National plan for increasing the number of nearly zero-energy buildings

(Article 9 of Directive 2010/31/EU on the energy performance of buildings)

Athens, December 2017

Contents

1 Introduction

This report aims to define nearly zero-energy buildings and describe the policies and actions that need to be adopted for increasing the number of nearly zero-energy buildings, in accordance with the requirements laid down in Article 9 of Directive 2010/31/EU.

In the context of the European Energy Union and evaluating the level of the contribution of energy efficiency towards reducing carbon dioxide emissions, promoting the security of energy supply, reducing energy dependence and the cost of energy, and strengthening the competitiveness of the European economy, also taking into account the progress made by the Member States in achieving the 20 % energy savings target by 2020.

Buildings play a major role in achieving the above target, as their effect on energy consumption and carbon dioxide emissions is very significant. The building sector in Greece accounts approximately for one third of the carbon dioxide (CO_2) emissions and approximately 36 % of the total amount of energy consumed.

It should also be noted that the construction sector is one of the key pillars of the Greek economy, closely linked to the construction materials industry, architectural/design activities, commerce, and the implementation of investment projects in such sectors as tourism, industry and commerce.

Directive 2010/31/EU on the energy performance of buildings, transposed into Greek legislation by Law 4122/2013, includes numerous provisions on reducing energy consumption in the buildings sector and improving the energy performance of buildings. One of the most important components of the Directive is the reference made to nearly zero-energy buildings.

More specifically, Article 2 of the above Law defines a 'nearly zero-energy building' as a building that has very high energy performance, in which the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

Article 9 of the Directive and the Law goes on to state that all new buildings should be nearly zero-energy buildings by 1 January 2021, and that this should be achieved for new buildings occupied by public services and the broader public sector by 1 January 2019.

The above Article also states that a decision should be issued by the Minister for the Environment and Energy to approve a national plan for increasing the number of nearly zero-energy buildings, which may include different targets according to the category of building and should be communicated to the Commission.

This National Plan was prepared to meet the requirements laid down in Article 9 of the Directive and the Law, which states clearly that Member States should draw up national plans for increasing the number of nearly zero-energy buildings. The national action plan should include the following elements:

(a) the technical characteristics of nearly zero-energy buildings, reflecting national, regional or local conditions, and including a numerical indicator of primary energy use expressed in kWh/m^2a per year;

(b) intermediate targets for improving the energy performance of new buildings;

(c) information on the policies and financial or other measures taken for the promotion of nearly zero-energy buildings, including details of national requirements and measures concerning the use of energy from renewable sources in new buildings and existing buildings undergoing major renovation.

The report refers initially to the current situation in Greece, and describes the characteristics of the building stock and mentions the regulations on the energy performance of buildings. Then it sets out the characteristics of nearly zero-energy buildings and the intermediate targets set for improving the energy performance of new buildings. Finally, it describes the policies that need to be adopted and the measures that need to be implemented to achieve the targets, and also details the possible obstacles that could prevent Greece achieving them, and stresses the major role that can be played by the available funding instruments.

This National Plan was prepared in this context and to improve the energy performance of buildings, aiming to serve as a key tool in policy making for the energy upgrade of buildings. The National Plan, in particular the measures and policies proposed therein, will be revised to better reflect changing technological developments, the needs of Greek society, proposals from stakeholders and the current state of play in the Greek economy.

The report was prepared in cooperation with staff members of the Ministry of the Environment and Energy (YPEN) and the Coordinating Committee established and set up by decision ref. ΥΠΕΝ/ΕΔΕΣΠΑ/170914/109 of 22 January 2016 on the updating of national legislation on the energy performance of buildings and with the collaboration of the Centre for Renewable Energy Sources and Saving (CRES) under its Contract No 170803/64/20.1.2017 with YPEN on the 'Preparation of required reports establishing cost-optimal minimum requirements on the energy performance of buildings and nearly zero-energy buildings (nZEB)'.

The methodology for drawing up the National Plan is based, as far as possible, on the following:

- Commission Recommendation (EU) 2016/1318 of 29 July 2016 on guidelines for the promotion of nearly zero-energy buildings and best practices to ensure that, by 2020, all new buildings are nearly zero-energy buildings;
- Report from the Commission to the European Parliament and the Council on the progress by Member States towards nearly zero-energy buildings (7.10.2013) 483 final/2;
- document from the Commission for the EPB Committee meeting of 23 September 2015 entitled 'Implementation of the requirements for nearly zero-energy buildings under Directive 2010/31/EU on the energy performance of buildings';
- study BUIDE13616/15.05.2013 from Ecofys entitled 'Guidance document for national plans for increasing the number of nearly zero-energy buildings' (order of European Commission);
- study BUINL13782/19.08.2014 from Ecofys entitled 'Role of Building Automation related to Renewable Energy in nZEB's' (order of European Copper Institute);
- study BESDE10788/14.02.2013 from Ecofys entitled 'Towards nearly zero-energy buildings Definition of common principles under the EPBD' (order of European Commission);
- study BUIDE14975/08.10.2014 from Ecofys entitled 'Overview of Member States information on NZEBs: Working version of the progress report - final report' (order of European

Commission).

For the preparation of the National Plan, the information and proposals included in the 'Report on the long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private (Article 4 of Directive 27/2012/EU), December 2014' from YPEN, were also taken into account;

The National Plan uses information on the building stock which was based on censuses and reports from the Hellenic Statistical Authority (ELSTAT), as well as on statistics kept at the Energy Inspection Departments of the Energy Inspectorate of North and South Greece of the Ministry of the Environment and Energy.

It should be stressed in particular that the 'Report on the long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private' focuses on the shift towards a Sustainable Building Stock by 2050. That is, the aim is to have the building stock renovated in a gradual and coordinated manner, to ensure that all buildings have high energy performance, or ideally zero and/or minimum energy consumption, by 2050, in conjunction with the maximum possible utilisation and integration of renewable energy sources.

2 Description of the existing situation

2.1 Characteristics of the building stock

The building stock in Greece consists primarily of residential buildings and a number of other tertiary sector buildings, of which a census is taken every ten years across Greece. On the basis of the census of buildings taken in 2011 (May 2015) by ELSTAT, there are 4 105 637 buildings in Greece. Out of all buildings, 3 775 848 (92.0 %) are single use, and 329 789 (8.0 %) are mixed use. The table below lists the single use buildings per use and per region. Households use 83.68 % of the building stock (72 % in terms of floor area), which demonstrates how important they are for ensuring energy savings under the national strategy.

Table 1: Single use buildings per use and per region

Description	Single use buildings																				
	Total number of single use buildings	Use of buildings																			Total number of single use buildings
		Residential building	%	Church, monastery	%	Hotel	%	Factory, workshop	%	School building	%	Shop - Offices	%	Car park	%	Hospital, clinic, etc.	%	Other use	%	
GREECE TOTAL	3 775 848	2 990 324	79.2	47 872	1.3	34 736	0.9	30 731	0.8	19 474	0.5	153 510	4.1	16 952	0.4	1 749	0.0	480 500	12.7	100.0
EASTERN MACEDONIA AND THRACE	263 167	187 310	71.2	1 723	0.7	1 024	0.4	1 739	0.7	1 577	0.6	9 995	3.8	1 142	0.4	125	0.0	58 532	22.2	100.0
CENTRAL MACEDONIA	533 601	404 726	75.8	3 040	0.6	2 743	0.5	5 629	1.1	2 888	0.5	19 645	3.7	2 860	0.5	287	0.1	91 783	17.2	100.0
WEST MACEDONIA	132 823	88 508	66.6	1 778	1.3	316	0.2	962	0.7	950	0.7	4 094	3.1	1 766	1.3	57	0.0	34 392	25.9	100.0
EPIRUS	166 715	126 302	75.8	3 399	2.0	1 145	0.7	1 075	0.6	1 139	0.7	5 678	3.4	489	0.3	51	0.0	27 437	16.5	100.0
THESSALY	325 750	246 990	75.8	2 861	0.9	2 322	0.7	2 358	0.7	1 556	0.5	12 377	3.8	689	0.2	132	0.0	56 465	17.3	100.0
CONTINENTAL GREECE	280 277	229 363	81.8	4 308	1.5	1 677	0.6	2 426	0.9	1 298	0.5	9 070	3.2	694	0.2	89	0.0	31 352	11.2	100.0
IONIAN ISLANDS	133 501	103 780	77.7	1 840	1.4	4 557	3.4	756	0.6	523	0.4	6 740	5.0	1 190	0.9	39	0.0	14 076	10.5	100.0
WESTERN GREECE	281 266	229 541	81.6	4 012	1.4	1 046	0.4	1 777	0.6	1 572	0.6	9 596	3.4	463	0.2	112	0.0	33 147	11.8	100.0
PELOPONNESE	334 089	267 128	80.0	6 843	2.0	2 459	0.7	2 638	0.8	1 629	0.5	9 849	2.9	1 350	0.4	99	0.0	42 094	12.6	100.0
ATTICA	696 647	624 278	89.6	3 098	0.4	1 293	0.2	7 126	1.0	3 454	0.5	35 545	5.1	1 447	0.2	470	0.1	19 936	2.9	100.0
NORTH AEGEAN	147 898	113 483	76.7	3 059	2.1	1 998	1.4	961	0.6	602	0.4	6 168	4.2	1 585	1.1	73	0.0	19 969	13.5	100.0
SOUTH AEGEAN	205 206	150 638	73.4	6 352	3.1	8 946	4.4	1 221	0.6	770	0.4	11 808	5.8	2 834	1.4	101	0.0	22 536	11.0	100.0
CRETE	274 908	218 277	79.4	5 559	2.0	5 210	1.9	2 063	0.8	1 516	0.6	12 945	4.7	443	0.2	114	0.0	28 781	10.5	100.0

The graph below shows the single use buildings per use.

