Report on long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private.

(Article 4, Directive 2012/27/EU)

Athens, December 2014

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1. INTRODUCTION

This report is a first version of the long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private, as provided for in Article 4 of Directive 2012/27/EU on energy efficiency[1].

The European Commission recently adopted Directive 2010/31/EU on the energy efficiency of buildings (recast of Directive 2002/91/EU) and Directive 2012/27/EU on energy efficiency. The above two directives stress the importance of the energy upgrade of buildings and, in particular, the significance of a long-term consideration of the investment required for renovating the building stock.

The energy consumption of buildings (in both the residential and tertiary sectors) represents a large percentage of the total energy consumption, which, as shown in Figure 1, corresponded to 45% of domestic consumption in 2012.

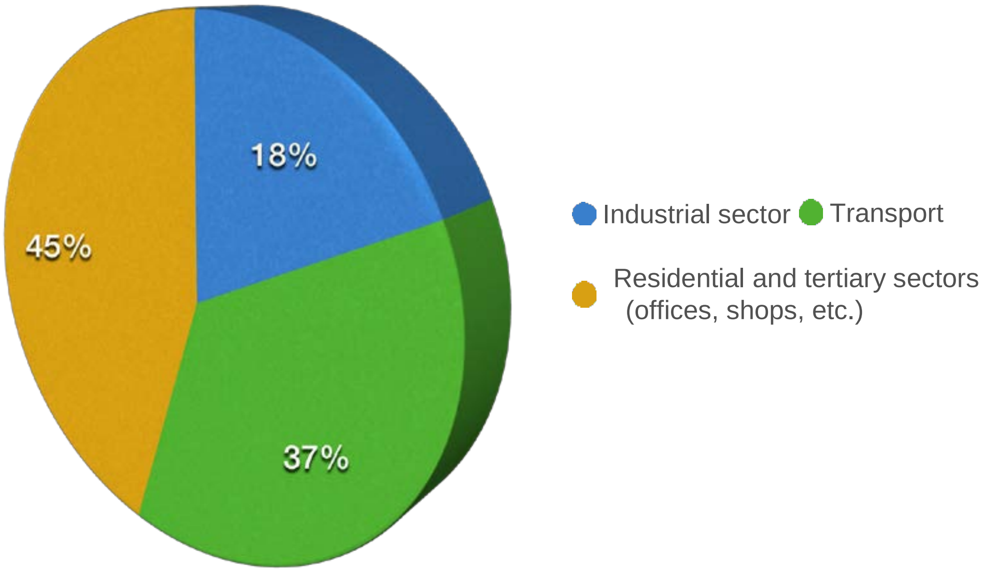
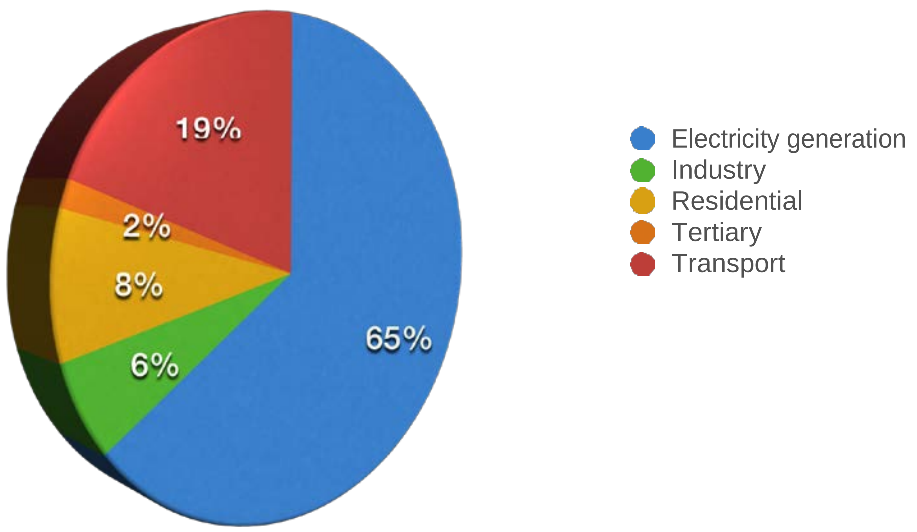


Figure 1: Breakdown of final energy consumption per use, 2012 [1]

[1]*The report was prepared in cooperation with staff members of the Ministry of the Environment, Energy and Climate Change (MEECC) and the Laboratory of Soft Energy Applications and Environmental Protection of the Mechanical Engineering Department of the Technological Education Institute of Piraeus (LSEA&EO) on the basis of contract No* 13/10/11234/911/2.7.2014, entered into with the MEECC.

Use	Consumption percentage (%)	Consumption (ktoe)
Industrial sector	18	2 998
Transport	37	6 380
Residential and tertiary sectors (offices, shops, etc.)	45	7 751
TOTAL	100	17 129

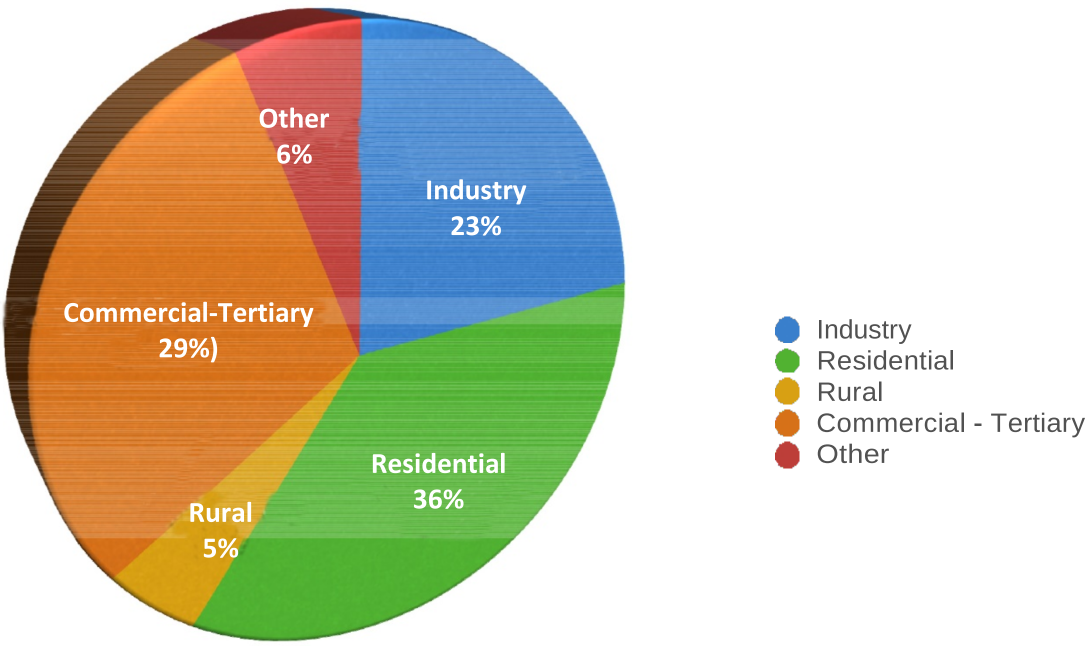
Moreover, Figure 2, which shows a breakdown of the percentages of carbon dioxide (CO_2) emissions per energy sector, indicates that the share of the residential and tertiary sectors stood at 10% in 2012.



Sectors	Electricity	Industry	Residential	Tertiary	Transport	Total
Amount of CO_2 (Mt)	54.51	5.50	6.95	1.34	15.84	84.14

Figure 2: Breakdown of CO_2 per energy sector, percentage breakdown of a total of 84.14 Mt CO_2, 2012 [2]

The percentage of electricity consumed by buildings in Greece is also high. Based on Figure 3, 65% of the electricity consumed in Greece in 2012 related to the residential (36%) and tertiary (29%) sectors, based on data from the Public Power Corporation (PPC).



Use	Electricity consumption (GWh)
Industry	12 095
Residential	18 878
Rural	2 781
Commercial - Tertiary	15 016
Other	3 176
TOTAL	51 946

Figure 3: Breakdown of electricity consumption per use, 2012 [3]

It should also be stressed that the construction industry in Greece is a traditionally strong economic sector representing approximately 7% of Greece's GDP (with a peak of 8.8% in Q4 2006), and approximately 400 000 people were directly and indirectly employed in or dependent on construction in 2007. Due to the economic crisis, however, construction activity has dropped significantly and has been affected more than any other economic sector in Greece (construction represented 3.75% of the GDP in Q1 2012). In the last 3 years, the annual change of the production indicator in construction dropped by approximately 28%, and 157 000 jobs were lost in the construction industry in the period 2008-2011 [4].

