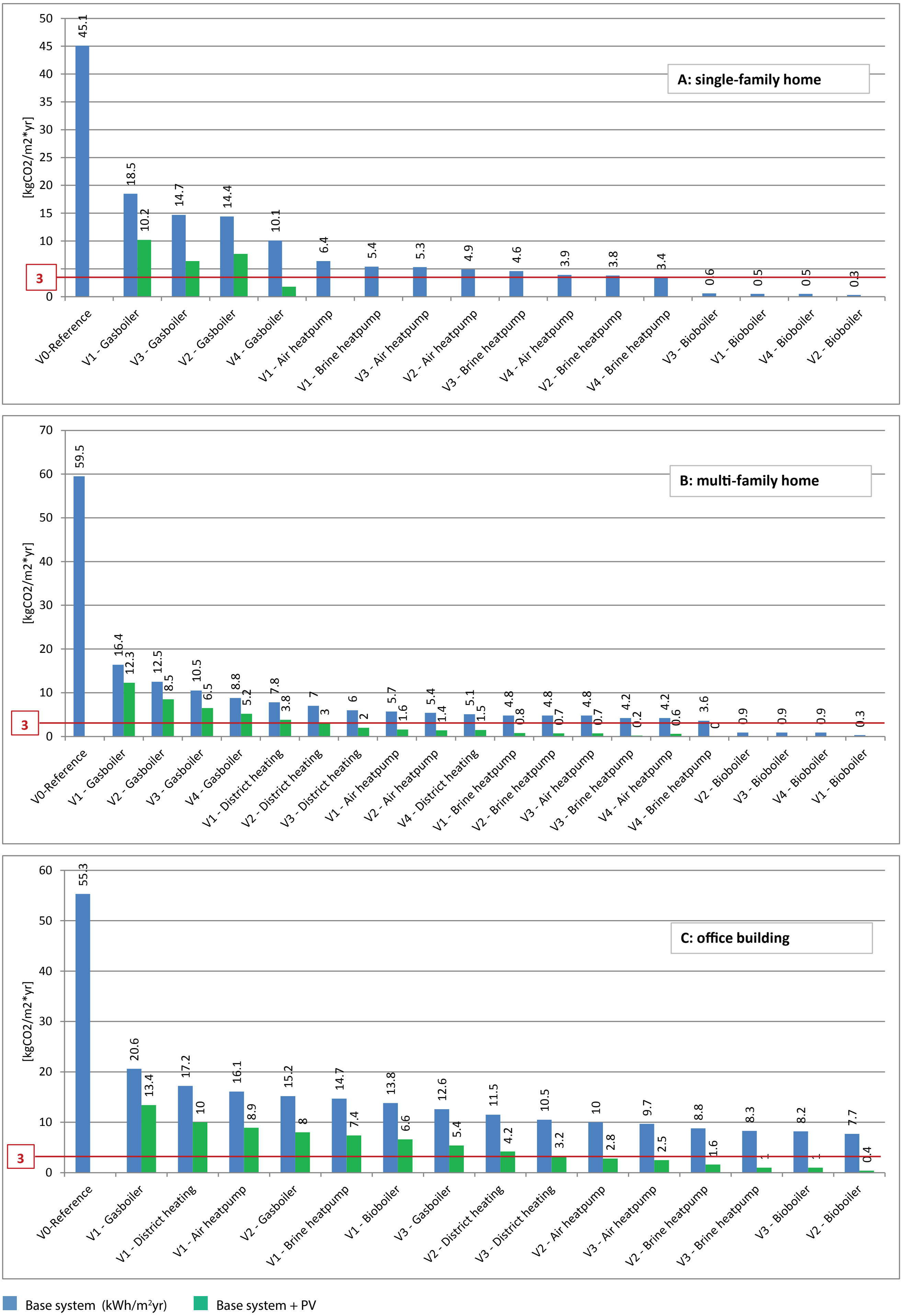


Figure 8: Renewable energy share for SFH, MFH and offices

6. FINANCIAL ANALYSIS

The financial impact 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 slightly differing price increase rates of the energy carriers for the two main periods considered (2011-2020 and 2021-2040). Different prices for private households (MFH and SFH) and industry (OFFICE) have been assumed.

All calculations were based on an interest rate of 7.5% as currently existing in Bulgaria.

Table 18: Assumed energy prices for private households and offices/industry (average 2011-2040)

ASSUMED ENERGY PRICES FOR PRIVATE HOUSEHOLDS (AVERAGE 2011-2040)			
	Energy price average[37]	Yearly price increase 2011 to 2020[38]	Yearly price increase 2021 to 2040
Gas [€/kWh]	0.092	5%	1.5 %
Conventional electricity [€/kWh]	0.125	5%	1.5 %
Feed-in electricity<30 kWp [€/kWh]	0.205	0	0.0 %
Feed-in electricity >30 kWp[€/kWh]	0.189	0	0.0 %
District heat (54% RES) [€/ kWh]	0.107	5%	1.5 %
Wood pellets [€/kWh]	0.092	5%	1.5 %

[37]Based on "State Energy and Water Regulatory Commission" (SERWRC), PV feed in tariffs dated July 2012

[38]Increase rate still 2020 estimated by local expert based on increase rates of the last five to ten years

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]	0.092	5%	1.5 %
Conventional electricity [€/kWh]	0.154	5%	1.5 %
Feed-in electricity<30 kWp [€/kWh]	0.205	0	0.0 %
Feed-in electricity >30 kWp[€/kWh]	0.189	0	0.0 %
District heat (54% RES) [€/kWh]	0.107	5%	1.5 %
Wood pellets [€/kWh]	0.092	5%	1.5 %

The assumed investment costs as identified on the Bulgarian 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 does not 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 nZEBs is required) if proper policies are in place.

Table 19: Assumed additional* investment costs of building components for Bulgaria (local experts, own investigations)

Component	SFH	MFH	Office	Unit
Additional costs triple glazed windows	28	28	28	€/ m^2 glazing
Additional costs PH windows	40	-	-	€/ m^2 glazing
Additional costs automatic external shading	-	-	101	€/ m^2 shading
Additional costs ventilation with heat recovery	34	-	-	€/(m3/h)
Additional costs improved heat recovery	51	35	11	€/(m3/h)
Additional costs air tight construction	354	6 235	-	€
Additional costs automatic lighting control	-	-	14.3	€/ m^2
Additional costs floor heating	7	8	-	€/ m^2
Additional costs 1 cm roof insulation	0.40	0.40	0.40	€/m^2
Additional costs 1 cm wall insulation	0.37	0.37	0.37	€/ m^2
Additional costs 1 cm floor insulation	0.40	0.40	0.40	€/ m^2
Spec. costs PV system	2 827	2 056	2056	€/kWp
Spec. costs solar hot water system	554	399	-	€/m^2 collector

*) compare to the reference variants

Table 20: Assumed investment costs of heating system for Bulgaria(local experts, own investigations)

Heating system incl. exhaust system [prices €]	SFH (4...6 kW)	MFH (71...127 kW)	OFFICE (44...65 kW)
Wood boiler	4 090	-	-
Gas boiler	2 430	9 150...12 400	7 550...8 770
Air heat pump	2 360	15 290...27 260	9 380...13 880
Brine heat pump	4 890...7 770	65 630...11 6980	4 0250...5 9580
Pellet boiler	4 420	15 940...20 590	13 650...16 400 [39]
District heating	-	3 380	3 380

[39]Including investment costs for production system and peripherals (no distribution system costs)

6.2. FINANCIAL ANALYSIS OF THE nZEB SOLUTIONS

The results of cost simulations are presented in Figures 9 and 10. Figure 9 shows the results for the basic options without PV compensation and Figure 10 shows the results of the financial analysis for nZEB solutions with the PV compensation (that reduces the building's CO_2 emissions as much possible to zero within the space limitation of the roof). The graphs show the specific annualised costs (on m2 of net floor area) over a period of 30 years, which is the usual time period over which a new building does not need major intervention and hence an additional investment.

Compared to the reference all simulated nZEB solutions for SFH are economically feasible. The main reason is the comparably low costs of most of the energy efficiency measures (especially the building shell improvements). For MFH only the air heat pumps solutions for variants V1-V3 are economically feasible. Overall, for residential buildings the most economical 'green' nZEB solutions are the air heat pump solutions followed by the brine heat pump and the wood pellet boiler solutions.

In contrast to residential buildings, office building solutions offer no economically feasible option. The air heat pump solution of V2 is the most economical solution with about 3 €/m^2/yr. The highest share of the extra cost for the office building is due to the automatic external shading. These costs could be controlled by a reduction of glazing area.