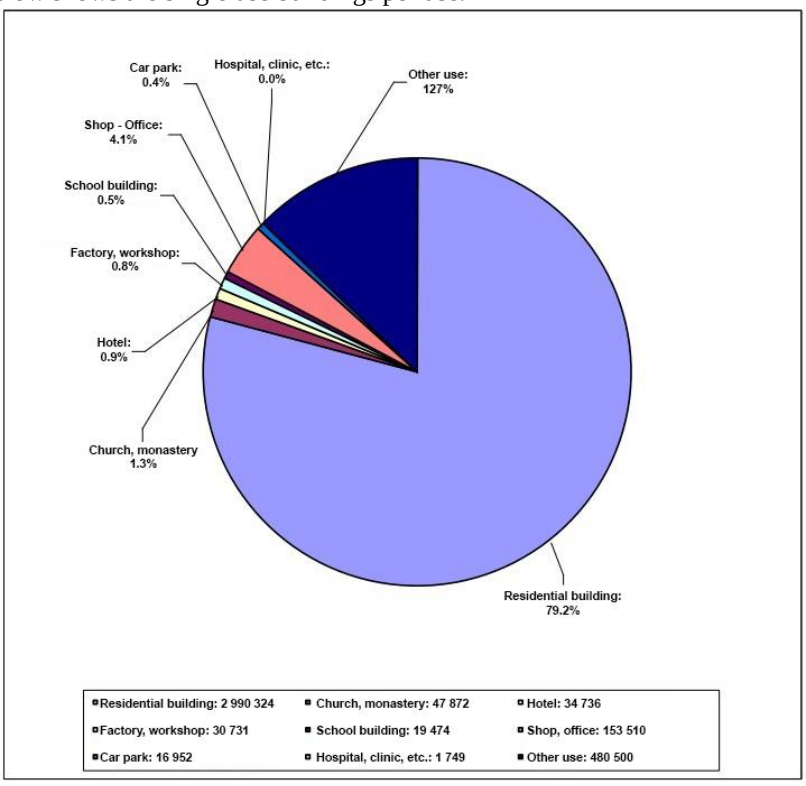


Figure 1: Single use buildings per use

In terms of the date of construction of buildings, the table below shows their distribution per region,

which demonstrates that most of them (704 340 buildings) were constructed between 1971 and 1980 (17.2 %). 15.6 % of the total number of buildings (639 475 buildings) were constructed from 1961 to 1970, and 14 % (573 250 buildings) were constructed from 1946 to 1960.

Table 2: Construction period of buildings per region

Description	Total number of buildings	Construction period of building																		Total number of buildings
		Before 1970	%	1971 -1980		1981 -1985		1986 - 1990	%	1991-1995	%	1996-2000	%	2001 -2005	%	2006 onwards	%	Under construction	%	
GREECE TOTAL	**4 105 637**	**1 691 432**	**41.2**	**704 340**	**17.2**	**402 368**	**9.8**	**316 799**	**7.7**	**259 394**	**6.3**	**254 797**	**6.2**	**237 460**	**5.8**	**186 861**	**4.6**	**52 186**	**1.3**	**100.0**
EASTERN MACEDONIA AND THRACE	286 365	135 062	47.2	48 185	16.8	22 727	7.9	16 599	5.8	15 406	5.4	15 655	5.5	16 741	5.8	12 849	4.5	3 141	1.1	100.0
CENTRAL MACEDONIA	600 436	226 942	37.8	113 242	18.9	59 756	13.3	47 070	7.8	39 756	6.6	38 120	6.3	38 073	6.3	31 124	5.2	6 353	1.1	100.0
WEST MACEDONIA	142 816	58 619	41.0	26 279	18.4	13 093	5.2	9 181	6.4	7 042	4.9	15 438	10.8	6 690	4.7	4 842	3.4	1 632	1.1	100.0
EPIRUS	176 352	74 686	42.4	33 705	19.1	18 508	13.5	12 907	7.3	9 677	5.5	8 870	5.0	8 718	4.9	7 705	4.4	1 576	0.9	100.0
THESSALY	342 557	163 279	47.7	64 162	18.7	31 878	9.3	21 832	6.4	16 661	4.9	15 030	4.4	14 476	4.2	11 600	3.4	3 589	1.0	100.0
CONTINENTAL GREECE	302 172	124 269	41.1	50 602	16.7	33 564	11.1	24 614	8.1	19 613	6.5	17 550	5.8	15 870	5.3	12 343	4.1	3 747	1.2	100.0
IONIAN ISLANDS	140 810	65 863	46.8	16 530	11.7	12 067	3.5	11 599	8.2	8 840	6.3	8 302	5.9	8 208	5.8	7 621	5.4	1 780	1.3	100.0
WESTERN GREECE	303 064	122 797	40.5	56 645	18.7	31 663	10.4	24 362	8.0	19 490	6.4	18 018	5.9	14 628	4.8	11 474	3.8	3 987	1.3	100.0
PELOPONNESE	355 761	172 596	48.5	50 001	14.1	32 951	5.3	25 882	7.3	19 693	5.5	17 843	5.0	17 654	5.0	15 329	4.3	3 812	1.1	100.0
ATTICA	783 752	231 875	29.6	163 074	20.8	90 833	11.6	72 863	9.3	60 653	7.7	57 801	7.4	55 942	7.1	38 055	4.9	12 656	1.6	100.0
NORTH AEGEAN	153 957	90 310	58.7	16 396	10.6	11 122	7.2	8 849	5.7	7 358	4.8	6 648	4.3	6 091	4.0	5 362	3.5	1 821	1.2	100.0
SOUTHAEGEAN	219 681	87 132	39.7	27 109	12.3	19 841	5.3	18 908	8.6	16 938	7.7	16 262	7.4	15 574	7.1	12 987	5.9	4 930	2.2	100.0
CRETE	297 914	138 002	46.3	38 410	12.9	24 365	8.2	22 133	7.4	18 267	6.1	19 210	6.4	18 795	6.3	15 570	5.2	3 162	1.1	100.0

It should be noted that the building stock can be broken down into 3 key age groups, in accordance with the legal framework in force, which was initially adopted in 1980 by the Regulation on the Thermal Insulation of Buildings (KTHK) and then in 2010 by the Regulation on the Energy Performance of Buildings (KENAK), and in accordance with their quality and the technologies used for their envelopes and electromechanical installations. Therefore, the age groups affecting energy performance are:

- before 1980, when buildings had no thermal protection;
- from 1981 to 2000, when thermal insulation systems and other energy efficiency measures came into gradual use;
- from 2001 to 2010, when new technologies and products were developed and used.

On the basis of the census taken in 2011 (ELSTAT 2014), 55 % of residential buildings in Greece were constructed before 1980, i.e. they have no thermal protection, and due to the economic recession, the number of buildings constructed after 2010 in accordance with the minimum requirements laid down in the KENAK represent only 1.5 % of the total stock of normal residential buildings used by households.

The ages of Greek residential buildings are shown in Figure 2 below on the basis of a survey carried out in 2009 by the Laboratory of Steam Boilers and Thermal Plants of the School of Mechanical Engineering of the National Technical University of Athens entitled 'Investigation and recording of the standards used to describe energy consumption parameters in the Greek family'. The average age of residential buildings, according to the latest census taken by ELSTAT in 2011, is 31 years.

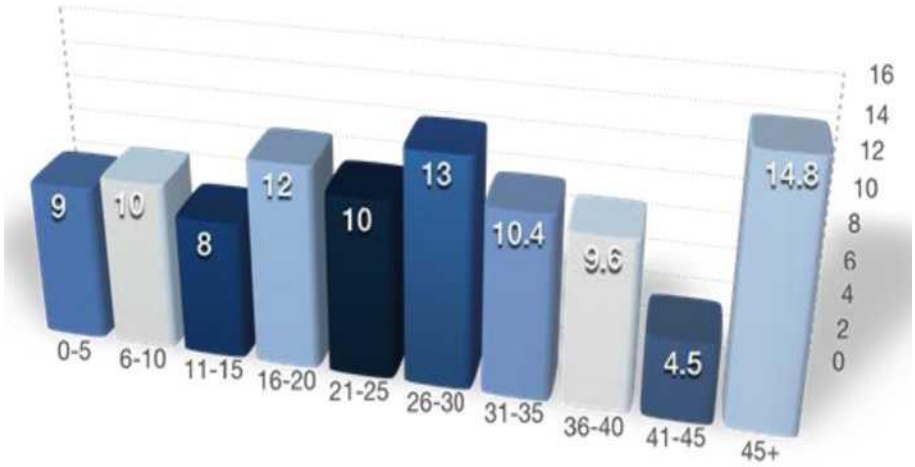


Figure 2: Average age of residential buildings, in accordance with the census taken by ELSTAT in 2011

Please note that there was a significant drop in the number of building permits issued from 2008 to 2011 as a result of the economic crisis. Construction activity had increased from 2000 to 2005, but fell steadily afterwards, from 2006 to 2011, with an average annual rate of decrease of 20 %. Overall construction activity (both private and public) dropped by a further 25.0 % in 2012, compared to the same period in 2011 (based on an analysis of data from ELSTAT).