This long-term strategy for the renovation of the Greek building stock was prepared in this context and with a view to improving the energy performance of buildings. The strategy aims to provide a key tool both for policy-making in the energy upgrade of buildings and attracting investment and mobilising private funding. It should be noted that this report, and the measures proposed and policies concerned in particular, will be revised to ensure that they respond better to the changing needs of Greek society, stakeholders' proposals and current developments in the Greek economy.

2. METHODOLOGY

Preparation of this report was meant to comply with the requirements set out in Article 4 of Directive 2012/27/EU, which states specifically that Member States must establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. This strategy should encompass:

(a) an overview of national building stock based, as appropriate, on statistical sampling;

(b) identification of cost-effective approaches to renovations depending on the building type and climatic zone;

(c) policies and measures to stimulate the cost-effective renovations of buildings, including gradual major renovations;

(d) a forward-looking perspective to guide investment decisions of individuals, the construction industry and financial institutions;

(e) an estimate of expected energy savings and wider benefits based on specific data and a specific methodology;

The methodology used to prepare this report has also utilised, to the degree possible, Annex B to Commission Staff Working Document SWD(2013)180 final/22.5.2013, which describes certain individual sections that need to be analysed.

The methodology has also included methods, tools and techniques already developed by the LSEA&EO in the context of national and European programmes, such as the recently completed creating innovative sustainable pathways (CRISP) [5] project. The CRISP methodology combines the use of future scenarios, participation of stakeholders and analysis of alternative scenarios based on a backcasting methodology, which is particularly appropriate for the drawing up of long-term strategies in uncertain and highly unclear environments. This methodology is recommended by researchers and experts in policy-making in the energy upgrade of buildings [6], [7] with a view to ensuring energy savings and the participation of stakeholders. The key principles of the CRISP programme are detailed in Annex I.

It was also possible to utilise the significant experience gained from the cooperation of groups working for the concerted actions of the directives on the energy efficiency of buildings, energy performance and renewable energy sources (Joint Working Group CA EED, CA EPBD, CA RES, 2013), and the report ‘Towards assisting

EU MS on developing long term strategies for mobilising investment in building energy renovation' [8] in particular, as prepared with a view to developing long-term strategies for mobilising investment in the energy upgrade of buildings.

The long-term strategy is based on an estimate of the building stock established based on the censuses conducted by the Hellenic Statistical Authority (ELSTAT), on records from researchers and scientists in related fields, on studies from laboratories and R&D centres, as well as on reports from individual branches and/or sectors (sources from the Hellenic Chamber of Hotels, the health sector, the School Buildings Organisation, the Central Union of Municipalities and Communes of Greece) [9].

It was established, as already known, that the largest percentage of buildings were used for residential purposes. The other, non-residential buildings, i.e. buildings in the tertiary sector, were broken down into four (4) key uses: (i) shops / commercial buildings / offices, (ii) schools and educational buildings, (iii) hotels and (iv) hospitals. The rest of the buildings, such as churches, car parks, sports venues (stadiums and general sports facilities) were not included in the analysis.

Based on international experience, there are three (3) key approaches used to estimate the energy performance of the building stock in the context of energy savings, in particular where a large-scale building stock is analysed in terms of number and surface area [10] [11]. The first approach used is the top-down approach, the second one is the bottom-up approach and the third one is the middle approach, starting with an intermediate estimate of the stock and of its energy-related behaviour, both in bottom-up and top-down directions at an individual residence level. The top-down approach was used for the analysis carried out in the present phase, and information from individual surveys and studies used for improvement and correction purposes was also taking into account, depending on the category of use of the buildings.

The key five (5) categories of the building stock in terms of quantity and energy consumption were examined using five (5) scenarios by properly combining the type and rate of renovation. The rate of renovation represents the number of buildings renovated in a certain period of time. The type of renovation is determined based on the energy savings percentage achieved for a given number of buildings undergoing renovation. The above scenarios are further analysed in terms of the investment needed for each case of renovation and in terms of their individual social impact.

3. TARGETS – TIMEFRAME

The overall environmental-energy targets set by the European Union is represented by the well-known 20-20-20, i.e. a 20% reduction in greenhouse gas emissions, a 20% share of RES in the energy mix and 20% energy savings by 2020. However, in January 2014, the European Commission proposed a binding target for reducing greenhouse gas emissions by 40% by 2030 and a 27% share of renewable energy sources in the energy mix of the EU (which is not binding on Member States), without setting a binding target concerning energy performance.

The Commission, in its Communique of July 2014 [12], assessing the contribution of improved energy performance towards reducing carbon dioxide emissions, ensuring the security of the supply of energy, reducing the dependency and cost of energy, and strengthening the competitiveness of the EU economy, also taking into account the progress made by the Member States towards achievement of the target for 20% energy savings by 2020, finally proposed the setting of a corresponding 30% energy savings target for 2030. Besides, the overall EU target for 2050 is rather ambitious as it foresees an 80-95% reduction in greenhouse gas emissions by 2050 compared to the 1990 emissions levels [13], and buildings are vital for achieving that target.

As stated above, buildings play a critical role in achieving the above targets, as their share in energy consumption and CO_2 emissions is very significant. Although no specific target has been set for energy savings in the building sector, it should be noted that, in the context of Directive 2010/31/EU on the energy performance of buildings, the EU strategic target is that **all new buildings are nearly zero-energy buildings by 2020.**

It should be stressed at this point that, in the context of Directive 2012/27/EU on energy efficiency, a target has been set for 3% of the total surface area of buildings with a total useful surface area over 500 m^2 owned and occupied by the central government to be renovated annually. To comply with this requirement, the MEECC has posted an initial list of 82 buildings owned by the central government, with a total useful surface area of approximately 310 000 m^2, in order to start planning the renovation of 3% of their total surface area (approximately 10 000 m^2 annually).

Given the above, this report aims to assist with the realisation of the vision of having a **sustainable building stock** by 2050. That is, the target is to ensure the gradual and coordinated upgrade of the building stock, to ensure that **by 2050 the entire stock consists of high energy performance buildings and, ideally, of zero-energy buildings and/or buildings with the minimum possible energy consumption, also ensuring maximum utilisation and integration of renewable energy sources.**

As regards energy efficiency, the overall target set by the 1st national energy efficiency action plan (NEEAP), i.e. 9% by 2016, stands at 18.6 TWh, with the following breakdown per sector:
- Residential 5.5 TWh,
- Tertiary 5.7 TWh,
- Industrial 0.7 TWh, and
- Transport 6.7 TWh.

According to the 2nd NEEAP, as submitted to the Commission in September 2011, the resulting total primary energy savings based on specific scenarios stand at 33.1 TWh by 2020. Moreover, as regards the projected increase in the use of RES in buildings by 2020, based on the 1st national action plan for RES, the share of RES energy in the building sector is planned to reach 30% by 2020.

Furthermore, a new annual savings target has been set based on Article 7 of Directive 2012/27/EU, standing at 3 332.7 ktoe on a cumulative basis by 2020. To achieve that target, specific policy measures are to be adopted, including measures for the energy upgrade of buildings (residential and tertiary sector buildings), representing 600 ktoe of new energy savings. Those savings also include, in addition to measures covering investment relating to the construction and equipment of buildings, those aimed at changing the behaviour of building stock users (households and employees).
It is very important to stress that the implementation of measures for the energy upgrade of buildings in the overall framework of the national energy policy and of Directive 2012/27/EU also aims to:

- create new jobs;
- improve the living conditions and quality of interior environment both in residential and working areas;

- reduce energy dependency and the resulting outflows of foreign exchange spent on energy imports;
- ensure the optimal and long-term utilisation of natural resources; and
- train and inform final consumers on the efficient use of energy and energy savings.

4. PARTICIPATION OF STAKEHOLDERS

Identification and participation of stakeholders in adopting the measures contemplated herein will contribute substantially towards the successful implementation of a long-term strategy for the energy renovation of buildings. The bodies and agents are identified by analysing the entire model that describes the energy renovation of buildings. Figure 4 below shows the key factors involved in the decision-making process for the renovation of a building.