The annualised costs of nZEB solution without CO_2 compensation are presented in Figure 9.

The feed-in tariffs (FIT) are different for PV systems with less and more than 30 kWp installed capacity. This means that for the SFH and the Office building the FIT can be lower than for MFH if the PV compensation is higher than 30kWp.

However, the high investment costs for PV systems even below 30kWp and the extra-energy generated by a higher PV system may still generate economically feasible solutions over the considered period of time. Nevertheless all heating systems for SFH - except for the gas boiler ones- are economically feasible compared to the reference. For MFH the single economically feasible options are those based on air heat pumps (variants V1-V3).

The most economic nZEB solution for SFH and MFH is the V1 air heat pump solution by about -7.7 €/m^2/yr respectively -2.5 €/m^2/yr.

There are no economically feasible solutions for office buildings. The variant V2 with air heat pump is the most economical office solution by additional annualized costs of 4.3€/m^2/yr, fulfilling at the same time the nZEB criteria (CO_2 emissions below 3kg CO_2/ m^2/yr and low primary energy consumption).

The annualised costs of nZEB solution without CO_2 compensation are shown in Figure 10.

Figure 9: Annualised costs of nZEB solutions without CO_2 compensation

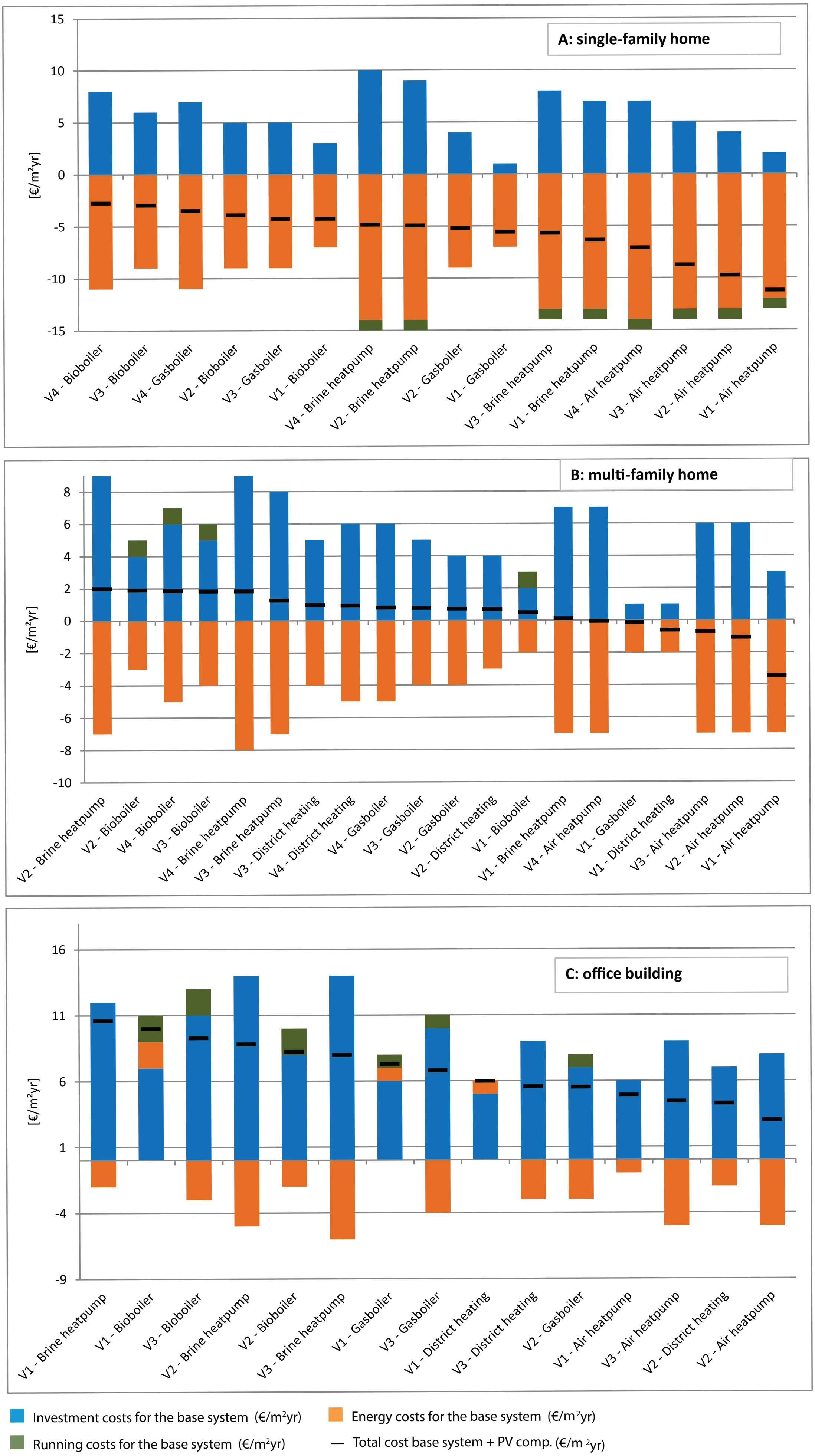
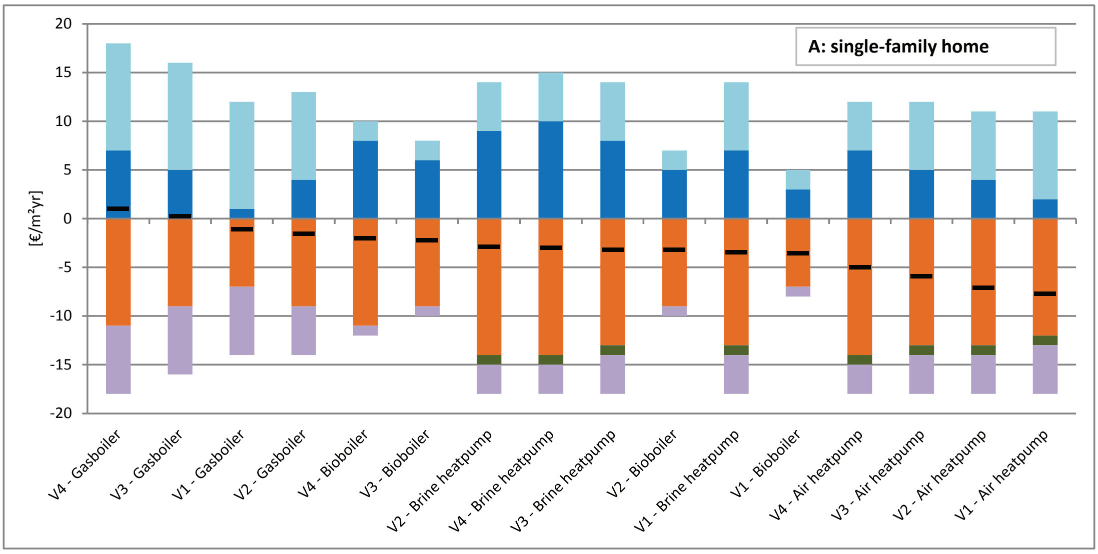
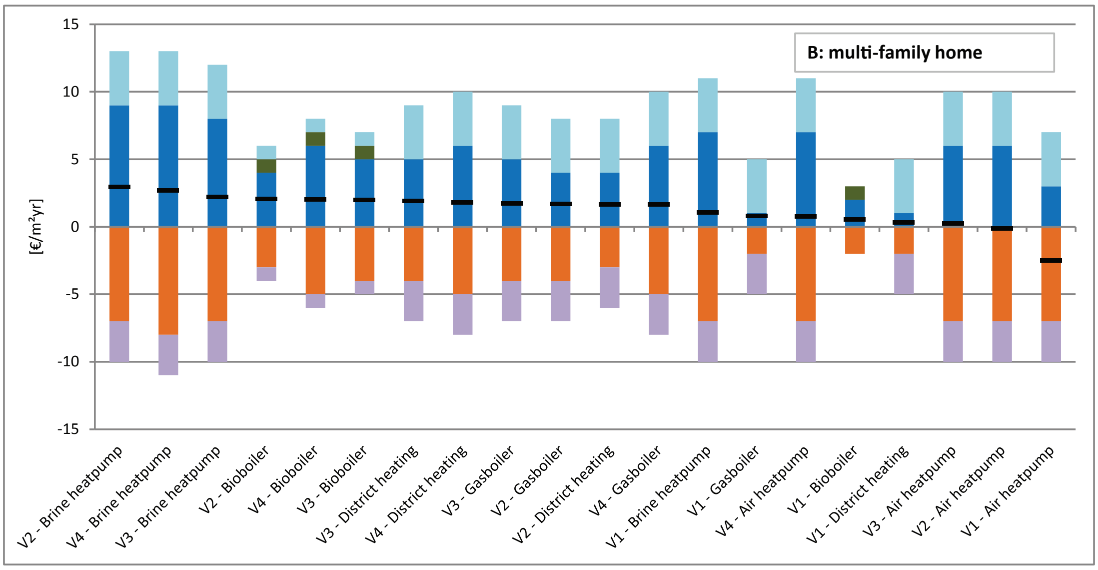
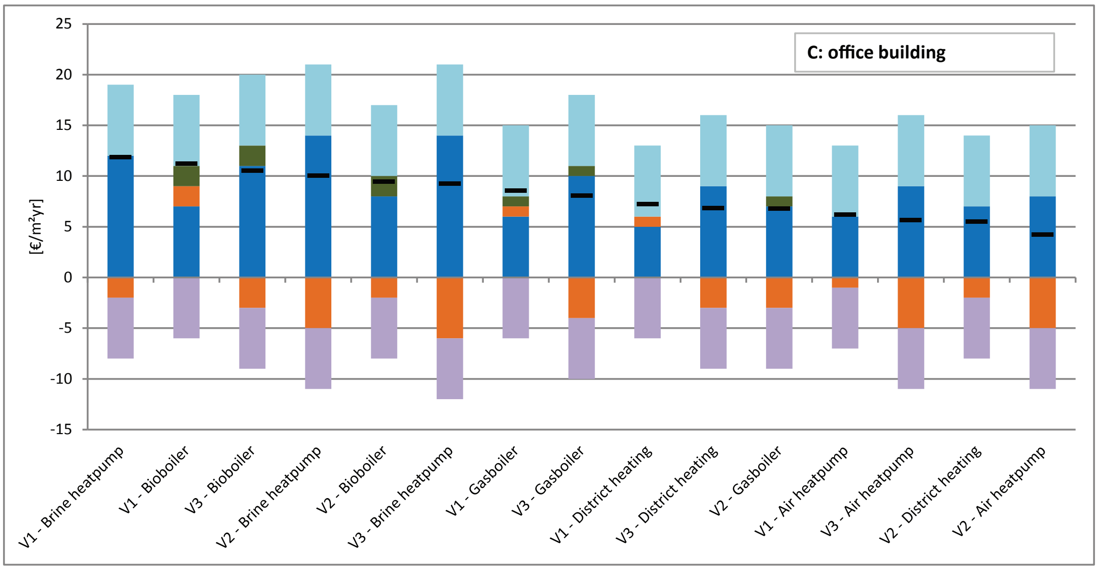