On the basis of information from the Energy Inspection Department of the Energy Inspectorate of Northern and Southern Greece of the Ministry of the Environment and Energy, the building permits issued for new buildings are shown in the table below (Southern Greece only).

Table 3: Building permits issued for the construction of new buildings

Year	Total permits for new buildings (Southern Greece)	Total floor area (m^2)
2012	**2 429**	**575 631**
2013	**3 924**	**2 113 128**
2014	**3 879**	**1 970 120**
2015	**3 996**	**1 982 869**
2016	**3 031**	**1 885 221**
Grand total	**14 454**	**8 526 971**

As regards the size of residential buildings, on the basis of information from the census taken in 2011 and in accordance with the figure below, 59 % of them have a floor area of 50-99 m^2, 14 % have a floor area below 49 m^2 and 27 % have a floor area of over 100 m^2.

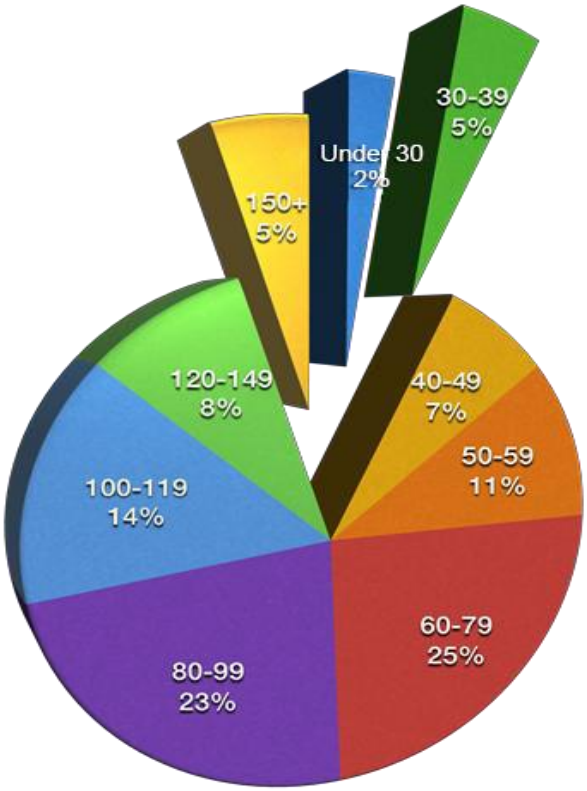


Figure 3: Average size of residential buildings, in accordance with the census taken by ELSTAT in 2011

Certain specific characteristics of the building sector are a high percentage of owner-occupancy (more than 80 %), low land purchasing mobility, as well as high transaction costs and a low volume of transactions in relation to the building stock.

In respect of buildings occupied by public authorities, it should be noted that there is no sufficient information on the exact number of those buildings in relation to their use and energy characteristics. The 2011 census estimated there were around 112 000 buildings occupied by central government and decentralised administration agencies, local authorities and legal persons governed by public and private law; the table below shows the ownership status of those buildings:

Agency which uses the building	Total number of buildings	Agency which owns the building		
		Hellenic State	Individual	Both
Central government/decentralised administration	4 141	3 449	631	61
Local authorities and their agencies	31 167	28 791	2 111	265
Other legal persons governed by public law	57 959	55 838	1 876	245
Other legal persons governed by private law	18 789	4 772	12 958	1 059

2.2 Development of national requirements on the energy performance of buildings over time

The **Presidential Decree of 1 June 1979** transposed into Greek legislation the **Regulation on the Thermal Insulation of Buildings**, which set out the requirements and measures to be implemented to ensure that inhabited buildings had proper thermal insulation.

Directive 2002/91/EC was transposed into Greek legislation with the publication of **Law 3661/2008** *setting out measures for the reduction of the energy consumption of buildings, and other provisions.* In the same year, **Joint Ministerial Decision No 14826/2008** *setting out energy efficiency improvement and energy savings measures in the public and wider public sector* was published.

In 2010, **Law 3851/2010** *setting out measures for the use of RES in buildings and compensatory contributions at local level for the establishment of RES plants* was published to foster the use of renewable energy sources.

In the same year, **Law 3855/2010** *setting out measures for improving end-use energy efficiency, energy services, and other provisions* provided the necessary framework for promoting energy savings measures in Greece, and also transposed into Greek legislation Directive 2006/32/EC on energy end-use efficiency and energy services.

Joint Ministerial Decision No 5825/2010, as revised by Joint Ministerial Decision No 178581/2017, ratified the **Regulation on the Energy Performance of Buildings (KENAK),** which provided for including an integrated energy design for buildings to improve their energy performance, ensuring energy savings and protecting the environment, through specific actions relating primarily to:

- preparing an energy performance design for buildings;
- classifying buildings in terms of energy (energy performance certificate); and
- carrying out energy inspections of buildings, boilers, and heating and air-conditioning installations.

The **KENAK** aims to reduce the amounts of conventional energy consumed for heating, cooling, air conditioning, lighting, and domestic hot water, while, at the same time, ensuring comfortable conditions inside buildings. This aim is achieved by the energy efficient design of the envelope, the use of energy efficient construction materials and electromechanical (E/M) installations, renewable energy sources (RES) and cogeneration of heat and power (CHP). Accordingly, the following is a summary of the contents of the KENAK:

- it sets out the methodology used to calculate the energy performance of buildings to estimate the amounts of energy consumed by buildings for heating, cooling, air conditioning, lighting, and domestic hot water;
- it sets out minimum energy performance requirements and categories for the energy classification of buildings;
- it sets out minimum specifications for the architectural design of buildings, the thermal characteristics of the structural elements of the envelope and specifications for the E/M installations of new buildings being designed and those undergoing major renovation;
- it sets out the contents of the energy performance design for buildings;

- it specifies the format and contents of the building energy performance certificate (EPC);

- it sets out the procedure used to carry out energy inspections of buildings and the procedure used to carry out inspections of boilers and heating and air conditioning installations.

Moreover, **Presidential Decree 100/2010** *concerning energy inspections of buildings, boilers, and heating and air-conditioning installations,* as replaced by Law 449/2016, specified the qualifications of building and air conditioning installation inspectors, the required procedures for them to enrol in a dedicated register, and their fees.

Directive 2010/31/EU was transposed into Greek legislation by **Law 4122/2013** *on the energy performance of buildings - transposing Directive 2010/31/EU of the European Parliament and of the Council into the national legislation, and other provisions.*

In 2015, **Law 4342** was published, which provided the required framework for Greece to fully comply with **Directive 2012/27/EU** on energy efficiency. Law 4342/2015 also provides measures to encourage energy efficiency, for Greece to contribute towards achieving the fundamental 2020 20 % energy efficiency target and lay the foundation for further energy performance improvements in the long run. There are also indicative national energy efficiency targets set for 2020, along with measures for promoting them and rules to overcome energy market weaknesses that prevent the efficient supply and use of energy.

Under Article 6 of the above Law and in accordance with Article 4 of Directive 2012/27/EU, Greece issued the initial version of a study entitled *'Report on the long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private'* (December 2014). The report includes *inter alia* a review of the building stock in Greece, energy renovation scenarios and an estimate of the energy savings to result from the implementation of policies and measures that foster renovation. The report is revised every 3 years as part of the **national energy efficiency action plan (NEEAP)**, in accordance with Directive 2012/27/EU, which stresses the importance of the energy upgrading of buildings, with emphasis placed on a long-term assessment of the investment in the renovation of building stock.

Under Article 7 of Law 4342/2015 on the exemplary role of public buildings, a target was set for renovating 3 % of the total floor area of heated and/or cooled buildings owned and occupied by the central government. Paragraph 12 of the above Article is very important, as it provides, with a view to achieving the above target, for the regions and municipalities to prepare an energy performance plan with specific energy performance savings and energy efficiency targets and actions, which must be revised every 2 years.

As far as the **national energy efficiency action plans (NEEAPs)** are concerned, they aim essentially to record the energy efficiency progress made by the implementation of policies, measures, market mechanisms and R&D actions. A strategy is formulated on the basis of that information which, upon being implemented, will ensure the achievement of the national energy savings target. Greece has prepared and published three NEEAPs, as follows:

- NEEAP No 1 (2008), under Directive 2006/32/EC;
- NEEAP No 2 (2011), under Directive 2006/32/EC and Law 3855/2010;

- NEEAP No 3 (2014), under Article 24(2) of Directive 2012/27/EU; and
- NEEAP No 4 (2017), under Article 24(2) of Directive 2012/27/EU.

Ministerial Decision No ΥΠΕΝ/ΕΔΕΣΠΑ/170914/109/22.01.2016 provided for the establishment and setup of a Coordinating Committee for updating the national legislation on the energy performance of buildings. The Committee shall:

- specify cost-optimal levels of minimum energy performance requirements for buildings and building elements (Article 5 of Directive 2010/31/EU and of Law 4122/2013);
- revise the minimum energy performance requirements (Article 3 of Directive 2010/31/EU and Article 4 of Law 4122/2013); and
- draw up a national plan for increasing the number of nearly zero-energy buildings (Article 9 of Directive 2010/31/EU and of Law 4122/2013).