Figure 4: Key factors involved in the decision-making process for the renovation of buildings

It should also be noted that there are a number of ministries and other public bodies which are associated with the policies relating to the building stock and, therefore, it is vital that they also take part in the energy saving policy-making, as regards the energy upgrade of public buildings in particular. The following is an indicative list of bodies:

- Ministry of Finance
- Ministry of the Interior
- Ministry of Development and Competitiveness
- The Ministry of Education and Religious Affairs
- Ministry of the Environment, Energy and Climate Change
- Ministry of Health

- Ministry of Infrastructure, Transport and Networks
- Regions and Decentralised Administrations
- Local authorities
- Etairia Akiniton Dimosiou SA [Public Property Company]
- Ktiriakies Ypodomes SA [Building Infrastructures SA] (merger of the School Buildings Organisation – OSK SA, the Public Company for Construction of Healthcare Units – Depanom SA and Themis Kataskevastiki)

Moreover, some other important bodies and institutions should be mentioned, as they are directly or indirectly associated with the energy upgrade of buildings, whose contribution is necessary for successfully implementing the strategy for the renovation of buildings in Greece. The following is an indicative list:

- Academic institutes
- The Technical Chamber of Greece
- The Centre for Renewable Energy Sources (CRES)
- Research institutes (e.g. National Observatory of Athens, etc.)
- Associations of real estate owners (e.g. Hellenic Property Federation)
- Associations of property developers (e.g. Federation of Property Developers and Construction Companies)
- Environmental NGOs and institutes (e.g. Greenpeace, WWF, INZEB, Hellenic Passive House Institute, etc.)
- Hellenic Bank Association

Techniques for meetings and for collecting data from consultation both with specialised scientists and the general public have already been applied in the context of the European programme CRISP for collecting opinions and views from stakeholders.

5. REVIEW OF THE BUILDING STOCK

5.1. NUMBER OF BUILDINGS

The Greek building stock comprises mainly residential buildings and a number of tertiary sector buildings used for other purposes, a census of which is conducted every ten years throughout Greece. The latest census was conducted in 2011, and its initial results were made available in September 2014 [14], without including all uses, however. The number of buildings in this report was determined on the basis of data from the previous census carried out in 2001 as well as the 2011 census, on data concerning new building permits issued and data from other relevant studies, such as those from the research programme TABULA (2012) [15] in which the Institute of Environmental Research and Sustainable Development of the National Observatory of Athens took part on behalf of Greece.

For the purposes of the analysis presented herein, the building stock is broken down into the following categories, in order to examine the possibility of defining individual building stock sections with a view to attracting investors[2]:

(a) Residential buildings (single-family residences and blocks of flats)

(b) Buildings intended for other uses:

- i. offices and shops
- ii. schools and educational buildings
- iii. hospitals and clinics
- iv. hotels

A short description of the above records of the stock is interesting as it indicates the growth of the building stock.

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[2] For example, interest has already been expressed in renovating school buildings under public private partnership (PPP) schemes for 38 schools with a budget of EUR 220 million (OSK-PPP, 2011, [17]) with funds to be obtained from a loan from the European Investment Bank and the Urban Development Fund, JESSICA (joint European support for sustainable investment in city areas).

Use of building	Number of buildings	
	2001 (ELSTAT)	2011 (TABULA)
Residences	2 755 570	2 468 124
Hotels	5 595	8 309
Schools - educational buildings	16 804	15 576
Offices - shops	111 097	152 550
Hospitals - clinics	1 961	1 742
Other	625 630	625 630
TOTAL	3 516 657	3 271 931

Table 1: Number and use of buildings in 2001 and 2011

As shown in Figure 5 below, there was a significant drop in the number of building permits issued in the period 2008-2011, due to the economic crisis. Construction activity had risen in the period 2000-2005, but then it steadily declined over the period 2006-2011 by an average of 20% annually. In 2012, the total construction activity (both private and public) further dropped by 25.0% in the period from January to July, compared to the same period in 2011.

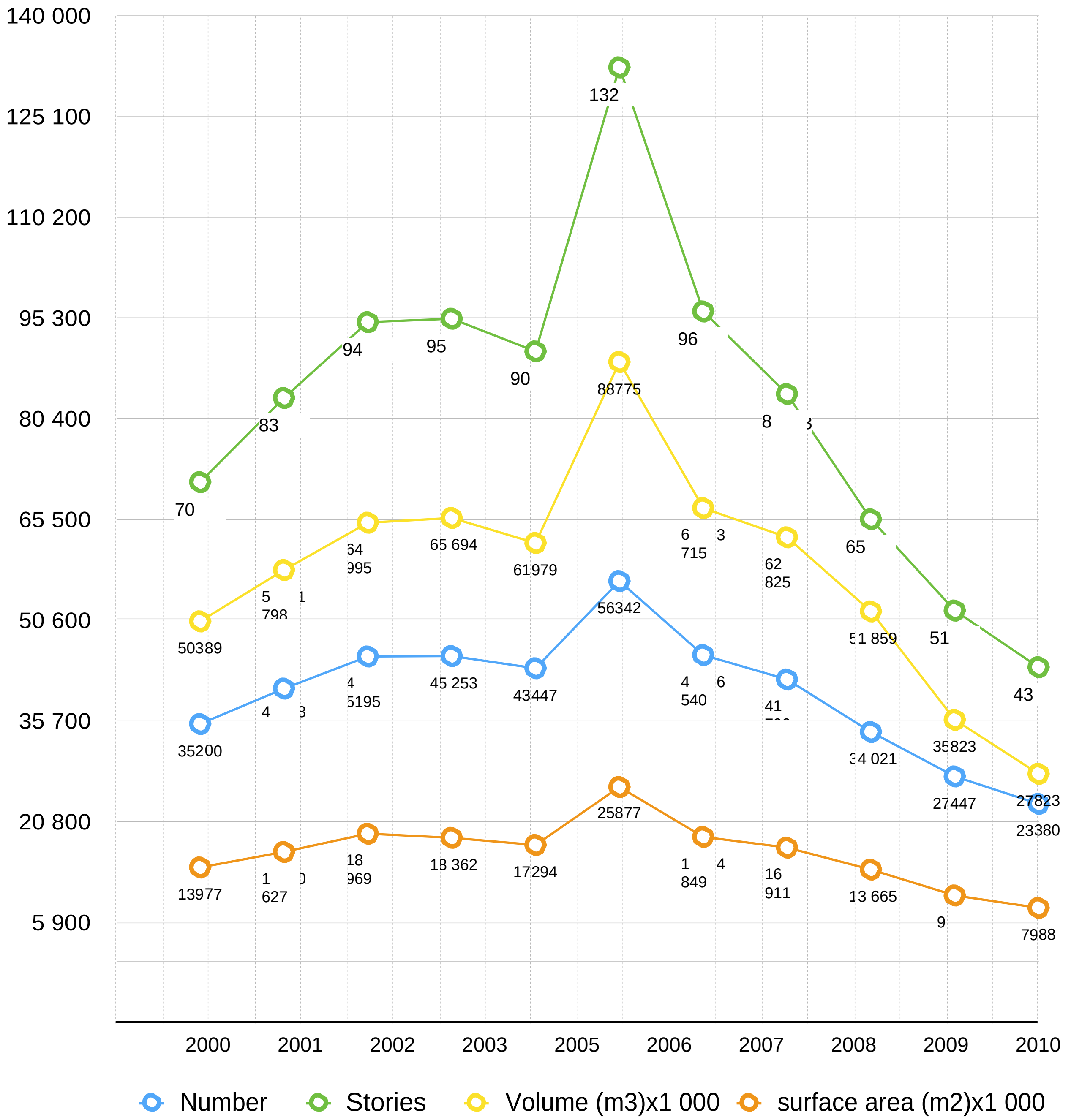


Figure 5: New building permits 2000-2011, [ELSTAT database]

Based on the building permits issued in 2001-2011, buildings of a total surface area of approximately 182 103 538 m^2 have been constructed. It should be noted that, although there are available data on building permits up until 2014, the buildings constructed after

2011 (the year of entry into force of the Regulation on the new energy efficiency of buildings–KENAK) are not included for the purposes hereof, i.e. renovation of buildings, as these are deemed to have a high level of energy efficiency already.

Based on the results of the 2011 census, as recently announced by ELSTAT, [16] there are **6 371 901 typical residences** throughout Greece. As defined by ELSTAT [16], 'typical residence' means a permanent and independent structure intended to be used as a **residence by one household** for at least one year. That size of typical residences is significant, as it will then be used for determining the total number of residences of interest, to be used as a basis for calculating the stock available for upgrade/renovation.

Based on the above announcement/report from ELSTAT, out of all those residences, a total of 4 134 540 are used by **households,** and there are a total of **4 122 088** which are actually inhabited, a number that corresponds to the number of households which resulted from the census[16]. These domestic residences will be the object of this long-term strategy study.

Based on the 2011 census and the data relating to the tertiary sector, the final building stock is shown in Table 2.

Use of building	Number of residences and tertiary sector buildings
Residences	4 122 088
Hotels	8 309
Schools - educational buildings	15 576
Offices - shops	152 550
Hospitals - clinics	1 742
Other	625 630
TOTAL	**4 925 895**

Table 2: Number and use of buildings in 2011

As shown in Figure 6, typical domestic residences represent 83.68% of the total number of buildings included in the stock (72% in terms of surface area), which indicates how important they are in the effort to ensure energy savings in the context of the national strategy for the renovation of existing buildings. Buildings other than residences represent approximately 16% of the stock, of which offices and shops, educational buildings, hospitals and healthcare facilities, and hotels represent approximately 3.62% of the stock.