Figure 10: Annualised costs of nZEB solutions with CO_2 compensation







Investment costs for the base system (€/m²yr)
Energy costs for the base system (€/m²yr)
Running costs for the base system (€/m²yr)
Adition costs for PV (€/m²yr)
Adition costs for PV Benefit from PV (€/m²yr)
— Total cost base system + PV comp.

6.3. SUMMARY OF THE RESULTS

The simulations have shown that in Bulgaria nZEB solutions are achievable even without major changes of the common building shapes. Nevertheless, an optimization of the building shape and the percentage of glazing should be considered during the project design phase. For a full CO_2 compensation and a high share of renewable energy, rooftop PV is sufficient for most of the residential building solutions.

For the analysed office building the high-energy consumption for lighting, ventilation and cooling demand don't allow a full CO_2 compensation but nevertheless secure a very low level (below 1kg CO_2/ m^2/yr) of CO_2 emissions associated to primary energy consumption of the building. For office buildings therefore the window fraction should be optimized to achieve firstly a high daylight share and secondly minimized solar loads. Also alternative cooling concepts like ground water cooling in combination with surface cooling systems can further drop the cooling demand of the office buildings. In general it can be stated that for a full CO_2 compensation by rooftop PV the number of floors needs to be limited. While with multi-family houses about six floors can be compensated, at office buildings obviously three floors are usually the maximum.

For residential buildings the most economical solutions without CO_2 compensation, but with specific CO_2 emissions below 3 kg/m^2a are the wood pellet boiler solutions.

The office building solutions do not offer an economically feasible option, compared to the reference.

When taking into account an additional rooftop PV system for CO_2 compensation it shows that larger systems benefit from lower system costs. This is the reason why the cost-increase impact of the CO_2 compensation in office buildings is smaller than for residential reference buildings.

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

The results of the simulation for each solution in terms of primary energy consumption, renewable share, associated CO_2 emissions and total annualised additional costs (investment, energy cost savings and other running costs such as maintenance) are shown in tables 21-23. Total final and primary energy demand for residential buildings include the energy consumption within the EPBD scope: heating, cooling, ventilation, domestic hot water. For office buildings, this also includes lighting energy consumption. The colour code used for highlighting the results of the different nZEB options considered in this study is in line with the nZEB principles as they were defined in the previous BPIE study[40].

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

Table 21: Overview of the results for the single family building

	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	169.9	86.4	45.1	90%	0	n.a	n.a.	n.a.	0
V1 - Air heat pump	25.5	51.1	6.4	35%	-11.23	0	0	135%	-7.73
V1 - Brine heat pump	21.2	42.5	5.4	35%	-6.37	0	0	135%	-3.46
V1 - Bioboiler	91	21.9	0.5	99%	-4.28	11.6	0	104%	-3.57
V1 - Gas boiler	91	102	18.5	1%	-5.58	36.4	10.2	37%	-1.07
V2 - Air heat pump	19.4	39	4.9	35%	-9.78	0	0	135%	-7.11
V2 - Brine heat pump	15	29.9	3.8	35%	-4.95	0	0	135%	-2.9
V2 - Bioboiler	71	16.6	0.3	99%	-3.93	6.3	0	106%	-3.22
V2 - Gas boiler	71	79.4	14.4	1%	-5.23	26.1	7.7	38%	-1.57
V3 - Air heat pump	20.8	41.8	5.3	35%	-8.78	0	0	135%	-5.92
V3 - Brine heat pump	18.1	36.4	4.6	35%	-5.69	0	0	135%	-3.2
V3 - Bioboiler	72.1	18.8	0.6	98%	-2.96	8.5	0	105%	-2.26
V3 - Gas boiler	72.1	81.6	14.7	1%	-4.27	15.9	6.4	47%	0.23
V4 - Air heat pump	15.6	31	3.9	35%	-7.12	0	0	135%	-4.99
V4 - Brine heat pump	13.5	27.1	3.4	35%	-4.85	0	0	135%	-2.99
V4 - Bioboiler	49.4	13.2	0.5	98%	-2.75	2.9	0	108%	-2.04
V4 - Gas boiler	49.4	55.9	10.1	1%	-3.51	-9.7	1.8	68%	1
	<40	<40	<4	>50	<5	<40	<4	>50	<5
	40<x<60	40<x< 70	4<x<7	30>x<50	5<x<10	40<x<70	4<x>7	30>x<50	5< x<10
	>60	>70	>7	<30	>10	>70	>7	<30	>10

Table 22: Overview of the results for the multi-family building

	Final specific demand [kWh/m²/yr]	Without CO_2 compensation				With CO_2 compensation (by additional PV)			
		Primary energy demand [kWh/m2/yr]	CO_2 emissions [$kgCO_2/m^2/yr$]	Renewable share [%]	Total additional annualised costs [Euro/m2/yr]	Primary energy demand [kWh/m2/yr]	CO_2 emissions [$kgCO_2/m2/yr$]	Renewable share [%]	Total additional annualised costs [Euro/m2/yr]
V0-Reference	87.1	115.9	59.5	0%	0%	n.a	n.a.	n.a.	0
V1 - Air heat pump	22.5	45.1	5.7	35%	-3.45	13	1.6	106%	-2.49
V1 - Brine heat pump	19.1	38.4	4.8	35%	0.1	6.3	0.8	119%	1.06
V1 - Bioboiler	78.5	18.1	0.3	99%	0.48	15.5	0	101%	0.53
V1 - Gas boiler	80.6	89.9	16.4	1%	-0.16	57.8	12.3	20%	0.8
V1 - District heating	71.5	45.5	7.8	54%	-0.63	13.4	3.8	76%	0.33
V2 - Air heat pump	21.4	43	5.4	35%	-1.09	10.9	1.4	110%	-0.14
V2 - Brine heat pump	18.9	37.8	4.8	35%	1.99	5.8	0.7	120%	2.95
V2 - Bioboiler	66.6	19.9	0.9	96%	1.9	12.6	0	102%	2.06
V2 - Gas boiler	60.9	70.3	12.5	2%	0.72	38.3	8.5	28%	1.68
V2 - District heating	60.9	42.2	7	53%	0.69	10.2	3	79%	1.64
V3 - Air heat pump	18.9	37.9	4.8	35%	-0.72	5.8	0.7	120%	0.24
V3 - Brine heat pump	16.8	33.7	4.2	35%	1.25	1.7	0.2	130%	2.21
V3 - Bioboiler	56	17.4	0.9	96%	1.83	10.5	0	102%	1.98
V3 - Gas boiler	51.2	59.5	10.5	2%	0.77	27.5	6.5	34%	1.73
V3 - District heating	51.2	36.1	6	53%	0.96	4	2	84%	1.91
V4 - Air heat pump	16.8	33.5	4.2	35%	-0.07	5.1	0.6	120%	0.78
V4 - Brine heat pump	14.1	28.3	3.6	35%	1.83	0	0	135%	2.67
V4 - Bioboiler	46.3	15.8	0.9	95%	1.86	8.5	0	103%	2.01
V4 - Gas boiler	42.4	49.9	8.8	3%	0.79	21.5	5.2	36%	1.64
V4 - District heating	42.4	30.9	5.1	52%	0.93	2.5	1.5	86%	1.78