In this context, the reports on the determination of cost-optimal minimum energy performance requirements for buildings and components [Article 5(2) of Directive 2010/31/EU and Law 4122/2013] on **buildings used as 'single family houses', 'multi-dwelling buildings', 'tertiary sector'** and for the building elements of their envelopes and systems, in accordance with Article 5(2) of Directive 2010/31/EU *on the energy performance of buildings*, were submitted to the EU by March 2017. The following are the contents of the reports:

- they define typical buildings;
- they set out measures and/or packages of measures and variants thereof;
- they calculate the demand for final and primary energy on the basis of the measures and packages of measures implemented for each typical building;
- they calculate the total cost of the measures for each typical building;
- they set out the cost-optimal levels of minimum energy performance requirements at building level;
- they set out the cost-optimal levels of minimum energy performance requirements at a building element and system level; and
- they compare the minimum energy performance requirements in force.

The reports provide a thorough description of the building stock in Greece and classify the buildings in terms of age, size, construction materials, uses and climate zones, and also look into the architecture and geometrical characteristics of typical buildings. Moreover, they defined 5 key categories according to the date of construction of the buildings, taking into account the construction method used, the different regulations in force which affected the construction and the morphology of the buildings. The 5 categories are as follows:

- buildings constructed from 1955 to 1980,
- buildings constructed from 1981 to 2000,
- buildings constructed from 2001 to 2010,
- buildings constructed from 2011 to 2016

- New buildings

It also specified the thermal and physical characteristics and the E/M systems for all categories. Then a list was created of measures/packages of measures which have a direct impact on the energy performance of buildings and ensure fair competition between the different technologies. Therefore, the following categories of measures were taken into account:

- complete wall structure in new buildings or additional insulation system in existing walls;
- complete roof structure in new buildings or additional insulation system in existing roofs;
- insulation of the whole of the slabs in new buildings or additional insulation system for existing slabs on a pilotis system or on the ground;
- replacement of door and window frames and glass panes with the simultaneous improvement of their level of air tightness;
- installation of shades (movable shading systems);
- replacement of the heating system;
- automatic devices used to monitor, measure and adjust room and hot water temperatures;
- replacement of the domestic hot water production system;
- replacement of the cooling system;
- installation of photovoltaic systems;
- installation of solar systems to assist heating and/or domestic hot water production systems;
- installation of small-scale heat and power cogeneration (CHP) systems;
- remote energy supply systems, district heating.

Then the costs were calculated for each measure proposed both in terms of a macroeconomic and financial analysis, and the cost-optimal thermal conductivity values (U-values) were calculated on the basis of a two-level sensitivity analysis of the results for the walls, roofs, openings and floors for the four climatic zones in Greece, for the four construction periods and for both existing and new buildings.

3 Characteristics of nearly zero-energy buildings

According to Article 2(2) of the Directive on the energy performance of buildings and Article 2(5) of Law 4122/2013, 'nearly zero-energy building' means a 'building that has a very high energy performance', as determined in accordance with the calculation methodology for the energy performance of buildings provided in Annex I to the Directive and Article 3 of the Law, respectively. 'The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby'.

3.1 Statistical recording of Energy Performance Certificates (EPC)

In order to record the energy consumption of residential and tertiary sector buildings per climatic zone and energy category, the data of the electronic Building Inspection Archive were subjected to statistical processing and sensitivity analysis by the Energy Inspection Departments of the Ministry of the Environment and Energy. The Building Inspection Archive is used to keep all energy performance certificates. Approximately 946 700 certificates were entered between 2011 and the end of 2016.

A sensitivity analysis of the information (degree of confidence: 95 %) resulted in the following ranges of values of the amounts of energy consumed in energy categories B to A+ (Table 4). It is clarified that, in the results shown in the Table, the lower limit of values was obtained assuming that 25 % of the annual primary energy values of the buildings per unit area of all EPCs (not average values) are higher than the lower limit, and 75 % of the annual primary energy values of the buildings per unit area of all EPCs are lower than the upper limit. All values follow a normal distribution.

Table 4: Range of values of the amounts of energy consumed in energy categories B to A+

Energy category	Amounts of energy consumed by residential buildings per climatic zone			
	A	**B**	**C**	**D**
A+	13 - 28	14 - 29	15 - 46	17 - 36
A	26 - 39	28 - 45	26 - 57	67 - 94
B+	42 - 63	48 - 75	62-103	60 - 118
B	60 - 92	70 - 109	93 - 141	89 - 171

Energy category	Amounts of energy consumed by tertiary sector buildings per climatic zone			
	A	**B**	**C**	**D**
A+	53 - 70	31 - 71	50 - 55	30
A	48 - 96	65 - 93	75 - 107	67 - 82
B+	105 - 161	98 - 153	113 - 143	105 - 156
B	149 - 216	167 - 221	161 - 209	149 - 211

In view of the above information, the indicative value of the amount of primary energy consumed in category A+ ranges:

- **from 13 to 46 kWh/m^{2}a per year for residential buildings;**
- **from 30 to 71 kWh/m^{2}a per year for tertiary sector buildings.**

3.2 Statistical recording based on a Cost-Optimal Study

The EPBD establishes a benchmarking system (principle of ‘cost-optimality’) to guide Member States in setting energy performance requirements contained in national or regional building codes, and keeping them under regular review. Under the EPBD, cost-optimality sets the minimum level of ambition for both building renovation and new buildings. In line with the cost-optimal requirements

under Article 5 of the Directive, national minimum energy performance requirements are to be reviewed every five years and strengthened if they are significantly less ambitious than the national cost-optimal levels.

The cost-optimal methodology allows for defining the range of NZEB requirements for 2020. This requires assessing and comparing different energy efficiency and renewable energy measures, both individually and in combination, as part of packages of measures to be applied to reference buildings.

Accordingly, to define and meet the NZEB level, different combinations of measures were used in the context of the cost optimality methodology concerning insulation or other energy efficiency measures (shading, frames, etc.), inclusion of highly-efficient technical building systems and use of on-site renewable energy sources (photovoltaics, solar systems for the production of domestic hot water and to assist heating, biomass boilers, heat pumps, etc.) that lead to an NZEB level.

The following are two examples of an existing typical building from the period 1955-1980 in climatic zone A and a new building in climatic zone C, which demonstrate both graphically and by calculation that energy category A+ is very close to the defined NZEB area as it fully covers the relevant requirements.

Table 5: Data used to define an NZEB zone for a typical building from the period 1955-1980 in climatic zone A

Period	Climatic zone	Primary energy category, kWh/ m^2. a - cost optimal	Primary energy category, kWh/ m^2. a - category B	Category maximum A+ kWh/ m^2.a	Category maximum A kWh/ m^2.a	Energy minimum kWh/ m^2.a	Defined area maximum kWh/ m2.a	Pareto line minimum euro/m^2	Defined area maximum euro/m^2	Difference in primary energy consumption between the defined NZEB area and zone A+
1955-1980	A	142.8	105.3	34.7	52.65	4.2	29.2	695	868.8	5.5

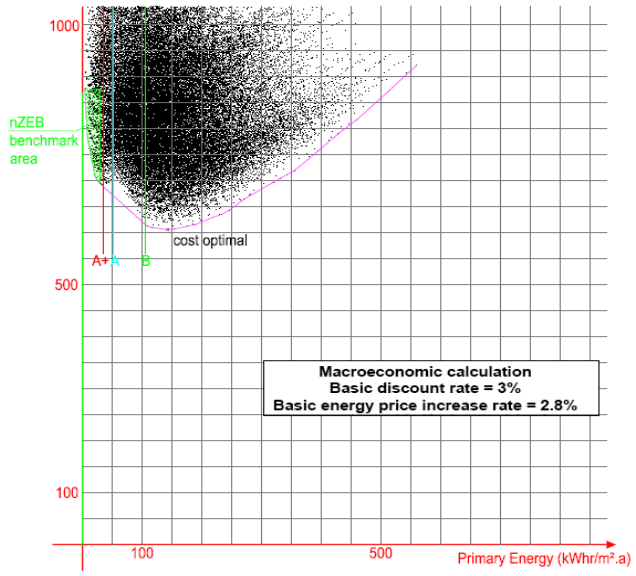


Figure 4: Defining an NZEB zone for a cloud of scenarios for a typical building from the period 1955-1980 in climatic zone A

Table 6: Data used to define an NZEB zone for a new typical building in climatic zone C

Period	Climatic zone	Primary energy category, kWh/ m^2. a - cost optimal	Primary energy category, kWh/ m^2. a - category B	Category maximum A+ kWh/ m^2.a	Category maximum A kWh/ m^2.a	Energy minimum kWh/ m^2.a	Defined area maximum kWh/ m^2.a	Pareto line minimum euro/m^2	Defined area maximum euro/m^2	Difference in primary energy consumption between the defined NZEB area and zone A+
NEW	C	112.6	162.8	53.7	81.4	17	42	1485	2086.3	11.7

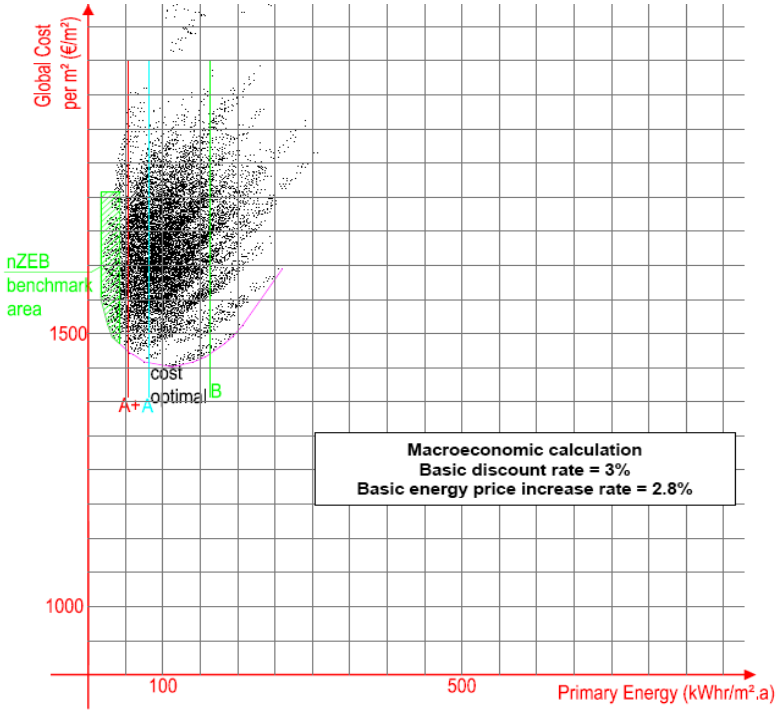


Figure 5: Defining an NZEB zone for a cloud of scenarios for a new typical building in climatic zone C

The table below shows the annual primary energy consumption thresholds for energy category A+ for all typical single family houses and multi-dwelling buildings per climatic zone and per period.