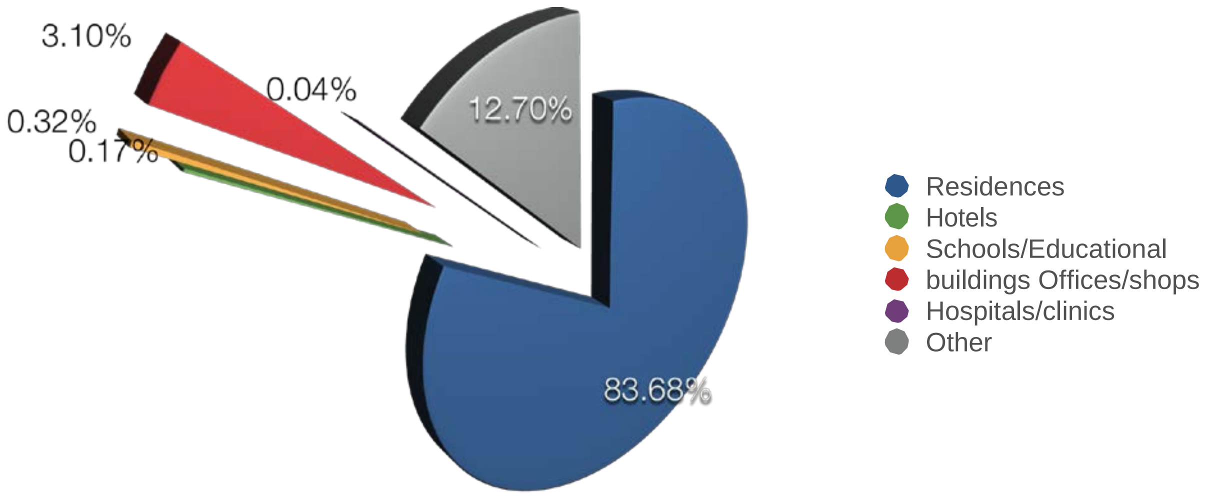
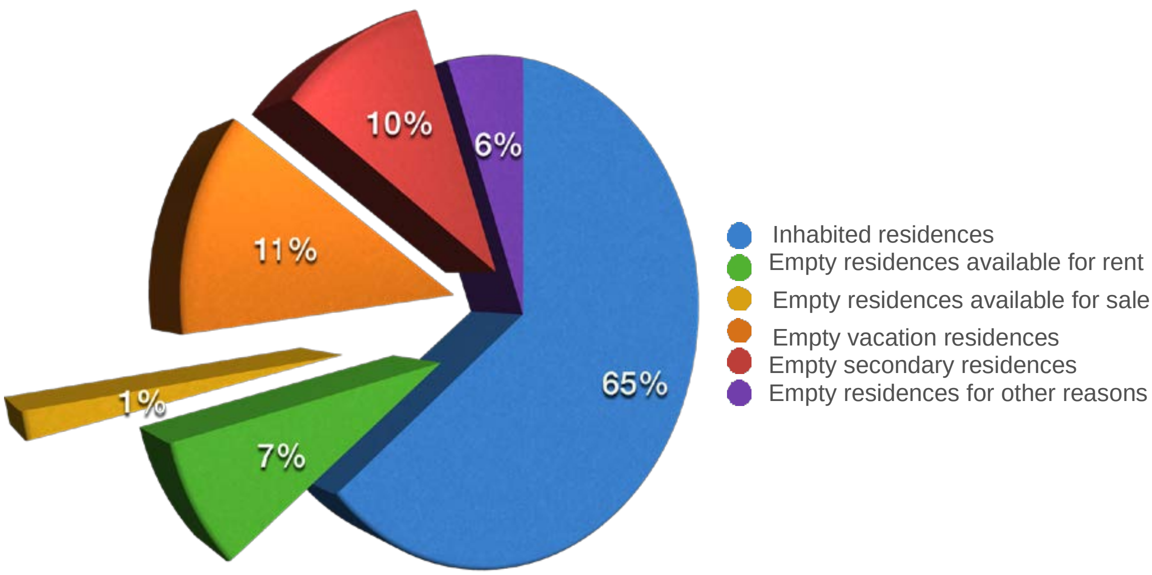


Figure 6: Percentage breakdown of the building stock by use

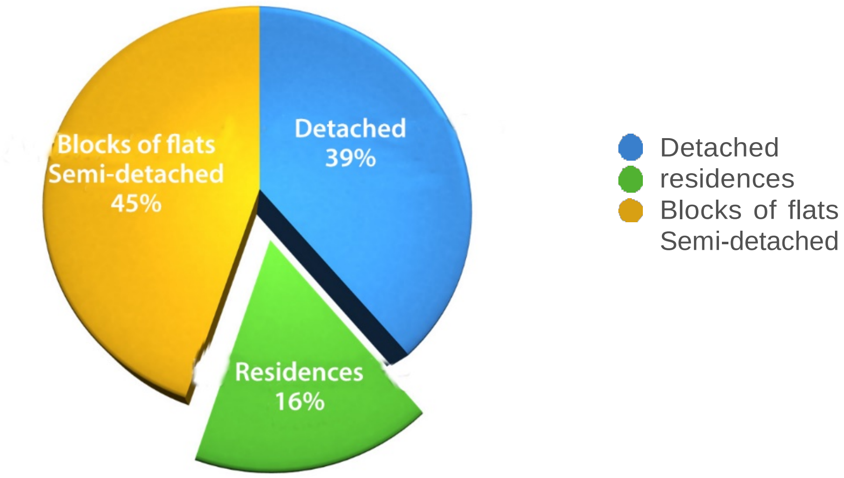
As regards typical residences in particular, the 2011 census [16] determined the number of typical domestic residences which were inhabited or empty, as shown in Figure 7. As referred to above, 4 122 088 domestic residences were inhabited.



STATUS OF (DOMESTIC) RESIDENCE	NUMBER
Inhabited	**4 122 088**
Empty residences available for renting	453 901
Empty residences available for sale	88 996
Empty vacation residences	729 964
Empty secondary residences	621 881
Empty residences for other reasons	355 071
TOTAL	**6 371 901**

Figure 7: Status of domestic residences, based on the 2011 census conducted by ELSTAT (2014) [16]

Moreover, based on Figure 8, 39% of the total number of residences were detached, and the other 61% were semi-detached or blocks of flats.



Type of residence	Number of buildings
Detached	2 457 437
Blocks of flats	1 049 001
Semi-detached	2 846 083
TOTAL	6 352 521(*)

Figure 8: Percentages of the building stock, based on the type of typical residence and household [16] (*) This number does not include 19 380 buildings, which are used for non-residential purposes

As regards the size of residences based on data from the 2011 census [16], according to Figure 9, 59% of them have a surface area of 50-99 m^2, 14% of them have a surface area of less than49 m2 and 27% of them have a surface area of more than100 m2.