	<40	<40	<4	>50	<5	<40	<4	>50	<5
	40<x<60	40<x<70	4<x<7	30>x<50	5<x<10	40<x<70	4<x>7	30>x<50	5<x<10
	>60	>70	>7	<30	>10	>70	>7	<30	>10

Table 23: Overview of the results for the office building

		Without CO_2 compensation				With CO_2 compensation (by additional PV)			
	Final specific demand [kWh/m²/yr]	Primary energy demand [kWh/m2/yr]	CO_2 emissions [kgCO_2/m²/yr]	Renewable share [%]	Total additional annualised costs [Euro/m2/yr]	Primary energy demand [kWh/m2/yr]	CO_2 emissions [kgCO_2/m2/yr]	Renewable share [%]	Total additional annualised costs [Euro/m2/yr]
V0-Reference	68.7	209.2	55.3	13%	0	n.a	n.a.	n.a.	0
V1 - Air heat pump	63.9	127.8	16.1	35%	4.91	70.5	8.9	80%	6.16
V1 - Brine heat pump	58.2	116.4	14.7	35%	10.58	59.1	7.4	84%	11.83
V1 - Bioboiler	88.3	116.5	13.8	60%	9.98	59.2	6.6	92%	11.24
V1 - Gas boiler	88.3	146.6	20.6	22%	7.28	89.3	13.4	54%	8.53
V1 - District heating	86.6	129.2	17.2	42%	5.98	71.8	10	75%	7.23
V2 - Air heat pump	39.7	79.3	10	35%	2.99	22	2.8	107%	4.24
V2 - Brine heat pump	34.9	69.7	8.8	35%	8.8	12.4	1.6	117%	10.05
V2 - Bioboiler	67.8	68.3	7.7	71%	8.22	11	0.4	113%	9.47
V2 - Gas boiler	67.8	101.9	15.2	16%	5.51	44.6	8	58%	6.77
V2 - District heating	65.8	82.5	11.5	45%	4.26	25.1	4.2	89%	5.51
V3 - Air heat pump	38.5	77.1	9.7	35%	4.42	19.7	2.5	109%	5.68
V3 - Brine heat pump	32.8	65.6	8.3	35%	7.97	8.3	1	122%	9.22
V3 - Bioboiler	54.5	69.9	8.2	61%	9.27	12.5	1	114%	10.52
V3 - Gas boiler	54.5	89.5	12.6	21%	6.78	32.1	5.4	74%	8.04
V3 - District heating	53.4	78.1	10.5	42%	5.55	20.8	3.2	75%	6.81

	<40	<40	<4	>50	<5	<40	<4	>50	<5
	40<x 60	40<x<70	4<x<7	30>x<50	5<x<10	40<x<70	4<x>7	30>x<50	5<x<10
	>60	>70	>7	<30	>10	>70	>7	<30	>10

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

On the basis of the economic analysis the three most appropriated solutions for each building type were selected fulfilling entirely the nZEB principles (as defined in the 2011 BPIE study). All solutions are with PV compensation and the variations of the most suitable technologies and facade qualities are considered. Table 24 presents these options.

Table 24: Overview of the (cost-) optimal variants

Building type	Variant	Brief Description	Heating system	Additional annualised costs (Base year 2010) [€/m²yr]	Additional annualised costs comparing with average reference actual price [42] [%]
SFH	V1A	Improved building shell	Air heat pump	-7.73	-14.7%
	V3B	Improved building shell + mech. ventilation with heat recovery	Brine heat pump	-3.20	-6.1%
	V3C		Bio Pellet	-2.26	-4.4%

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

MFH	V1C	Improved building shell	Bio Pellet	0.53	1.15%
	V3B	Improved building shell + mech. ventilation with heat recovery	Brine heat pump	2.21	4.8%
	V4C	Improved building shell + mech. ventilation with heat recovery + solar collectors	Bio Pellet	2.01	4.4%
Office	V2A	Improved building shell + external shading + improved lighting	Air heat pump	4.24	12.15%
	V2C		Bio Pellet	9.47	27%
	V3B	Improved building shell + external shading + improved lighting + improved windows + improved heat recov-ery	Brine heat pump	9.22	26.3%

In the residential sector in Bulgaria, the selected cost-optimal nZEB solutions have additional annualized costs ranging from -14.7% to26.2% compared to actual market prices for a new building in this category. The most cost-effective solutions for SFH (where all optimal nZEB solutions are very effective) have additional costs ranging between -14.7% and -4.4% compared to the reference building according to actual practice. For MFH, the nZEB cost-optimal solutions indicate additional costs between 1.1% and 4.8% as comparing to the cost of the reference building.

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

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

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

In this study, district heating solutions for multi-family buildings without CO_2 compensation turned out to be above the CO_2 emission target of 3 kg/m^2 per year, although the district heat was calculated with a share of about 54% renewable energies. For the examined solutions this share of renewable energy is still not sufficient to bring down the CO_2 emissions to or below the required 3 kg/m^2 per year.

As suggested in the BPIE study defining principles for nZEB[42], the strategy for district heating (DH) systems should be developed in strong relationship with buildings policies, in order to better identify future needs and to shape the economic instruments for reaching an overall sustainable buildings sector. District heating systems may offer a higher flexibility than other alternatives in changing the energy carriers and may be an important nZEB solution.

Based on the above analysis, on the simulation results shown in tables 21-23 and taking mainly into consideration the additional costs and results for basic variants without PV compensation, the following levels are proposed for consideration as nZEB definitions for Bulgaria (Table 25).

Table 25: Proposed nZEB definitions for Bulgaria

Building type	Minimum requirements	Year		
		2015/2016	2019	2020
Single family buildings	Primary energy [kWh/m2/yr]	60-70		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [kgCO_2/m2/yr]	<8		<3-5
Multi-family buildings	Primary energy [kWh/m2/yr]	60-70		30-50
	Renewable share [%]	>20		>40
	CO_2 emissions [kgCO_2/m2/yr]	<8		<3-5
Office buildings	Primary energy [kWh/m2/yr]	100		50-60
	Renewable share [%]	>20		>40
	CO_2 emissions [kgCO_2/m2/yr]	<15		<8-10
Public office buildings (exemplary role)	Primary energy [kWh/m2/yr]	80	40-60	
	Renewable share [%]	>20	>50	
	CO_2 emissions [kgCO_2/m2/yr]	<12	<5-8	

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

The thresholds suggested above for an nZEB definition in Bulgaria are fairly ambitious yet affordable as compared to actual practice. However, these thresholds are significantly less ambitious than in other Western Europe countries, which aim to reach climate neutral, fossil fuel free or even energy positive new buildings by 2020[43]. Thinking long-term, it should be ensured that the building concept could be improved towards specific CO_2 emissions below 3 kg CO_2/m^2yr (and aiming at: 0 kg/m^2yr), which is the identified EU average minimum requirement for achieving the EU 2050 decarbonisation goals.

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

It is important to highlight the fact that the financial and energy analysis are based on very conservative assumptions, using the actual interest rates and technology prices and according to the actual practices in construction. For instance, the optimization of building geometry (in line with those recommended by passive houses design) could lead to significant additional cost reductions. Moreover, by implementing ambitious nZEB requirements in the Bulgarian building codes will generate a wider market deployment of energy efficient and renewable technology which will consequently reduce prices and overall generate lower final costs for nZEB.

In addition, the financial evaluation of the nZEB solutions considered the actual interest rate on the Bulgarian market, i.e. 7.5%/yr. However, according to the estimated economic evolution, the interest rates are likely to decrease consistently by 2020 when the nZEB requirement becomes 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 increase their competitiveness with respect to buildings at today's standards. Overall, a reduction of the interest rate may impact positively the financial analysis and make nZEB investments profitable over a given period of time, as this is the case in other EU countries already profiting from better conditions.