Table 7: Annual primary energy consumption thresholds for energy category A+ for all typical single family houses and multi-dwelling buildings per climatic zone and per period

Time Period	Climatic Zone	Category maximum A+ (kWh/ m^2.a)	
		Single-family houses	Multi-dwelling buildings
1955-1980	A	35	25
	B	40	28
	C	58	42
	D	56	46
1980-2000	A	50	26
	B	63	29
	C	86	44
	D	94	48
2000-	A	50	27
2010	B	46	30
	C	72	46
	D	87	50
2010-2016	A	34	28
	B	36	31
	C	54	47
	D	58	51
NEW	A	34	28
	B	36	31
	C	54	47
	D	58	51

Therefore, the range for existing single family houses in energy category A+ is 34-94 kWh/m^2a, and the range for new ones is 34 - 58 kWh/m^2a. Moreover, in the existing multi-dwelling buildings, the energy category A+ is 25-51 kWh/m^2a, and the range for new ones is 28-51 kWh/m^2 a.

Table 8 shows the annual primary energy consumption thresholds for energy category A+ (maximum) for all tertiary sector buildings per climatic zone and per period.

Table 8: Annual primary energy consumption thresholds for energy category A+ for all tertiary sector buildings per climatic zone and per period

Time Period	Climatic Zone	Category maximum A+ (kWh/ m^2.a)
1955-1980	A	89
	B	90
	C	89
	D	90
1980-2000	A	86
	B	87
	C	89
	D	90
2000-2010	A	86
	B	87
	C	88
	D	89
2010-2016	A	78
	B	79
	C	75
	D	75
NEW	A	78
	B	79
	C	75
	D	75

The table shows that for the existing tertiary sector buildings, the energy category A+ is 75-90 kWh/m^2.a, and the range for new ones is 75-79 kWh/m^2.a.

3.3 Participation of Renewable Energy Sources (RES)

The forecast for the participation of RES in the buildings sector is given in the table below in

accordance with the National Renewable Energy Action Plan (NREAP).

Table 9: Rates of participation of RES in the building sector

(%)	2005	2010	2015	2020
Residential buildings	15 %	17 %	22 %	27 %
Commercial buildings	10 %	14 %	27 %	39 %
Industrial buildings				
Total	14 %	16 %	24 %	30 %

An analysis of the scenarios of defined NZEB areas from the clouds of implemented scenarios indicates that the penetration of RES is high, as most of the scenarios include the implementation of such measures as installation of photovoltaics, solar-assisted production of domestic hot water and heating and heating/cooling systems using heat pumps.

As regards the specific example of a new building, the following are the results from a total of 523 scenarios:

Table 10: Occurring scenarios with the use of RES in the defined NZEB area for a new typical single family house in climatic zone C

Measure under consideration	Number of scenarios	Rate of occurrence
Low temperature heat pump for space heating, cooling and production of domestic hot water	132	25.2 %
Geothermal heat pump for heating, cooling, and production of domestic hot water	391	74.8 %
Photovoltaics for the production of electricity	515	98.5 %
Solar-assisted system for the production of domestic hot water	127	24.3 %
Solar-assisted system for heating and production of domestic hot water	396	75.7 %
Total scenarios in the defined NZEB area	523	

Whereas in the existing building example, the following are noted from a total of 567 scenarios:

Table 11: Occurring scenarios with the use of RES in the defined NZEB area for a typical single family house from the period 1955-1980 and in climatic zone C

Measure under consideration	Number of scenarios	Rate of occurrence
Low or high temperature heat pump for space heating, cooling and production of domestic hot water	381	67.2 %
Geothermal heat pump for heating, cooling, and production of domestic hot water	186	32.8 %
Photovoltaics for the production of electricity	567	100.0 %
Solar-assisted system for the production of domestic hot water	226	39.9 %
Solar-assisted system for heating and production of domestic hot water	189	33.3 %
Total scenarios in the defined NZEB area	567	

Therefore, it is proved that defining NZEB areas on the basis of energy category A+ also ensures increased penetration of RES in building design. It is proposed to meet the needs for domestic hot water (DHW) using solar panels to a large extent (over 60 %).

In view of the foregoing, the following limits for NZEB are selected:

(a) For new residential buildings, a maximum use of primary energy of 80 kWh/m^2.a, with 60 % renewable energy minimum.

(b) For existing residential buildings, a maximum use of primary energy of 95 kWh/m^2.a, with 50 % renewable energy minimum.

(c) For new tertiary sector buildings, a maximum use of primary energy of 85 kWh/m^2.a, with

20 % renewable energy minimum.

(d) For existing tertiary sector buildings, a maximum use of primary energy of 90 kWh/m^2.a, with 15 % renewable energy minimum.

4 Intermediate targets

Although no intermediate targets were set for 2015, as required by the EPBD and Law 4122/2013, a number of actions have been implemented to foster the penetration of NZEBs, focusing in particular on acquainting technicians with the special NZEB parameters and the general public with their advantages.

The following are the most important NZEB-related actions, whether completed or still in progress, and Annex I describes some related actions implemented under EU programmes.

Table 12. Actions completed and in progress related to increasing the number of NZEBs

Type - Title	Institutional framework - regulations: Law 4122/2013 - Article 6 'New buildings', para. 4
Description	In new buildings or building units, it is necessary to meet part of the need for domestic hot water by the use of solar-powered heating systems. The minimum share of solar-powered systems is set at 60 % on an annual basis.
Building category/target groups	New buildings or building units with uses that require consumption of domestic hot water
Relation to energy performance/participation of RES	Mandatory coverage of the need for domestic hot water by the use of RES
Implementation framework	2011 to present (Law 3851/2010, Article 10)
Type - Title	Financial and other incentives: Law 4067/2012 - Article 25 'Incentives for constructing nearly zero-energy buildings':
Description	1. Where a building is classified, according to its energy design, in KENAK's highest energy category A+ … , an incentive is given by increasing the building ratio by 5 %. 2. A specific increase of the building ratio by 10 % is offered for minimum energy consumption buildings that also have excellent environmental performance. These buildings must have an annual primary energy consumption for heating, air conditioning, lighting, ventilation and domestic hot water of less than 10 kWh/m^2/year.
Building category/target groups	New buildings / Existing buildings undergoing major renovation
Relation to energy performance/participation of RES	Buildings with a high energy performance / minimum energy consumption
Implementation framework	2012 to present

Type - Title	Financial incentives: Offsetting fines against sums spent on the energy upgrading of buildings
Description	Joint Ministerial Decision No 42554 and Ministerial Decision No 42575 (Government Gazette, Series II, No 2440/2014): Offsetting the sums spent on the energy upgrading of buildings before 2003 against the sums of the specific fine provided for by Law 4178/2013 on fighting unauthorised construction - environmental balance, and other provisions.
Building category/target groups	Existing buildings
Implementation framework	2014-2020

Type - Title	Funding instruments: 'Saving at home' programme
Description	Energy upgrading of residential buildings
Building category/target groups	Residential buildings
Relation to energy efficiency	Upgrade per category or 30 % savings
Relation to energy performance / participation of RES	Installation of RES systems for domestic hot water
Implementation framework	2011-2015
Synergies	EPC, NEEAP, NREAP, long-term strategy report
Status / level of completion	Completed
Implementing body	NSRF implementing structure
Monitoring body	National Entrepreneurship and Development Fund/Environment, Construction, Energy and Mining Inspectorate
Savings / conclusions	70 000 residential buildings

Type - Title	Funding instruments: 'Savings' programme for local authorities
Description	Energy upgrading of public buildings occupied by local authorities
Building category/target groups	Public buildings
Implementation framework	2011-2015
Synergies	EPC NEEAP, NREAP, long-term strategy report
Status / level of completion	Completed
Implementing body	NSRF implementing structure
Monitoring body	National Entrepreneurship and Development Fund/Environment, Construction, Energy and Mining Inspectorate
Savings / conclusions	104 municipalities

Type - Title	Funding instruments: 'Savings II' programme for local authorities
Description	Energy upgrading of public buildings occupied by local authorities
Building category/target groups	Public buildings
Implementation framework	2011-2015
Synergies	EPC NEEAP, NREAP, long-term strategy report
Status / level of completion	Completed
Implementing body	NSRF implementing structure
Monitoring body	National Entrepreneurship and Development Fund/Environment, Construction, Energy and Mining Inspectorate
Savings / conclusions	139 municipalities