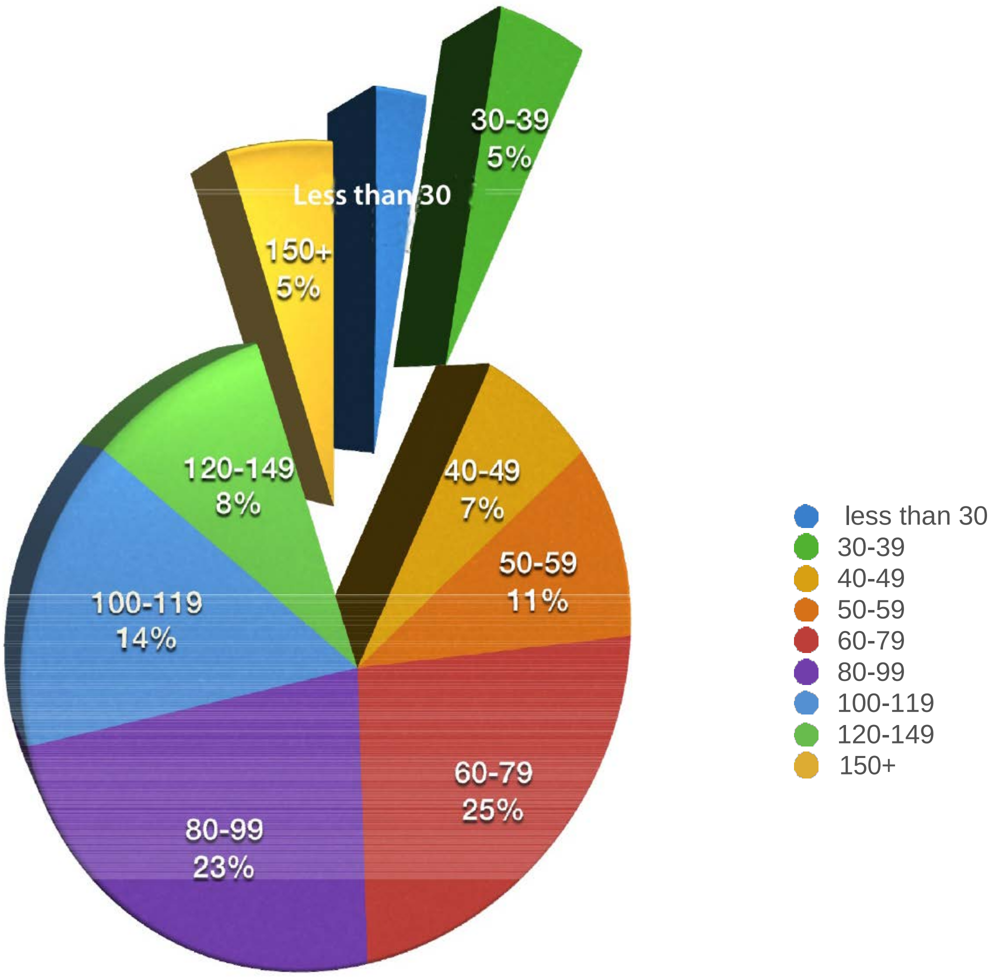


Figure 9: Size of residences (2011 population census [16])

ELSTAT's 2011 census established the division of the size of buildings.

The recent population and buildings census conducted in 2011 also established the surface area per resident, as shown in Figure 10, indicating an average of 34.6 m2 per resident.

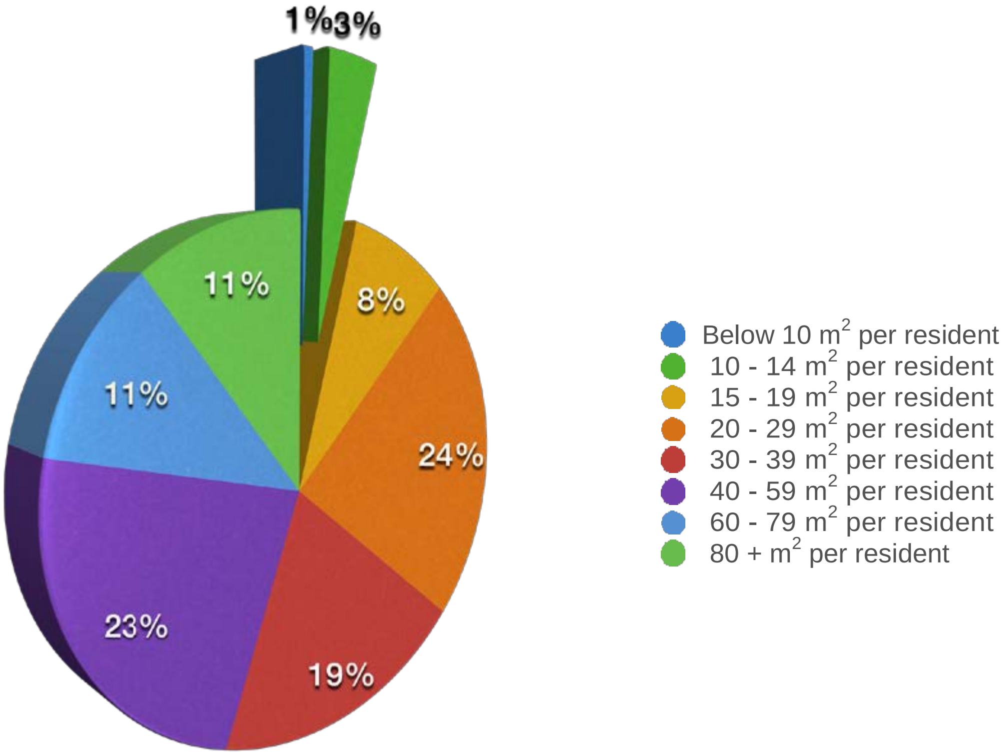


Figure 10: Residential density, surface area per resident (2011 population census [16])

Finally, as regards public buildings, which are deemed to consume large amounts of energy, it should be noted that there are no sufficient data on their exact number and energy characteristics. In terms of public buildings, only a very small percentage of the building stock belongs to the Hellenic State. The 2001 census established that there were a few thousand of those buildings, most of them educational and school buildings, typically owned by local authorities, as well as buildings used as hospitals and healthcare facilities, and there are an estimated 15 000 other buildings whose management, development and use falls under the responsibility of Etairia Akiniton Dimosiou SA (ETAD), which is supervised by the Secretariat-General for Public Property of the Ministry of Finance. Based on a recent inventory [23], there are 1 552 buildings used by the central government, of which 348 are used by central governmental agencies. It should be noted that half of those buildings are rented.

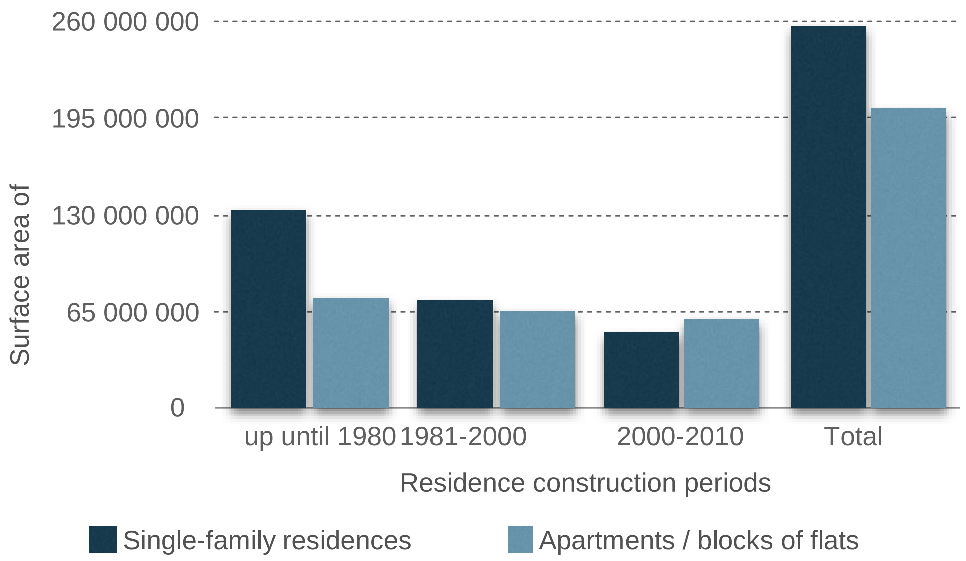
As already mentioned, Greece has already promised to renovate 3% of the total surface area of buildings with a total useful surface area over 500 m^2 owned by the central government.

5.2. AGE OF BUILDINGS

The age of buildings can be broken down into 3 basic periods, which are differentiated based on the legal framework in force, as adopted initially in 1980 by the Regulation on the thermal insulation of buildings (KTHK) and then in 2010 by the Regulation on the energy efficiency of buildings (KENAK) and depending on the quality of and technologies used in the shell and electromechanical installations of a building. Therefore, the age categories in terms of energy efficiency are as follows:

- before 1980, when buildings had no thermal protection at all;
- from 1981 to 2000, when thermal insulation and other energy efficiency improvement measures started to appear gradually;
- from 2001 to 2010, when new technologies and products were developed and applied[3].

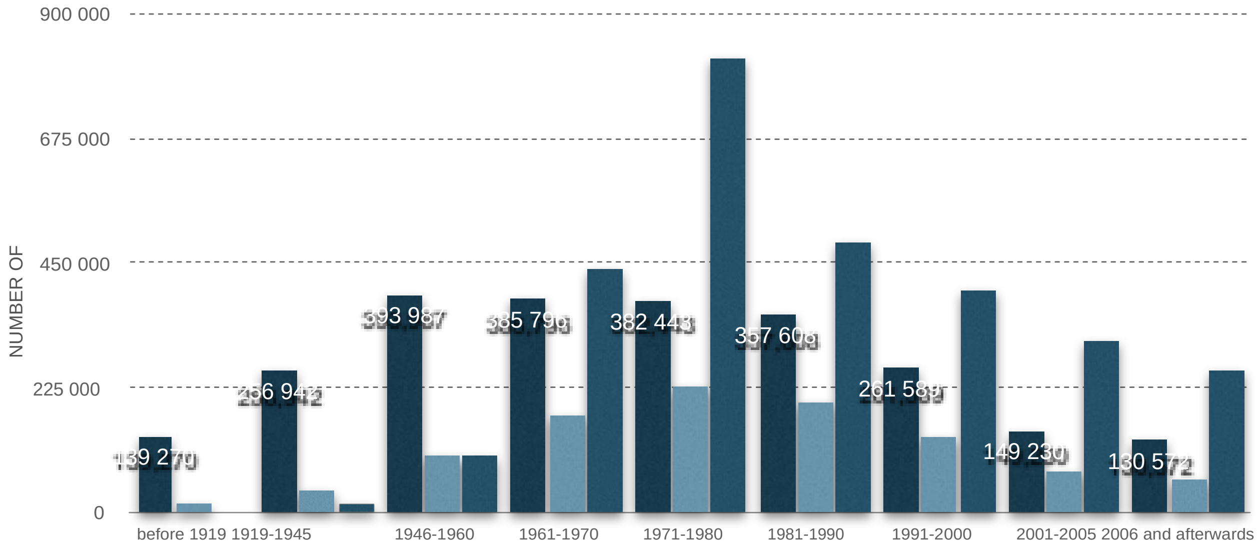
Figures 11 and 12 show a breakdown of the total surface area and number of residential buildings (detached houses and blocks of flats) into the 3 construction periods, in terms of square metres of surface area and number, respectively. Figures 13 and 14 show a breakdown for the other categories of buildings (offices and shops, educational buildings, hospitals and healthcare facilities, hotels).