7.1. ARE THE PROPOSED VARIANTS AFFORDABLE?

In the case of the single family house, almost all simulated nZEB solutions led to annualised cost savings between 2-7 €/m^2yr. This means that the analysed nZEB solutions for SFH are already affordable. In the case of the multi-family house, the implementation of nZEB cost-optimal variants will generate additional costs between 0.5-2.2 €/m^2yr.

However, the cost analysis assumed a rather conservative evolution of energy prices over time, but it is possible to achieve even more attractive costs for the simulated nZEB solutions. Moreover, if future prices of energy efficient technologies will decrease, the results will become more attractive and economically feasible. However, it is uncertain how the situation in Bulgaria will develop. It is also possible that an adaptation to the EU level will take place in Bulgaria, and due to a higher demand, prices could increase instead of decrease in the country. Also country specific circumstances for energy efficient -technology could have an impact on prices.

Overall, there is still the problem of higher investment costs for nZEB solutions compared to actual building practice. In order to address this problem, it will be important to establish financial support schemes to compensate for the additional upfront capital required by the introduction of nearly zero-energy Buildings in Bulgaria.

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

8. DIRECT AND INDIRECT BENEFITS OF IDENTIFIED nZEB SOLUTIONS

This chapter presents the direct and indirect benefits of implementing nZEBs.

The payback from investing in better buildings occurs over time. It contributes substantially to energy security, environmental protection, social inclusion by creating or preserving jobs and offering a better quality of life, as well as to the sustainable development of the construction sector and supply chain industry.

While the upfront investment is relatively high and the return on investment is usually longer than for other economic activities, there are multiple benefits for building users and owners, the construction industry, public budget and society as a whole.

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

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

In this study, the approach to quantifying some of the benefits is done in an approximate way by extrapolating results from the reference buildings to the national level, e.g. (average energy and CO_2 savings per m^2) x (m^2 built new per year) x 30 years (2020-2050). Therefore, in Table 26 we present the estimated macro-economic impact by 2050 in terms of additional investments, additional new jobs, CO_2 and energy savings.

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

However, this is a conservative approach without considering additional important factors that may positively influence the macro-economic benefits. As an example, the job creation impact is based on the job intensity of the construction industry and reflects only the additional work places that may be created at the execution level. It doesn't include the jobs in the supply chain industry induced by up-scaling the market and the indirect jobs in the administration of the processes (e.g. additional auditors and control bodies for new tech). Moreover, the move towards very efficient buildings and new technologies will create new job profiles such as renewable systems and heat pumps installers. Therefore, there will be an increased need for new activities all over the country. This need is not only driven by additional invested volumes (as we considered in this study) but also by local needs for such new job profiles[45]. Consequently, a much higher job creation potential than estimated in this study is very likely.

Table 26: Effect of the implementation of nZEB after 2020 in 2050

Indicator	Effect
CO_2 emissions savings in 2050	4.7-5.3 M t CO2
Cumulative energy savings in 2050	15.3 -17 TWh
Additional annual investments	€ 38 - 69 M
Additional new jobs[46]	649 - 1180 Full time employees

Table 27: Effect of the implementation of nZEB after 2020 in 2050

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

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

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

9. A 2020 ROADMAP FOR IMPLEMENTING nZEBs IN BULGARIA AND POLICY RECOMMENDATIONS

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

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

9.1. BUILDING CODES

The first condition for implementing nZEB 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.

Currently, in the Bulgarian building codes there are requirements for U-values of specific building components. The energy performance for each new building is calculated with the referent U-value prescribed by law. The technical documentation for the design of new buildings includes a compulsory estimation of the energy performance of buildings at the design stage and a report done by an independent expert for checking the compliance of the design with the existing energy performance and prescriptive requirements. In case of non-compliance, the permission for constructing the building is not given. Moreover, it is necessary to obtain a technical certificate for the building, issued after construction but before commissioning. If the buildings' energy performance is worse than the energy performance calculated on the basis of the U-values for building components (as indicated by the current legislation), than the building will not be commissioned.

[47]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

The upcoming legislation transposing the EPBD at national level will ensure that energy performance requirements are part of the 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 related CO_2 emissions. This means that the first measure to be implemented will 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 actual practices 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 covered 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 of the RES Directive. Implementing nZEBs will positively contribute to both the implementation of buildings and renewable energy policies and thereby help achieve the EU's 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's EPBD, energy performance certificates have to indicate both the 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 will also secure the sustainable development of the building sector.

The following table shows the state of the art regulation for new buildings in Bulgaria and foreseen adaptations towards nearly Zero-Energy Building regulations. It also shows the state of the art regulation for new buildings in Bulgaria and the forseen adaptations towards nearly Zero-Energy Buildings.

Table 28: Further steps for improving building codes in Bulgaria

Status quo	• Requirements for U-values for specific building components. The energy performance for each new building is calculated with the referent U-value prescribed by law. • Prescriptive requirements and calculated energy performance are compulsory for issuing the construction and commissioning certificates for a building. • No requirements for compulsory use of renewable energy in new buildings. However, in the Energy Efficiency Law it is mentioned that the renewable energy use should be considered as a possible option during the design phase of the buildings.
Gaps in the implementation of nZEB	• Building codes do not foresee minimum energy performance requirements for primary energy demand and by building type. The energy performance should be calculated case by case and based on prescriptive U-value for components. • There is no obligation to meet certain CO_2 emissions • There are no specific requirements for using renewable energy in buildings.
What can be improved to achieve the implementation of nZEBs?	• To secure the transition to nZEB in the future, the regulation should be improved. The changes should affect the structure of the regulation and its ambition level. • The structure should be adapted, including clearly defined obligations by building type regarding the primary energy use / CO_2 emissions and the use of renewable energy. • The ambition level of the obligations should be tightened over the time.
Intermediate steps	• Start to gradually tighten the energy related requirements for buildings: • Tighten requirements for building envelope (e.g. Energy class A become obligatory for new buildings) • Tighten max. primary energy use • Change structure of regulation: - limit primary energy use and CO_2 emissions - introduce obligation for renewable energy share

9.2. FINANCIAL SUPPORT AND INTERACTION OF POLICY INSTRUMENTS

For a successful implementation of nZEBs by 2020, the interaction of various policy instruments needs to be considered. The main issue is sufficient incentives and awareness-raising to comply with regulations. A financial scheme should be embedded in a successfully working regulation framework (as for example the Energy Saving Ordinance - EnEV in Germany) and to be accompanied by broad information campaigns creating awareness amongst building owners. In that sense, these instruments should be part of a wider holistic policy package, which should include regulatory, facilitation and communication elements.

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

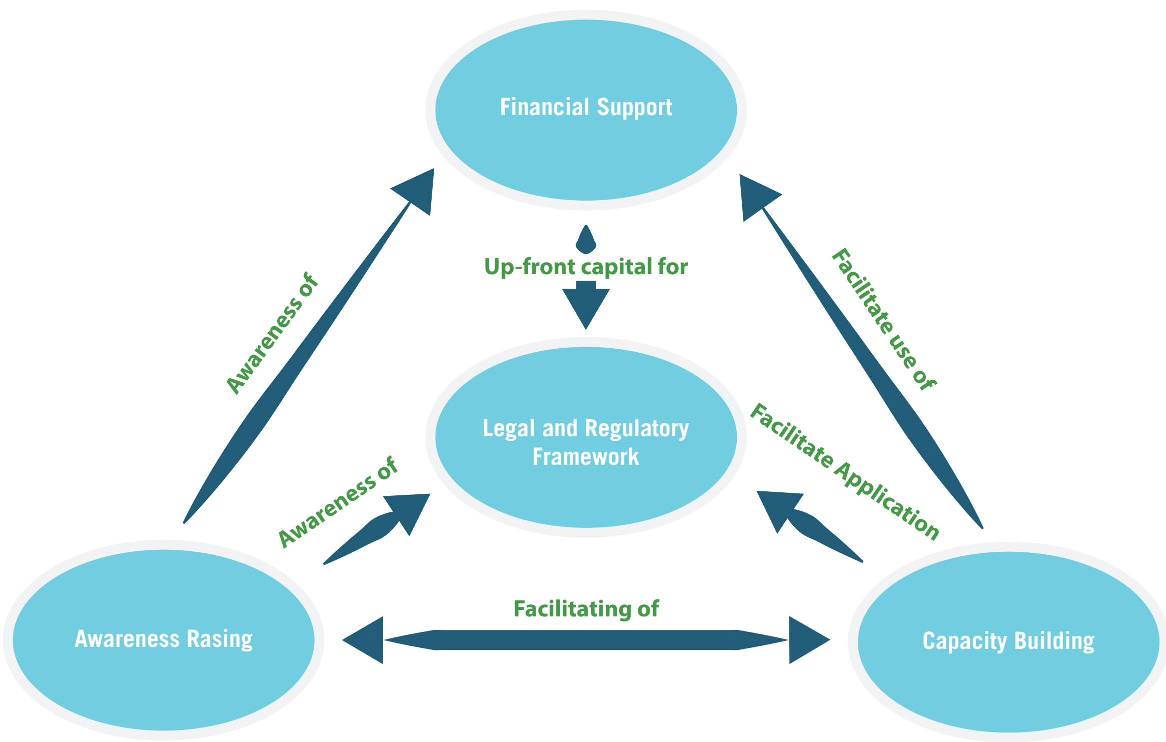
The existing market barriers for improving the energy performance of buildings should be identified and eliminated in order to allow a smooth implementation of low-energy buildings.