Type - Title	EPC: Issuance of EPCs in cases other than those referred to in Article 12 of the EPBD
Description	Issuance of EPCs as a requirement for implementing the above four measures/programmes Existing buildings
Building category/target groups	Existing buildings

Type - Title	Monitoring: Energy inspections archive
Building category/target groups	Ministry of the Environment and Energy - Ministry of Finance
Relation to energy performance/participation of RES	Article 18 of the EPBD: 'Independent control system'
Implementation framework	2010 to present

Type - Title	Information: Energy Inspectors Register - Building Inspection Archive
Building category/target groups	Owners / tenants
Relation to energy performance/participation of RES	Article 17 of the EPBD: 'Independent experts'
Implementation framework	2010 to present

Type - Title	Demonstration actions: Energy upgrading of social housing buildings - 'Pilot green urban neighbourhood' programme
Building category/target groups	Social housing
Implementation framework	2013 to present

Type - Title	Education - training: Training programme for energy inspectors
Building category/target groups	Candidate energy inspectors
Relation to energy performance/participation of RES	Article 17 of the EPBD: 'Independent experts'
Implementation framework	2011-2016
Status / level of completion	Completed
Implementing body	Higher education establishments and vocational training centres
Monitoring body	Environment, Construction, Energy and Mining Inspectorate

5 Policies and financial measures

It is not easy to increase the number of nearly zero-energy buildings within a short period of time, given that coordinated action is required at all levels to overcome the impediments and barriers. Appropriate political will is required in the first place, in the form of strong initiatives, and institutional action and related incentives must be implemented in conjunction with private sector mobilisation and commitment of appropriate funds. Moreover, a fundamental factor for the success of the new policy is to change the energy consciousness of the public, which can be achieved gradually and requires informative and awareness-raising actions as well as strong (financial, town planning, tax) incentives.

The policy for the energy performance of buildings by 2020 is formulated by institutional actions relating primarily to the implementation of EU directives and is also fostered by measures already planned for the new programming period 2014-2020. As part of the new programming period, priorities are included relating to the building stock aiming to ensure a shift towards a low carbon economy, with a view to meeting challenges and achieving the targets of Greece. Priority will be given to the following actions relating to the building stock:

- Implementing interventions for energy savings, improving energy efficiency and the use of RES in residential and tertiary sector buildings.
- Developing energy management systems in public and tertiary sector buildings.
- Promoting awareness-raising and informative actions to foster the rational use of energy.
- Strengthening the provision of energy services (ESCOs).
- Fostering research and technological development in technologies related to RES, energy savings, etc.

At this point, the results and proposals of the 'Report on the long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private' issued by YPEN in December 2014 (Article 4 of Directive 2012/27/EU) must be utilised, which indicated that the analysis of the social and technological shift required for the energy upgrading of the building stock can be described in three phases with the following general characteristics:

- Startup Phase (P1) - three (3) years (until 2020): This phase is used to determine the need primarily for modernising the institutional framework and implementing all necessary structures with a view to creating, in addition to the necessary mechanisms and infrastructure, proper energy consciousness. Information and awareness measures are also required in this direction, along with incentives, pilot programmes, subsidised actions, etc.
- Acceleration Phase (P2) - twenty (20) years (2020-2040): this phase is used for further technological development of innovative products and techniques, and it is also anticipated that there will be a reduction in energy renovation costs, and the consolidation of additional benefits that make possible the cost-optimal major renovation of buildings. Given the existence of suitable mechanisms, an effort will be made during this phase to speed up the rate of renovation of the building stock.
- Stabilisation Phase (P3) - ten (10) years (2040-2050): During this phase, the building energy upgrade market, which is currently immature, is expected to have matured enough to make it possible to implement interventions on almost the entire building stock, primarily in terms of private investment.

These phases were used to analyse the social and technological shifts under the CRISP project, in conjunction with the corresponding actions required to achieve long-term strategy shift at three levels:

- Governance;
- Structure; and
- Practices.

As shown in the figure below, the shift towards the Sustainable Building Stock by 2050 is not flat, but follows an s-curve.

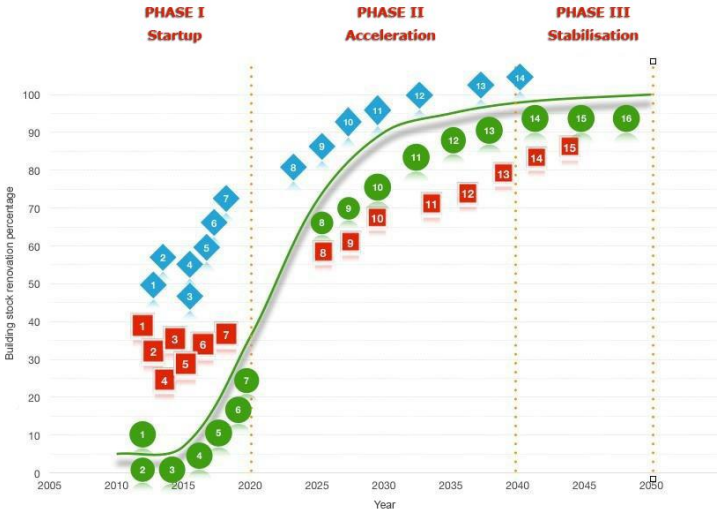


Figure 6: Shift curve towards the Sustainable Building Stock by 2050

The table below shows an indicative distribution of the required activities relating to nearly zero-energy buildings.

Table 13: Indicative distribution of the required activities relating to nearly zero-energy buildings

△	Governance	□	Structure	O	Practices
2017-2020 period					
1	Improving the legislative framework through cost-optimal minimum energy performance requirements	1	Strengthening the control mechanisms used for energy inspections	1	Carrying out energy-saving campaigns at schools, universities, individual work facilities
2	Setting out the requirements for nearly zero-energy buildings	2	Strengthening the control mechanisms used to ensure the installation of certified products and avoid the import of illegal products	2	Training consumers to use energy efficient technologies and materials in their properties
3	Securing resources to finance energy upgrading	3	Strengthening energy service companies (ESCOs)	3	Training contractors and technicians on the installation and maintenance of energy efficient technologies and materials in the building stock
4	Encouraging, including by reducing consumption taxes, domestic users to adopt energy efficient methods and/or renovations	4	Setting up structures to identify households affected by energy poverty (energy poverty observatory)	4	Implementing pilot renovation projects in public buildings through ESCOs
5	Encouraging: reducing taxes imposed on energy services	5	Appointing energy officers in each public building	5	Utilising funding instruments and schemes (e.g. funds for subsidising and granting loans, etc.)
6	Implementing energy upgrade subsidisation programmes for households, public buildings and tertiary sector buildings	6	Setting up a database for the energy mapping of public buildings	6	Green loans granted under more favourable conditions
7	Adopting incentives for subsidising green materials	7	Including the installation of smart meters in each energy-saving intervention	7	

△	Governance	□	Structure	O	Practices
	2020-2040 period				
8	Including external costs in the pricing of energy	8	Setting up local smart grids	8	Implementing pilot programmes for the energy and technological modernisation of neighbourhoods and residential blocks
9	Adopting policies and measures to speed up and facilitate the penetration of energy efficient practices and nearly zero-energy buildings	9	Research and development into new construction materials and products (using less stored and more environmentally friendly energy)	9	Associating the energy consumption of a building with its objective value
10	Adopting measures for renovating entire multiple-owner buildings instead of individual properties/apartments	10	Creating a green material market/register	10	Creating flexible financing/banking products for the energy upgrading of buildings
11	Adopting measures for renovating building complexes	11	Expanding the natural gas network	11	Upgrading public and tertiary sector buildings through ESCOs and PPPs
12	Providing incentives for purchasing/renting energy efficient buildings	12	Mechanisms used to directly measure the energy footprint of an area	12	Implementing energy management systems in public buildings and organisations
13	Establishing stricter energy performance requirements for new buildings	13	Promoting RES systems	13	Utilising funding instruments and schemes (e.g. funds for granting loans, guarantees, etc.)