3 After the Regulation on the energy efficiency of buildings (KENAK) was adopted (in 2010), buildings complied with the minimum requirements and, therefore, they are not specifically targeted in the present phase in terms of energy upgrade and improvement of energy efficiency.

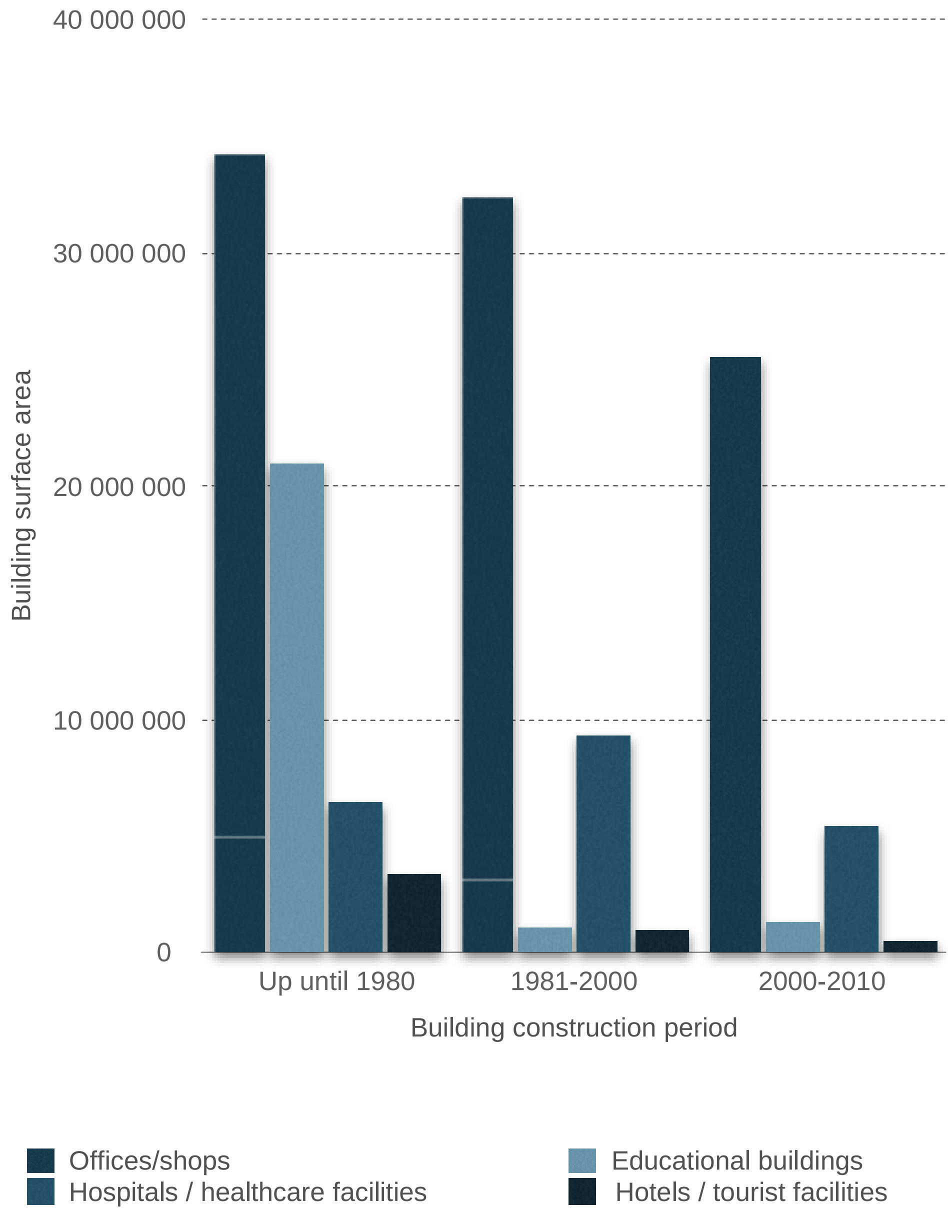
	up until 1980	1981-2000	2000-2010	Total
Single-family residences	133 676 472	73 436 925	50 685 146	257 798 543
Apartments/blocks	74 606 924	65 725 857	60 785 250	201 118 031

Figure 11: Breakdown of residences based on construction period (surface area, m^2) [15]



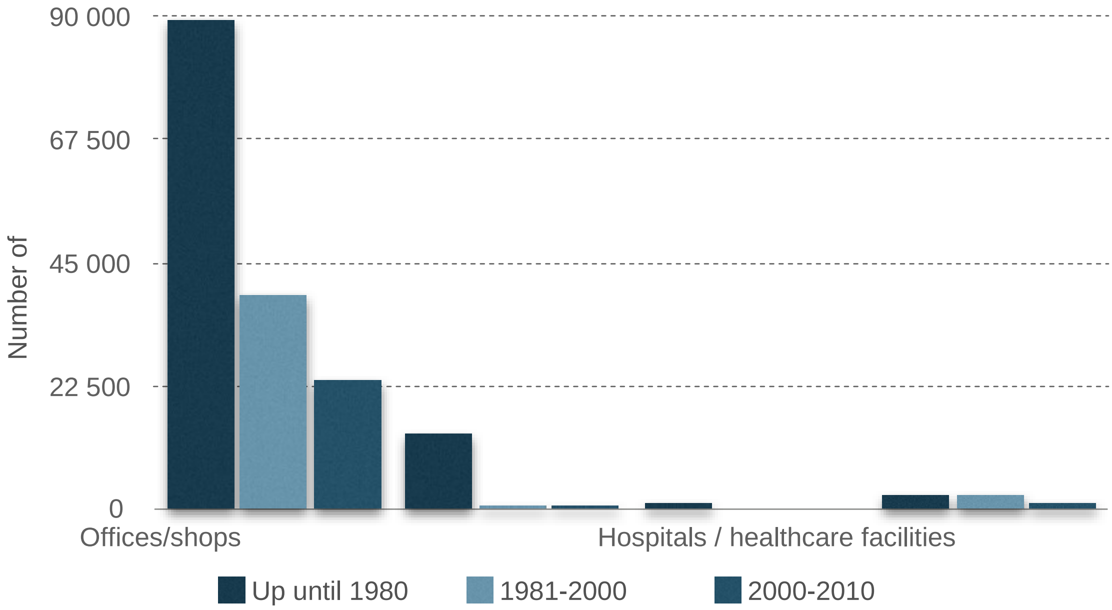
	detached residence	semi-detached residence	block of flats
before 1919	139 270	18 952	5 016
1919-1945	256 942	43 748	16 902
1946-1960	393 987	105 838	104 431
1961-1970	385 796	174 220	440 342
1971-1980	382 443	229 831	820 853
1981-1990	357 608	202 350	486 189
1991-2000	261 589	138 610	403 882
2001-2005	149 230	76 783	311 497
2006 onwards	130 572	58 669	256 971

Figure 12: Breakdown of household residences based on construction period (number of buildings) [16]



	Offices/shops	Educational buildings	Hospitals / healthcare	Hotels / tourist
Up until 1980	34 176 657	20 966 906	6 524 219	3 394 400
1981-2000	32 361 389	1 164 145	9 380 098	1 004 400
2000-2010	25 544 135	1 322 299	5 430 632	580 041

Figure 13: Breakdown of tertiary sector buildings based on construction period (surface area, m^2) [15]



	Offices/shops	Educational buildings	Hospitals / healthcare facilities	Hotels / tourist facilities
Up until 1980	89 352	14 126	1 566	3 015
1981-2000	39 348	700	177	2 58
2000-2010	23 85	750	59	1 214

Figure 14: Breakdown of tertiary sector buildings based on construction period (number of buildings) [15]

Based on the 2011 census (ELSTAT 2014), **55% of residential buildings in Greece were constructed before 1980** and therefore they have no thermal protection and, given the economic recession, the number of buildings constructed after 2010 in compliance with the minimum requirements set out in the Regulation on the energy efficiency of buildings (KENAK) represent only 1.5% of the total stock of typical residences used by households.