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 overcome;
- Effective types of economic instruments;
- The required level of economic support;
- Financing and other economic support instruments that facilitate the uptake of the new technologies.

Financial schemes have the objective to foster market development and create 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 (figure 11), 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 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 support for renewable technologies.
2. Financial schemes are key in the successful implementation of nZEBs. Grants and preferential loans are the most prevalent forms of instrument and, based on available 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 volume of applications increases. A low interest rate works as an incentive as it is perceived to be the most important factor. The Thermo Modernisation Fund in Bulgaria[48] is a good practice that may be used for the elaboration of a financing scheme for a new nZEB.
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, the available financing schemes of International Financial Institutions, the dedicated lines from European Investment Banks should be considered, but mainly EU 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 greatly 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 loan duration[49].
5. Complex application and transactional procedures can negatively affect the take up of an instrument. It is necessary to create easily accessible and 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 29.

Table 29: Further steps for improving financial support schemes in Bulgaria

State of art	• All support schemes for the implementation of energy efficiency and RES measures in buildings are exclusively targeted to existing buildings
Gaps in the implementation of nZEBs	• No holistic policy package in place at the moment. • There is no support scheme for the implementation of energy efficiency and renewable energy in new buildings, e.g. to stimulate the construction of only A class energy buildings or only with a certain energy performance (e.g. a better interest or a premium for buildings with primary energy consumption lower than 50kWh/ m^2/yr).

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

[49]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 at: http://ec.europa.eu/regional_policy/conferences/energy2011nov/index_en.cfm

What can be improved for implementing nZEBs	• Create financial/ fiscal instruments for energy efficiency and renewable energy in new buildings that are embedded in a holistic policy package and which should include regulatory and communication elements. • Where possible, extend and adapt existing support schemes also for new buildings. • Make energy efficiency measures affordable (remove barriers) by introducing support mechanisms such as soft loans and grants. • Facilitate the use of renewable technology (remove barriers): • Support local technology (financial support, knowledge transfer) or/and where necessary, facilitate the import of only very efficient materials and renewable technology from other (EU)countries
Intermediate steps	Create an in-depth gap analysis to find out: • which EE measures and RE technologies to support • which barriers exist on the market • which type of instruments effectively help to overcome identified barriers, • what level of support is needed • which auxiliary instruments are needed to make the financing work • how to overcome budget limitations for support programmes • what is the investors opinion (how do people understand EE and RES)

9.3. MARKET UPTAKE

An important condition for achieving a liberalised energy market and the uptake of energy efficient and renewable is to gradually decrease harmful subsidies for energy prices. At the same time it is important to elaborate support policies to ease the social burden, possibly by using the budget saved from subsidies on energy prices.

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. An insufficiently developed market that is not able to keep pace with the demand for new energy efficient and renewable technologies represents indeed one of the biggest market barriers.

The most commonly used renewable energy sources for single family houses in Bulgaria are solar panels and small biomass boilers. According to EurObserv'ER, the total solar thermal installed capacity (all technologies) in 2010 was at 62 MWth and 88 100 m^2[50] , (10% growth in terms of installed area from 2009 to 2010). Air-to-air thermal pumps are also growing in popularity on the Bulgarian market.

Based on our analysis within this study, the nZEB implementation would require using thicker or improved insulation materials, triple-glazed windows in every building, installing mechanical ventilation with heat recovery in about 90% of the buildings, heat pumps in about 50% of the buildings, pellet boilers in about 50% of the buildings, solar thermal systems in about 15% of the buildings and PV systems in more than 75% of all new buildings (see Table 30). The exact shares correlate strongly with the distribution of variants that are built.

[50] 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

Table 30: Comparison of current 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 [51]	Existing	Very small	Small	Small	Small	Existing	Very small
Demand of new nZEBs	100%	90%	100%	~50%	~50%	~15%	>75 %
Required growth of market	High	Very high	Very high	High	High	Normal	Very high

The market analysis indicates that investments need to rise to satisfy the additional demand created by new nZEBs. However, there are significant challenges. To achieve a mature nZEB market, it will be necessary to significantly increase the growth rates of ventilation systems with heat recovery, of triple glazed windows and heat pumps.

9.4. RAISING AWARENESS AND INFORMATION

In Bulgaria, there is still a significant need for awareness-raising. It is our recommendation to accompany all new regulation and future market instruments by awareness-raising campaigns[52, 53]. Awareness-raising campaigns are very important and an effective instrument for overcoming many market barriers, which are caused by a lack of proper information from both large public and contractors. Without proper awareness and information support, the public opinion may become distorted and the future introduction of nZEB may be wrongly perceived as a threat to households, leading to greater expense and costs.

While national strategies and legislation foresee awareness on energy performing buildings as a necessary step forward, there is often no financial support and the information activities are not properly implemented. So far, local authorities in Bulgaria were not very active in information, dissemination and awareness activities due to financial constraints.

Most of the public campaigns are organized at local level and accompany projects financed by the EU or International Funds. Usually, the local NGOs are also involved in this process.

To date there is no strategic approach to communication and information activities concerning energy efficiency and renewable energy in buildings. The main sources of information concerning energy efficiency and renewable energy are professional chambers and associations and specialised NGOs[54].

[51]Own estimation

[52]TrainRebuild (2012b). *Training for Public Authority Civil Servants.*Available at: http://trainrebuild.eu/wp-content/uploads/2011/07/Draft-Toolkit-for-Local-Authorities.pdf

[53]TrainRebuild (2012a). *Guidance Document for Trainers.* Available at: http://trainrebuild.eu/wp-content/uploads/2011/07/Guidance-Document-for-Trainers.pdf

[54]Idem 53

9.5. 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. With rising requirements on building energy certification and expert capacity, problems are expected to rise. Therefore, the basic education curricula have to be adapted to both the 'blue' and 'white' collar workers 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.

Nowadays in Bulgaria there are five accredited passive house planners, according to the Passive House Institute Darmstadt.

Bulgaria participates in the Build UP Skills IEE programme[55] dedicated to the integration of energy efficiency and renewable energy technology in buildings. The project aims to:

- Analyse the demand for skilled workers in the construction sector
- Evaluate the actual education and training capacity of the vocational training sector,
- Detect existing barriers and gaps and to finally
- Develop a national qualification and training roadmap with the participation of all relevant stakeholders.

In addition, there is a strong need for the training of design engineers and architects. This is of primary importance in Bulgaria. Unfortunately, most universities are not yet ready to provide an adequate education and postgraduate qualification in very low energy buildings. Therefore it will be necessary to improve the existing educational curriculum in the near future. Moreover, it is necessary to further develop the international cooperation in this area for exchanging best practice and experience[56].

To conclude, there is still a significant need for capacity building in Bulgaria. To prepare the effective nZEB implementation, it will be key to elaborate programmes addressing workforce qualification in the building sector.

9.6. 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 demonstrate and showcase the effectiveness of new technologies and their affordability.

9.7. 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 generally improve the living standard and welfare.

The integration of building policies in the wider context of national energy policies and strategies will ensure coherence and ease future implementation. In addition, it will minimise investment costs by optimising the efforts.

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[55]Build Up Skills Bulgaria (2012). Web Page: *the Build UP Skills Bulgaria project Available* at: http://www.buildupskillsbg.com/

[56]TrainRebuild (2012b). *Training for Public Authority Civil Servants.*Available: http://trainrebuild.eu/wp-content/uploads/2011/07/Draft-Toolkit-for-Local-Authorities.pdf

9.8. PROPOSAL FOR AN nZEB ROADMAP FOR BULGARIA

We demonstrate in this report that the additional financial efforts involved in moving towards nearly Zero-Energy Buildings are manageable with appropriate policy measures. By improving the thermal insulation of new buildings and by increasing the share of renewable energy use in a building's energy consumption, the implementation of nearly Zero-Energy Buildings in Bulgaria can generate 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 campaigns. 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 then ZEB 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. Halfhearted measures make any market transformation process longer and ineffective, putting at the same time additional burden on society and economy.