△	Governance	□	Structure	O	Practices
	2040-2050 period				
14	Establishing stricter energy performance requirements for new buildings	14	Expanding a network of geothermal energy and high efficiency cogeneration of heat and power	14	Energy upgrading of degraded residential communities
		15	Expanding the natural gas network all over Greece	15	Expanding the institution of ESCOs to include the energy renovation of residential buildings
				16	Energy upgrading of all public buildings

5.1 Policies and measures for improving the energy performance of buildings so that all new buildings are NZEBs by 1 January 2021 and all new buildings occupied by public authorities and the broader public sector are NZEBs by 1 January 2019

Table 14: Policies and measures for improving the energy performance of buildings so that all new buildings are NZEBs by 1 January 2021 and all new buildings occupied by public authorities and the broader public sector are NZEBs by 1 January 2019

Type - Title	Institutional framework: Ministerial decision on NZEBs
Description	Determination of the numerical indicator of primary energy use and coverage of final energy by RES
Building category/target groups	All buildings
Implementation framework	Start 2018

Type - Title	Financial and other incentives: Revision of Law 4067/2012 - Article 25 'Incentives for constructing nearly zero-energy buildings'
Description	1. Where a building is classified, according to its energy design, in KENAK's highest energy category A+ … , an incentive is given by increasing the building ratio by 5 %. 2. A specific increase of the building ratio by 10 % is offered for minimum energy consumption buildings that also have excellent environmental performance. These buildings must have an annual primary energy consumption for heating, air conditioning, lighting, ventilation and domestic hot water of less than 10 kWh/m^2/year.
Building category/target groups	New buildings / Existing buildings undergoing major renovation
Implementation framework	Start 2012

Type - Title	Education / training: Technical guidelines (Manual)
Description	Drawing up and making available on the internet a technical manual on the implementation of NZEBs and their technical characteristics.
Building category/target groups	Architects/engineers – construction sector
Implementation framework	Start end 2018

Type - Title	Education / training: NZEB training seminars
Description	Training seminars on the practical implementation of NZEBs and their technical characteristics.
Building category/target groups	Architects/engineers – construction sector – administration [Central government – Local authorities]
Implementation framework	Start end 2018

5.2 Policies and measures for the major renovation of existing buildings to the level of NZEB

Table 15: Policies and measures for the major renovation of existing buildings to the level of NZEB

Type - Title	Institutional framework - regulations: Revision of Law 4122/2013, Article 21 'Building permits'
Description	Where work is carried out for which a small-scale work permit is required under Laws 4030/2011 and 4067/2012, an EPC must be issued. Where a building or building unit is classified category D or lower, at least one of the recommendations should apply, to meet the minimum energy performance requirements.
Building category/target groups	Existing buildings
Implementation framework	Start 2018
Type - Title	Demonstration actions: Pilot implementation of projects for improving the energy performance of public buildings
Description	New office buildings occupied by the central government, whether owned or rented for 20 or more years, undergo major renovation towards NZEB level by energy service companies (ESCOs) with co-financing from the public investment programme.
Implementation framework	Start 2018

6 Description of impediments - barriers

To ascertain the feasibility of the implementation of the policies and measures proposed for increasing the number of nearly zero-energy buildings, it is important to discuss certain impediments and barriers, which are due to the inherent features of Greece and its economic situation.

Firstly, we should mention the **reduced income and change of household consumption patterns** as a result of the economic crisis. On the basis of the findings of a family budget survey carried out by ELSTAT for 2013, there have been remarkable changes to the spending structure of Greek households in recent years, relating *inter alia* to declining thermal comfort conditions and increasing energy poverty levels, which make it impossible for them to improve the energy performance of their buildings.

Secondly, we should mention the **increasing difficulty in accessing bank funding**. Bank lending was the key funding instrument for meeting consumer and investment needs in Greece. The credit crunch in the domestic financial system over the last four years (given its declining lending capacity) has contributed to a reduction in investment spending on building renovation. For example, the gross fixed asset creation rate in the Greek residential building market has dropped at an annual average rate of 27 % since 2008 (from EUR 19.3 billion in 2008 to EUR 4 billion in 2013). In respect of the funding granted to households for the construction and/or repair of residential buildings, the annual rate of change of housing loans granted by banks began to fall in 2008 and reached negative levels in 2010, resulting in a declining balance of housing loans. Domestic financial institutions have gradually started to include more and more energy performance projects in their portfolio of loans in recent years. A significant contribution has been made in this direction over the course of time by the taking of legislative initiatives and adoption of rules concerning the energy performance of buildings, the installation of photovoltaic systems on the rooftops of residential buildings and the utilisation of renewable energy sources, which encouraged a significant number of banks to develop specialised products and finance related energy performance projects.

However, the increased vulnerability of banks and the need to secure refinancing and protection against ever-increasing competition has led to significant restructuring in the banking sector, primarily through mergers and buyouts that have taken place. This has led to a reduction in the number of available banks and in the range of available funding instruments, and therefore **there are currently no banking products for financing energy performance improvement actions.**

ANNEX I - Exemplary buildings and NZEB promotion actions

IA. Exemplary buildings
City Hall of Farsala

GENERAL INFORMATION

Title: Energy upgrading of the City Hall of Farsala and converting it into a nearly zero-energy building.
Duration: 2015-2020

Financing: National programmes/ Green Fund

Budget: EUR 300 000.00

ENERGY PERFORMANCE

Primary energy per end use	Reference building	Existing building	Scenario 1
Heating (kWh/m²)	21.1	67.0	23.3
Cooling (kWh/m²)	42.6	58.5	28.1
Domestic hot water (kWh/m²)	0.0	0.0	0.0
Lighting (kWh/m²)	123.5	123.6	81.1
Contribution from RES-CHP	0.0	0.0	76.7
Total	187.2	249.1	55.8
Classification	-	C	A+
Operating cost (EUR)	11 867.2	18 277.4	3 277.1
Primary energy savings (kWh/m²)	-	-	193.3
Primary energy savings (%)	-	-	77.6
Reduction of CO_2 emissions (Kg/m²)	-	-	61.2

BENEFITS

- Energy-related: 168 000 kWh/yr
- Environmental: 87.20 t CO_2/yr
- Financial: Reducing energy costs

Further information: AIDA project, www.aidaproject.eu

Cultural Centre of the Municipality of Farsala

GENERAL INFORMATION

Title: Energy upgrading of the Cultural Centre of the Municipality of Farsala and converting it into a nearly zero-energy building

Duration: 2015-2020

Financing: National programmes/Green Fund

Budget: EUR 300 000.00

ENERGY PERFORMANCE

Primary energy per end use	Reference building	Existing building	Scenario 1
Heating (kWh/m²)	15.5	19.8	14.3
Cooling (kWh/m²)	35.8	38.3	7.6
Domestic hot water (kWh/m²)	2.8	1.1	1.0
Lighting (kWh/m²)	46.6	43.6	26.3
Contribution from RES-CHP	0.0	0.0	42.9
Total	100.6	102.8	6.3
Classification	-	C	A+
Operating cost (EUR)	5 493.6	5 845.5	694.8
Primary energy savings (kWh/m²)	-	-	96.5
Primary energy savings (%)	-	-	93.8
Reduction of CO_2 emissions (Kg/m²)	-	-	31.8

BENEFITS

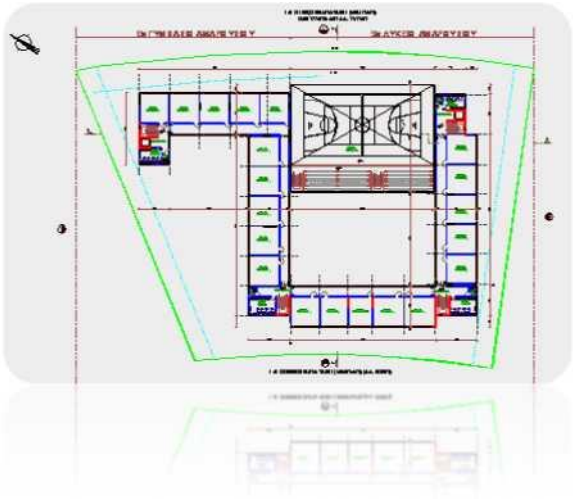
- Energy-related: 71 400 kWh/yr
- Environmental: 34.41 t CO_2/yr
- Financial: Reducing energy costs

Further information: AIDA project, www.aidaproject.eu

8th Junior High School - 9th Senior High School of Amarousion

GENERAL INFORMATION

Title: Preliminary design for the energy upgrading of the school complex comprising the 8th Junior High School and the 9th Senior High School of Amarousion, Attica



ENERGY PERFORMANCE

The building is expected to be upgraded from energy category B to category A+, and to have such primary energy consumption levels as shown in the table below:

Primary energy per end use	Existing building	Scenario
Heating (kWh/m²)	40.5	32.3
Cooling (kWh/m²)	19.7	12.7
Domestic hot water (kWh/m²)	0	0
Lighting (kWh/m²)	79.2	40.7
Contribution from RES-CHP	-	79.0
Total	139.4	6.7
Classification	B	A+

BENEFITS

- Energy savings - nearly zero-energy building
- Reducing energy costs

Further information: AIDA project, www.aidaproject.eu

4th Primary School of Thessaloniki

GENERAL INFORMATION

Title: Pilot conversion of a building undergoing renovation into a nearly zero-energy building

ENERGY PERFORMANCE

Primary energy per end use Heating (kWh/m²)	36.3
Cooling (kWh/m²)	2.8
Lighting (kWh/m²)	14.6
Contribution from RES-CHP (kWh/m²)	71.00
Total	34.20
CO_2 (Kg/m2)	10
Classification	A+
Primary energy savings (kWh/m²)	72.4
Primary energy savings (%)	68

BENEFITS

- Energy savings - nearly zero-energy building
- Reducing energy costs

Further information: AIDA project, www.aidaproject.eu

Pilot green urban neighbourhood (Agia Varvara)

GENERAL INFORMATION

Title: Pilot green urban neighbourhood - Energy upgrading of 4 apartment blocks in Agia Varvara, Attica, Greece
Financing: Operational programme 'Environment and Sustainable Development' (OP-ESD), NSRF.
Budget: EUR 5 000 000 + 256 408 from sponsorships

ENERGY PERFORMANCE

Energy demand for heating	32 kWh/m^2
Energy demand for cooling	17.85 kWh/m^2
Energy savings	76 %
Contribution from geothermal energy	0.350 MWp
	21.7 kWh/m^2
Photovoltaic system	0.040 MWp
CO_2 (Kt)	0.7

- **BENEFITS**
  - Energy savings
  - Combating 'energy poverty'
  - Fostering the use of domestic products and highly energy and environmentally efficient technologies
  - Promoting energy and environmental policy

Further information: CRES www.cres.gr

Municipal Library of Loutraki

GENERAL INFORMATION

Title: Renovation and addition, integration of passive systems, Loutraki, Greece

Energy demand for heating	1.36 kWh/m^2
Energy demand for cooling	57.68 kWh/m^2
Energy savings	91 % Heating
	41 % Cooling
Geothermal heat pumps	16.6 kW heating
	14.0 kW cooling

- Energy savings

- Reducing energy costs

Further information: *CRES*, www.cres.gr

School complex at Kleanthous Street, Thessaloniki

GENERAL INFORMATION

Title: Energy upgrading with RES, Thessaloniki, Greece

Financing: Operational programme 'Environment and Sustainable Development'

Budget: EUR 6 152 000

Energy demand for heating	20.25 kWh/m^2
Energy demand for cooling	2.30 kWh/m2
Energy demand for lighting	19.50 kWh/m^2
Production of primary energy by RES	26.85 kWh/m^2 for heating
Energy savings	85 %

- Energy savings - nearly zero-energy building
- Reducing energy costs

Further information: AIDA project, www.aidaproject.eu

Office buildings, Region of Central Macedonia

GENERAL INFORMATION

Title: Example of good implementation: Office buildings, Region of Central Macedonia

Financing: The construction was financed with own funds.