Based on a survey conducted in 2009 by the Laboratory of Steam Boilers and Thermal Plants of the School of Mechanical Engineering of National Technical University of Athens entitled ‘Looking into and recording the standards used to describe the energy consumption patterns of Greek families’, the ages of Greek residences are shown in Figure 15 below, with the average age being approximately 25 years:

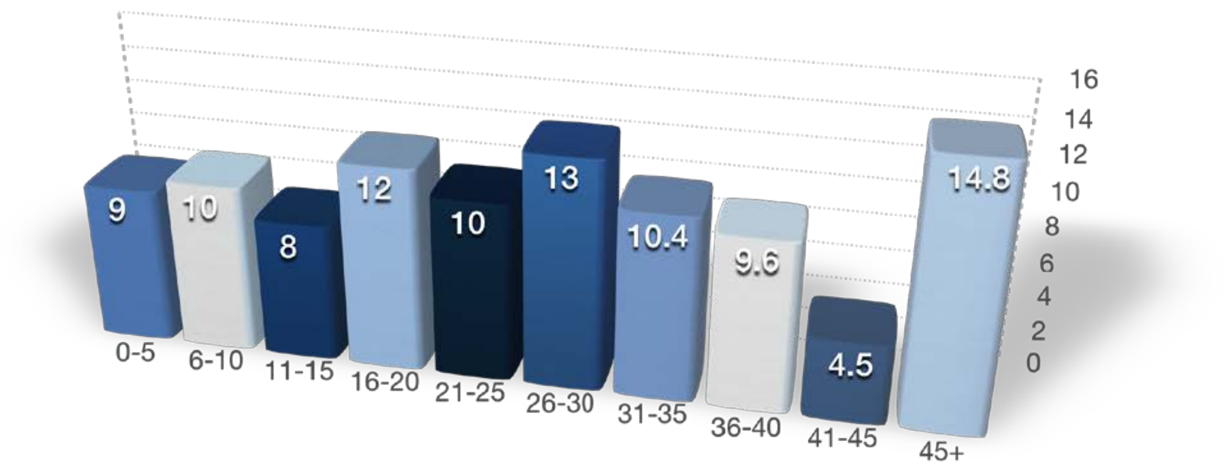


Figure 15: Age of residences

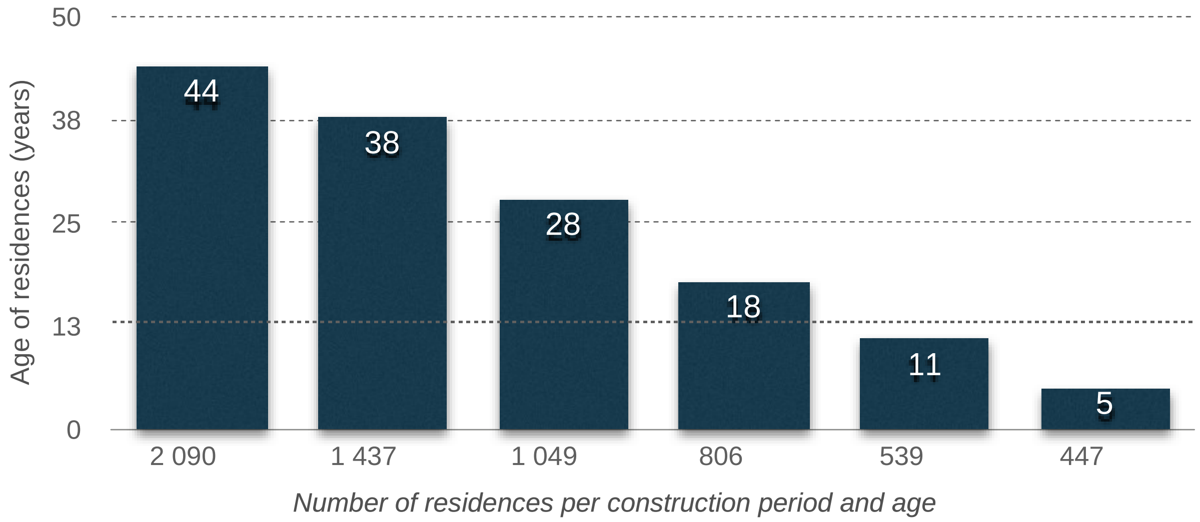
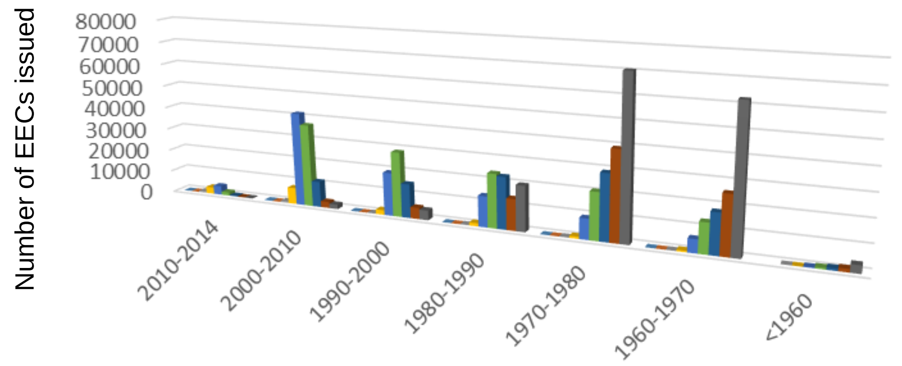


Figure 16: Age of residences [14]

However, the average age of residences, based on the latest 2011 census conducted by ELSTAT [14] is 31 years and is shown in Figure 16.

The link between the construction period of a building and its energy efficiency, given the developments in the legislative framework and technology, is also confirmed by the statistics drawn from the energy efficiency certificates[4] (EECs) issued to so far (approximately 600 000).

Number of EECs per ten-year building construction period and per energy category



	2010-2014	2000-2010	1990-2000	1980-1990	1970-1980	1960-1970	<1960
A+	13	171	5	2	4	6	
A	51	119	20	24	13	12	
B+	595	629	185	159	146	100	3
B	2964	7358	2033	1383	937	612	34
Γ	3996	41652	19193	13630	9151	5921	299
Δ	1471	36830	28727	23794	20801	13278	685
E	331	11522	15071	22881	29034	17841	981
Z	95	2740	5026	13852	39321	25768	1434
H	76	1962	4297	20026	70579	62552	3454

Figure 17: Number of energy efficiency certificates (EECs) per ten-year building construction period and per energy category (MEECC, 2014) [20]

According to Figure 17, in the periods before the entry into force of the Regulation on the thermal insulation of buildings regulation (KTHK) (in 1980), most buildings were rated category H. While the Regulation on the thermal insulation of buildings (KTHK) was in force (1981-2009), buildings started improving gradually, thus being rated category D and C, and the buildings constructed after 2010 were upgraded to categories C and B.

[4] Based on the Regulation on the efficiency of buildings (KENAK), buildings are placed into 9 energy categories A+ to H) depending on their energy efficiency, and the minimum requirement for new buildings and existing ones undergoing major renovation is that they must be in category B.

5.3. CLIMATIC ZONES

For the purpose of calculating the energy efficiency of buildings, the territory of Greece has been broken down into 4 climatic zones (A, B, C and D – from warmest to coldest) based on heating degree days. Figure 18 below shows the 4 climatic zones, as established by the Regulation on the efficiency of buildings (KENAK).