A policy roadmap for implementing nZEB buildings in Bulgaria

ANNEX 1: SKETCHES OF DEFINED REFERENCE BUILDINGS

REFERENCE BUILDING N°1: SINGLE FAMILY HOUSE (SFH)

Figure A1: Facade view of North (left side) and South (right side) elevation of the single family house

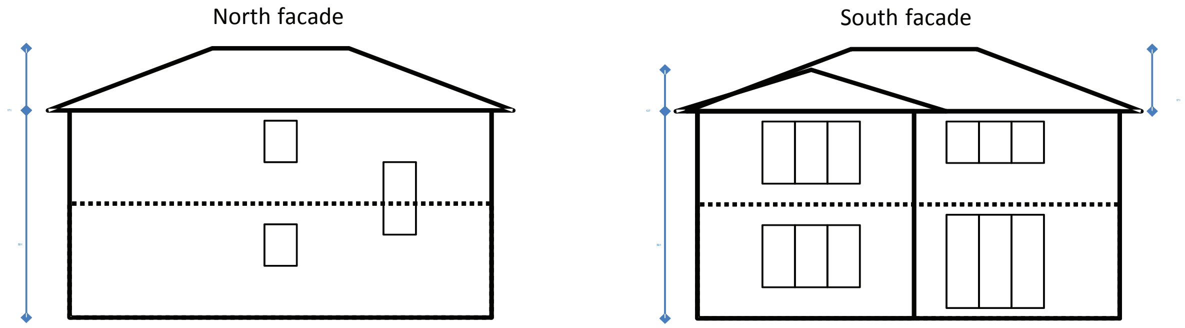


Figure A2: Facade view of East (left side) and West (right side) elevation of the single family house

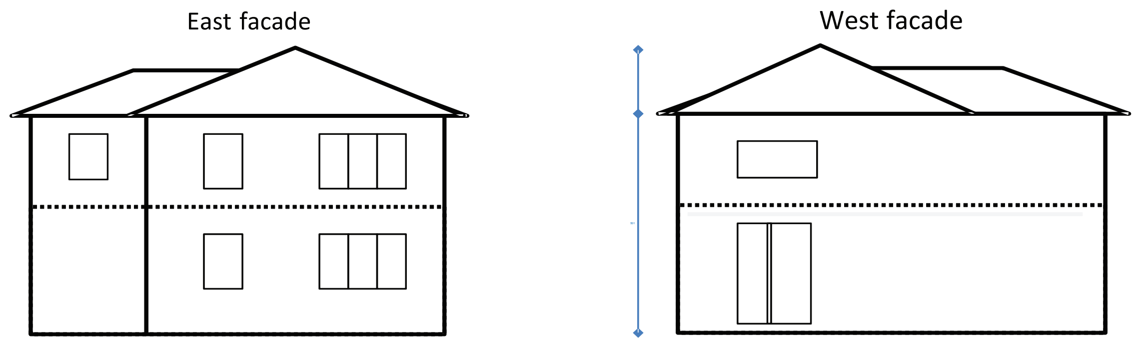
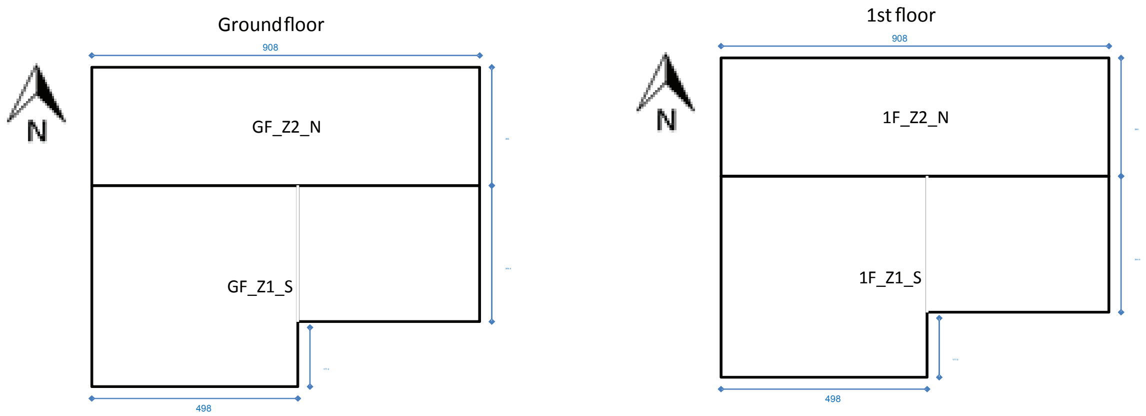


Figure A3: Floor plans (ground floor, 1st floor) with the simulated zones of the single family house



The floor plans above show the two floors of the simulated single family house with the considered zone classification. The zones are classified by orientation (North or South) and by the type of usage. The Southern ground floor zone (GF_Z1_S) includes both the living room and the kitchen. The Northern zones (GF_Z2_N, 1F_Z2_N) are the bed- and bathroom while the Southern zone (1F_Z1_S) on the first floor only includes two bedrooms.

REFERENCE BUILDING N°2: MULTI-FAMILY HOUSE (SFH)