Budget: EUR 43 804 896.00

Certification:	According to the KENAK, the building is classified category B, with a primary energy consumption level of 155.5 kWh/(m²/yr), while the KENAK reference building is classified as category B with a consumption of 206.5 kWh/(m²/yr).
Primary energy consumption:	155.5 kWh/(m^2/yr)
Primary energy consumption for heating:	42.5 kWh/(m^2/yr)
Primary energy consumption for lighting:	68.0 kWh/(m^2/yr)
CO_2 emissions:	52.0 kg CO_2 /(m^2/yr)

- Energy savings
- Reducing energy costs

Further information: AIDA project, www.aidaproject.eu

R.C.TECH- office building, Athens

GENERAL INFORMATION

Title: Example of good implementation - R.C.TECH office building, Athens, Greece

Financing: The construction was partly financed by the European Union, through a programme for the design and construction of sustainable buildings.

Certification:	According to the KENAK, the building would be classified as category B+, with a primary energy consumption level of 198.8 kWh/(m²/yr), while the KENAK reference building is classified as category B with a consumption of 279.4 kWh/(/yr).
Primary energy demand (in accordance with measurements and invoices):	149.5 kWh/(m²/yr)
Demand for primary energy for heating:	32 kWh/(m^2year)
Demand for primary electric energy:	117.5 kWh/(m^2year)
CO_2 emissions:	47.7 kg CO_2 /(m^2year)

- Energy savings
- Reducing energy costs

Further information: CRES, www.cres.gr

Office building, Athens

GENERAL INFORMATION

Title: Creating a computer tool (Turin Polytechnic, Italy) to simulate the current situation and determine cost-optimal and nearly zero-energy consumption solutions, the payback period and the CO_2 emissions reduction.

ENERGY PERFORMANCE

Primary energy per end use	Current situation	Cost-optimal scenario	NZEB scenario
Heating (kWh/m²)	141	56	28
Cooling (kWh/m²)	108	46	43
Lighting (kWh/m²)	57	9	9
Contribution from RES-CHP (kWh/m²)	0	72	39
Total	306	112	80
Electricity from photovoltaic systems (kWh)	0	1 815	1 815
Energy costs (€/m^2)	457	140	102
Investment costs (€/m^2)	0	95	127
Operating and maintenance costs (€/m^2)	97	57	71
Payback period (years)	-	5	6
CO_2 emissions (tons)	537	214	152

BENEFITS

- Energy savings:
- Reducing energy costs

Further information: *RePublic ZEB project* http://www.republiczeb.org

School building, Athens

GENERAL INFORMATION

Title: Creating a computer tool (Turin Polytechnic, Italy) to simulate the current situation and determine cost-optimal and nearly zero-energy consumption solutions, the payback period and the CO_2 emissions reduction.

ENERGY PERFORMANCE

Primary energy per end use	Current situation	Cost-optimal scenario	NZEB scenario
Heating (kWh/m²)	312	144	98
Cooling (kWh/m²)	12	11	8
Lighting (kWh/m²)	61	8	7
Contribution from RES-CHP (kWh/m²)	0	138	126
Total	385	162	113
Electricity from photovoltaic systems (kWh)	0	4 900	4 900
Energy costs (€/m^2)	661	224	156
Investment costs (€/m^2)	0	74	187
Operating and maintenance costs (€/m^2)	56	95	107
Payback period (years)	-	2	7
CO_2 emissions (tons)	163	81	56

BENEFITS

- Energy savings:
- Reducing energy costs

Further information: *RePublic ZEB project* http://www.republiczeb.org

REQUEST2ACTION project

GENERAL INFORMATION

Title: REQUEST2ACTION *'Removing barriers to low carbon retrofit by improving access to data and insight of the benefits to key market actors'*

Description: The project includes actions for encouraging, and taking decisions for, the energy upgrading of residential buildings by owners and tenants, thus ensuring easy access to accurate and reliable data concerning energy performance certificates (EPCs).

Duration: 3/2014 - 3/2017

Financing: 'Intelligent Energy for Europe' programme

Greek HUB for the energy performance of buildings - 'EnergyHUB for ALL':

- Communication 'hub' among the parties involved in the renovation of residential buildings, energy.
- Data and information 'hub' concerning the energy performance of buildings.
- Specific section on NZEBs:
  - Definition of NZEB
  - EU / national legislation
  - Methodology used to calculate the energy performance of NZEBs.
  - Collection and presentation of European projects (completed or current), focusing primarily on NZEBs.

'Home energy check' tool

It is intended for ordinary users, to inform them of how they can cut down on energy costs at home by taking simple steps. The key results of the application include comparing the amounts of energy consumed

before and after the energy improvement interventions, while using this tool to calculate the indicative cost of the intervention chosen by the user. Finally, users can save the results and assess the interactive tool in terms of its quality, benefit and usefulness.

Further information: www.energyhubforall.eu,www.building-request.eu

Republic ZEB project

GENERAL INFORMATION

Title: Refurbishment of the Public Building Stock towards NZEB

Description: The project provides contact for partners from SE European countries to develop and promote tools for the major renovation of buildings to NZEBs. The project aims to provide the means to reduce the amounts of energy consumed by public buildings to a nearly zero level, in accordance with Article 9 of the EPBD.

Duration: 3/2014 - 10/2016

Financing: 'Intelligent Energy for Europe' programme

- Analysing the existing stock of public buildings and identifying characteristic examples (in accordance with the specifications of the project, e.g. m^2, no insulation, etc.).
- Assessing the current situation and analysing the potential for renovating public buildings to NZEBs. Analysing the current classification of buildings in accordance with the KENAK, good practices (the school of Agios Stratis and the building of the Region of Epirus), selecting interventions (envelope, E/M installations, photovoltaic and solar-powered systems) and packages of measures (combined interventions).
- Analysing the return on the cost of 'packages of measures' intended for the renovation of buildings to NZEBs. Acknowledgments for estimating the energy performance (technical guidelines from the Technical Chamber of Greece) and of the energy, maintenance, operating, replacement and investment costs. Developing a calculation tool (POLITO), recording all selected interventions and selecting combined energy interventions. Using the calculation tool to simulate the current situation of buildings and determine cost-optimal and nearly zero-energy consumption solutions, the payback and the CO_2 emissions reduction period.
- Strategies and guidelines for nearly zero-energy buildings (NZEBs)
- - Dissemination and information actions.

Further information: AIDA project, www.aidaproject.eu

AIDA project

GENERAL INFORMATION

Title: AIDA_Affirmative Integrated Energy Design Action

Description: Information and dissemination actions for the implementation of nearly zero-energy buildings by local authorities across Greece

Duration: 2012 - 2015

Financing: 'Intelligent Energy for Europe' programme

PROJECT ACTIONS IN GREECE

Under the project, the designation 'nearly zero-energy buildings' (NZEBs) was given to buildings classified category A+ (or A), with a primary energy consumption of ~<60 kWh/m^2, which met a large part of their energy needs from RES. It was found that it was technically possible for some of the existing municipal service and school buildings to meet the above requirements.

- There were certain municipal and other tertiary sector buildings identified which could serve as examples of converting existing buildings and designing new ones towards NZEB.
- More than 400 representatives of local authorities and engineers received training and took part in study tours of the exemplary buildings.
- There were meetings held (in Athens and Thessaloniki) with supporters and coordinators of the Mayors' Agreement (regional authorities, Regional Association of Municipalities, Technical Chamber of Greece, Central Association of Greek Municipalities, etc.) to strengthen the promotion of NZEBs.
- Engineers from the Region of Central Macedonia received NZEB training.

PROJECT RESULTS

- The technical options and energy consumption were looked into concerning municipal NZEBs.
- Actions were included in the Sustainable Development Plans of the Municipalities of Thessaloniki and Farsala for converting existing buildings into NZEBs.
- The impediments and prospects towards NZEBs concerning buildings used by local authorities were identified and analysed.
- Memoranda of cooperation were signed for the further promotion of NZEBs between CRES and the Association for Sustainable Development of Cities.
- Three (3) daily workshops for the promotion of NZEBs were organised.

Further information: http://www.republiczeb.org