Figure A4: North and South facade view of the Bulgarian multi-family house

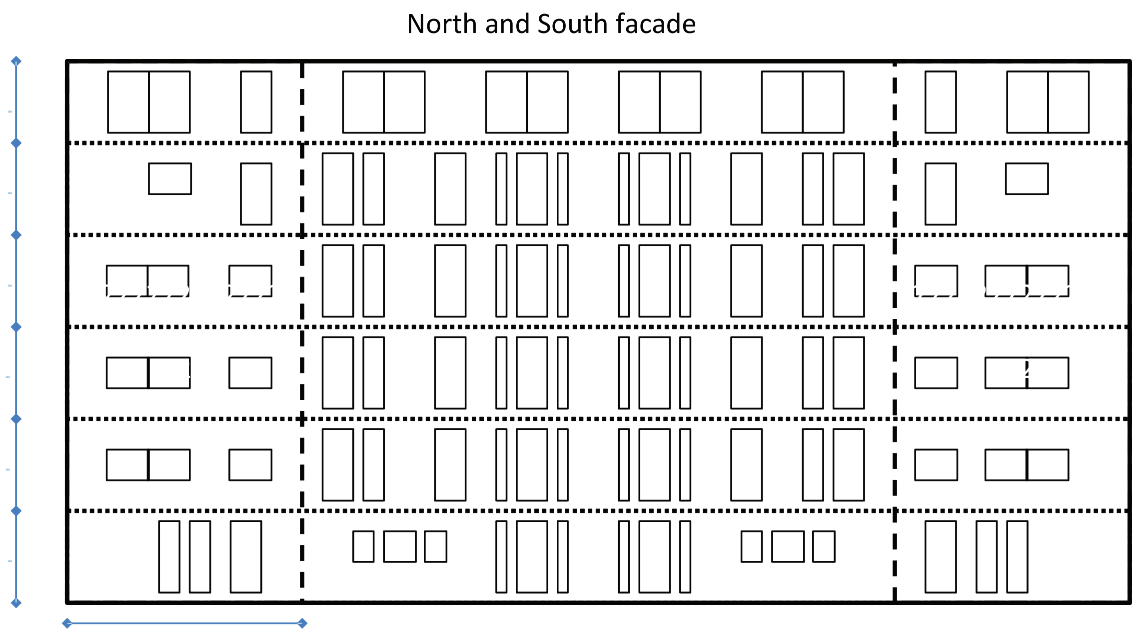


Figure A5: East and West facade view of the Bulgarian multi-family house

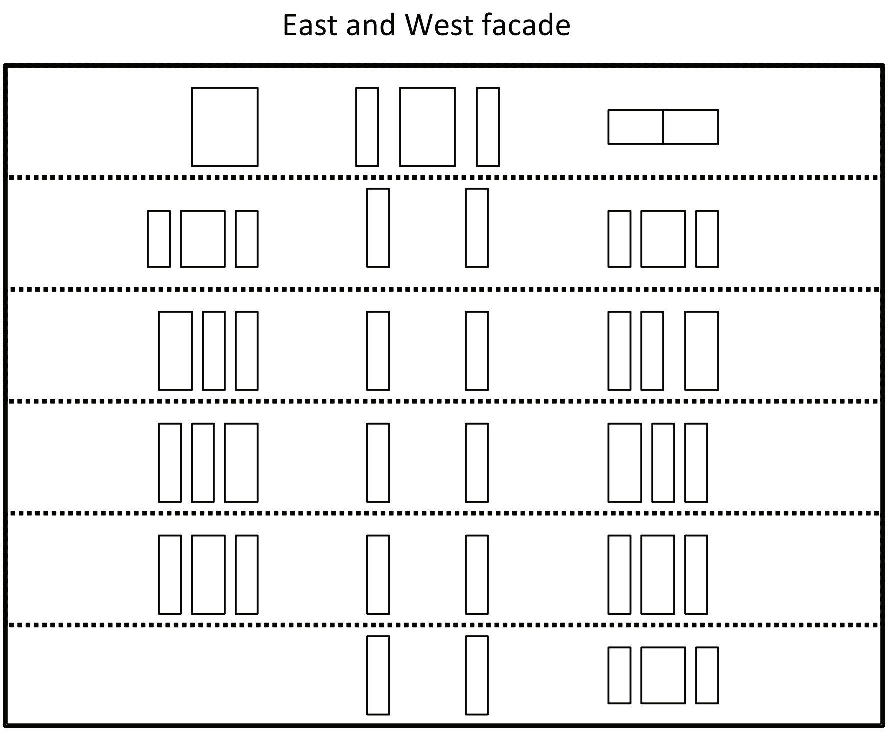
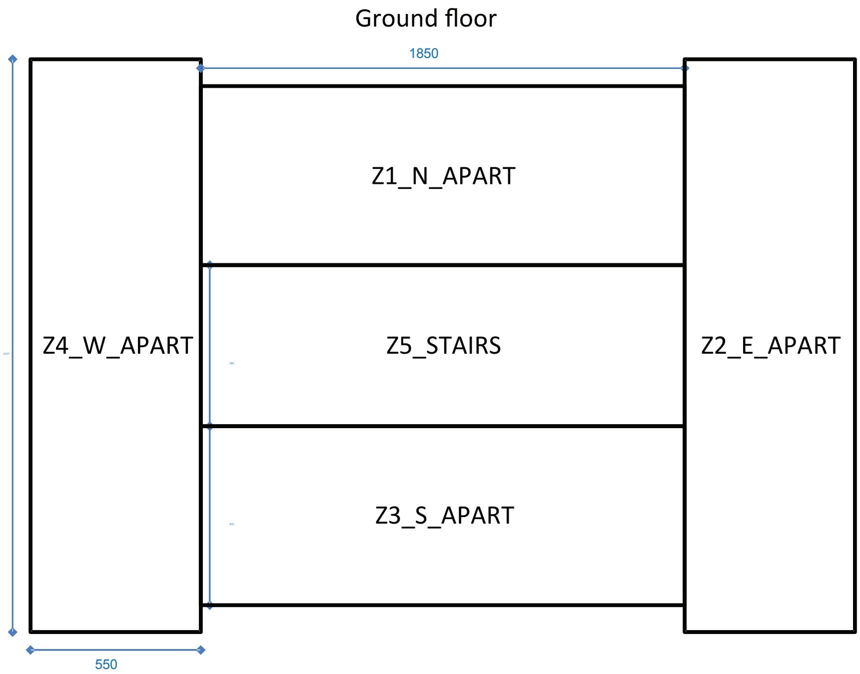


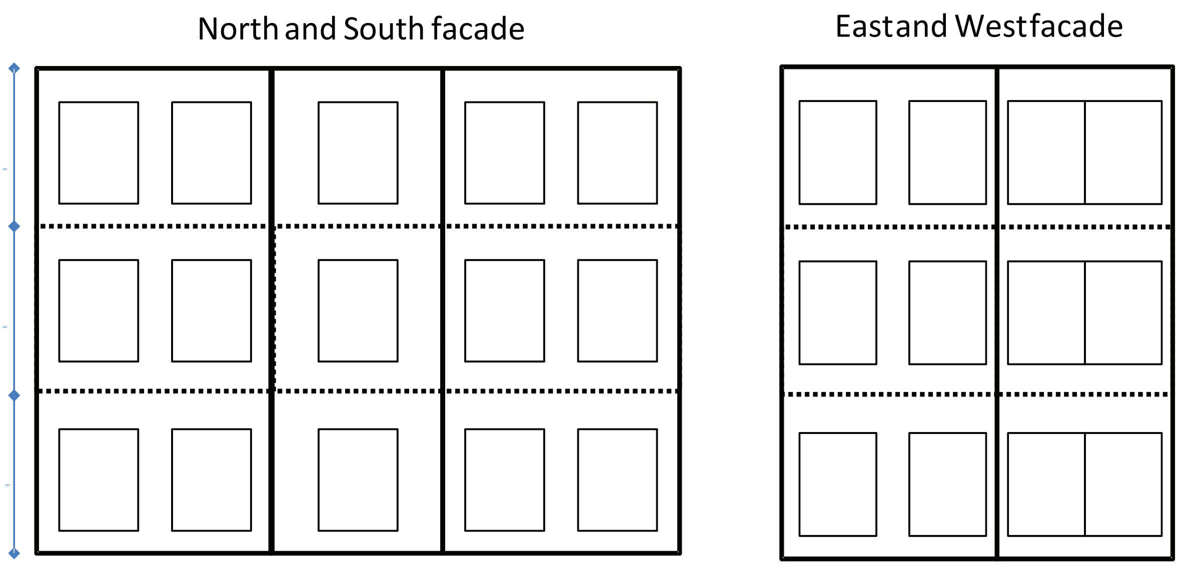
Figure A6: Floor plan standard floor) with the simulated zones of the Bulgarian multi-family house



The floor plan above 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.

REFERENCE BUILDING N°3: OFFICE BUILDING

Figure A7: North, South, East and West facade view of the office building



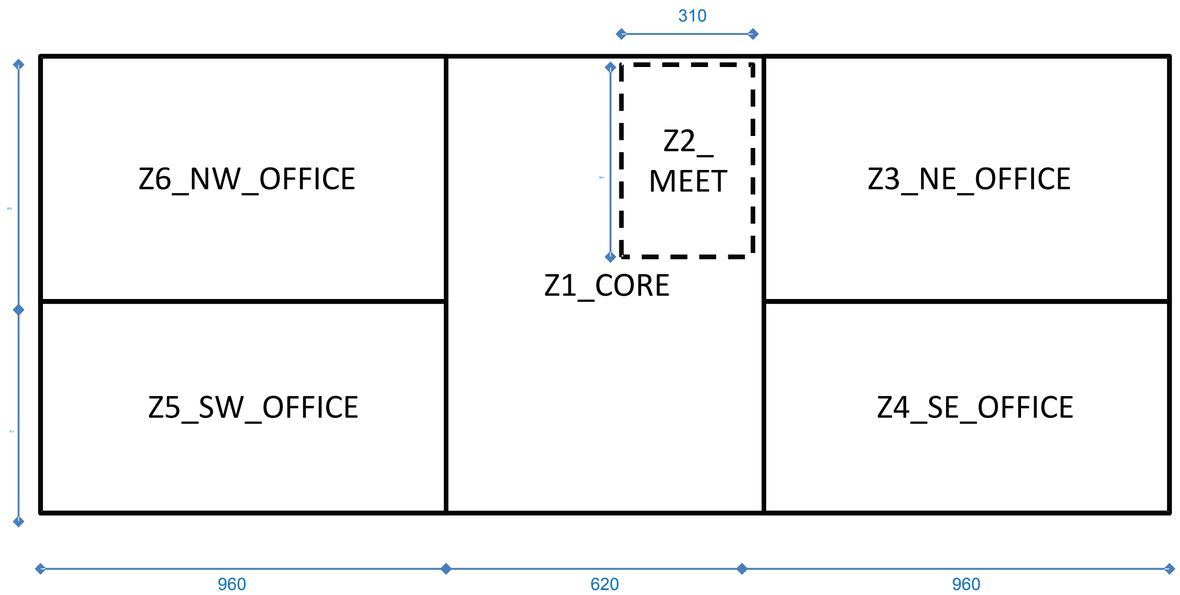


Figure A8: Floor plan (ground floor) with the simulated zones of the office building

The floor plan above shows the six zones, which have been considered for simulations. The central entrance zone (Z1_CORE), the conference rooms on the 2nd and 3rd floor (Z2_MEET) and the four office areas either with orientation to the North (Z3_NE_OFFICE, Z6_NW_OFFICE) and to the South (Z4_SE_OFFICE, Z5_SW_OFFICE). Apart from the conference zone all zones enclose three floors.

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