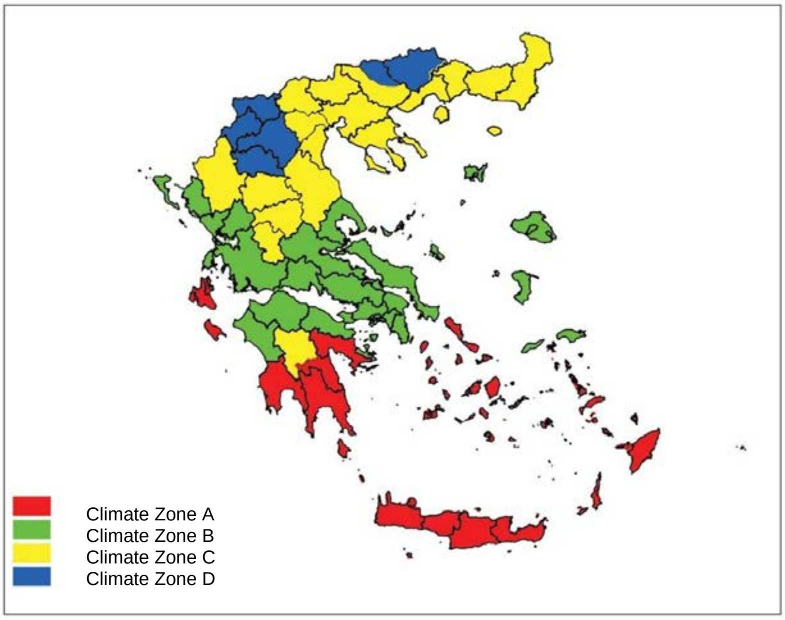
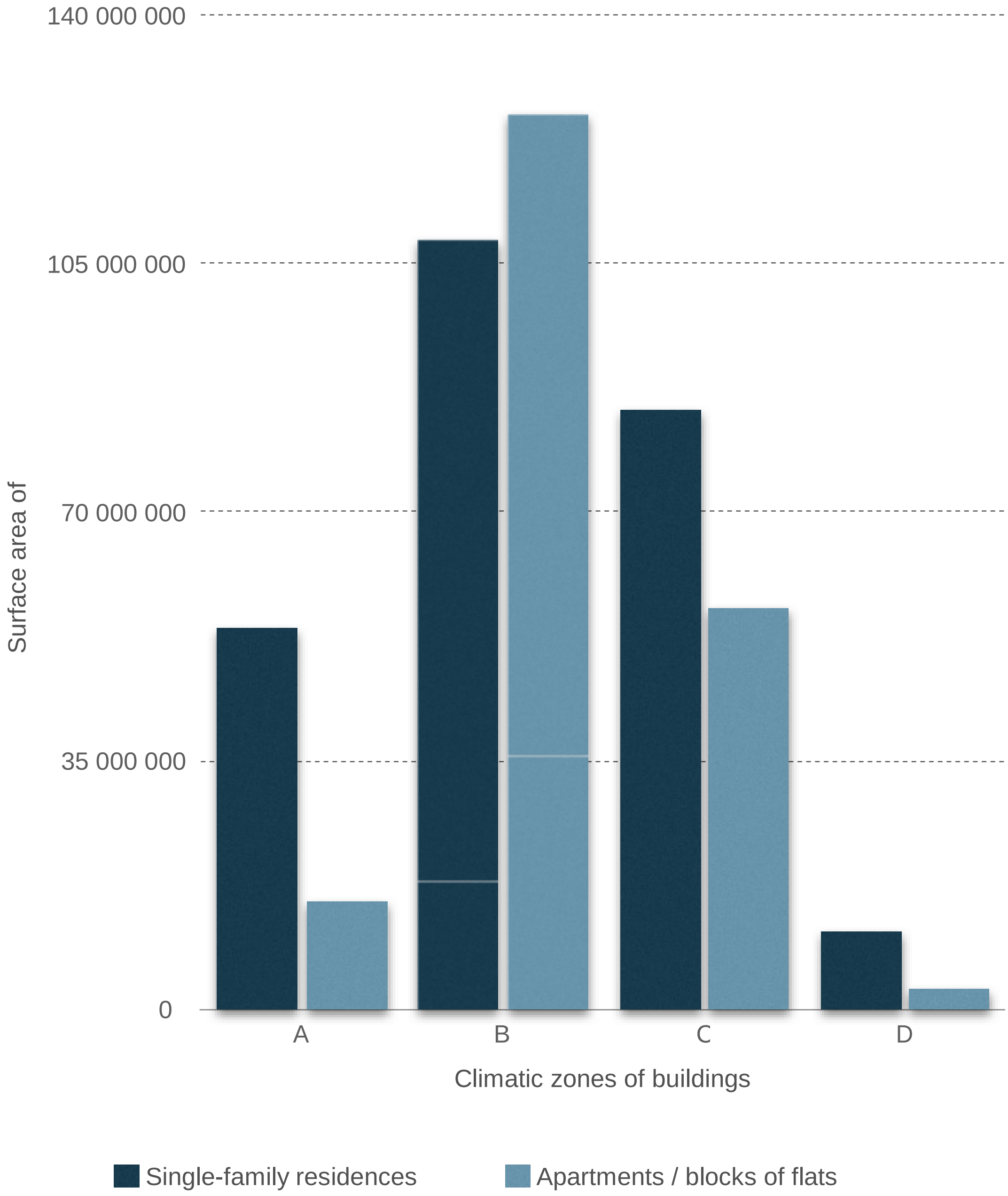


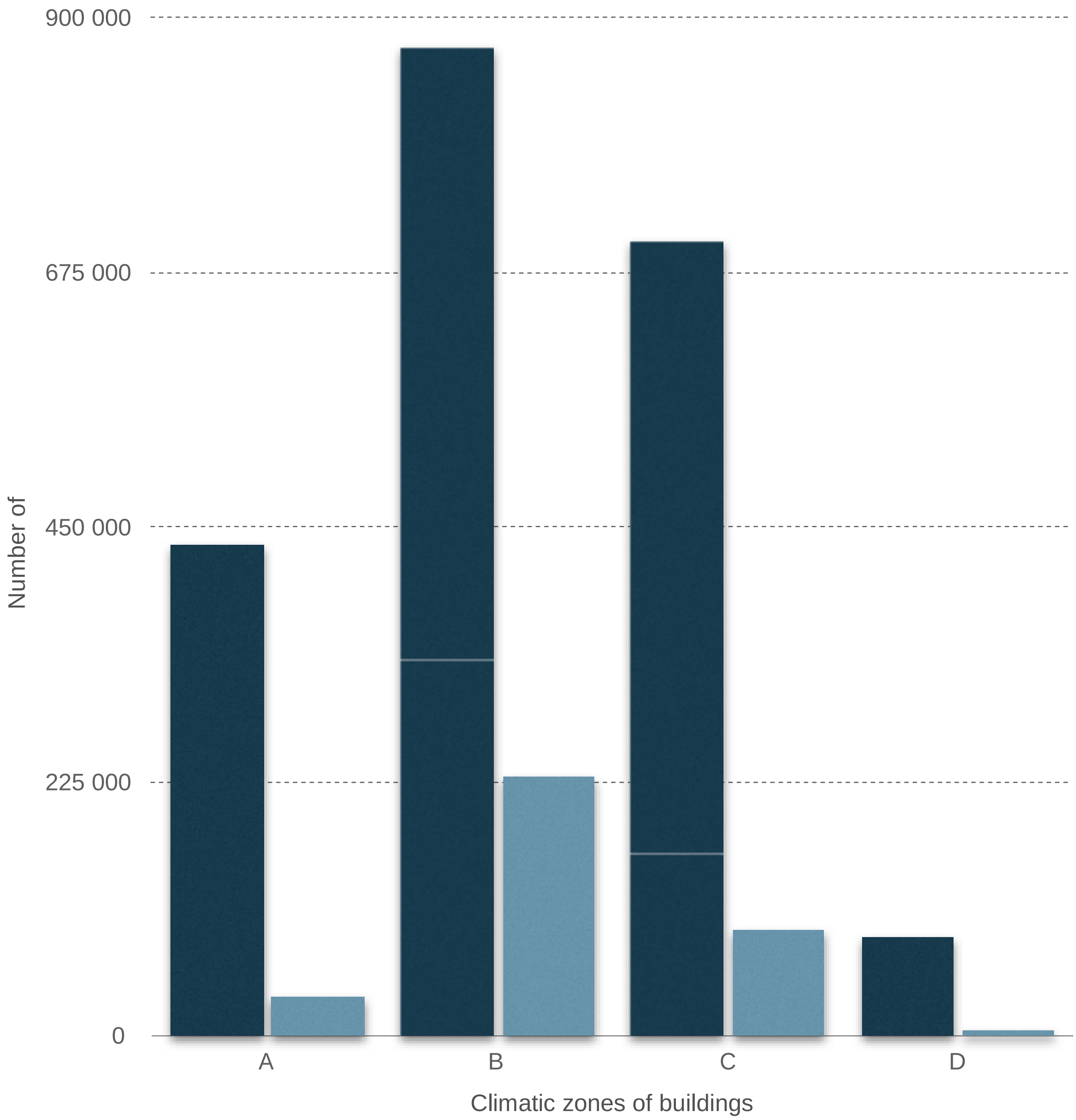
Figure 18: The four climatic zones in Greece, based on the Regulation on the efficiency of buildings (KENAK)[21]

Figures 19 and 20 below show the total recorded surface area of residences (detached residences and blocks of flats) per climatic zone in terms of total surface area. Figures 21 and 22 show the respective breakdown for other buildings.



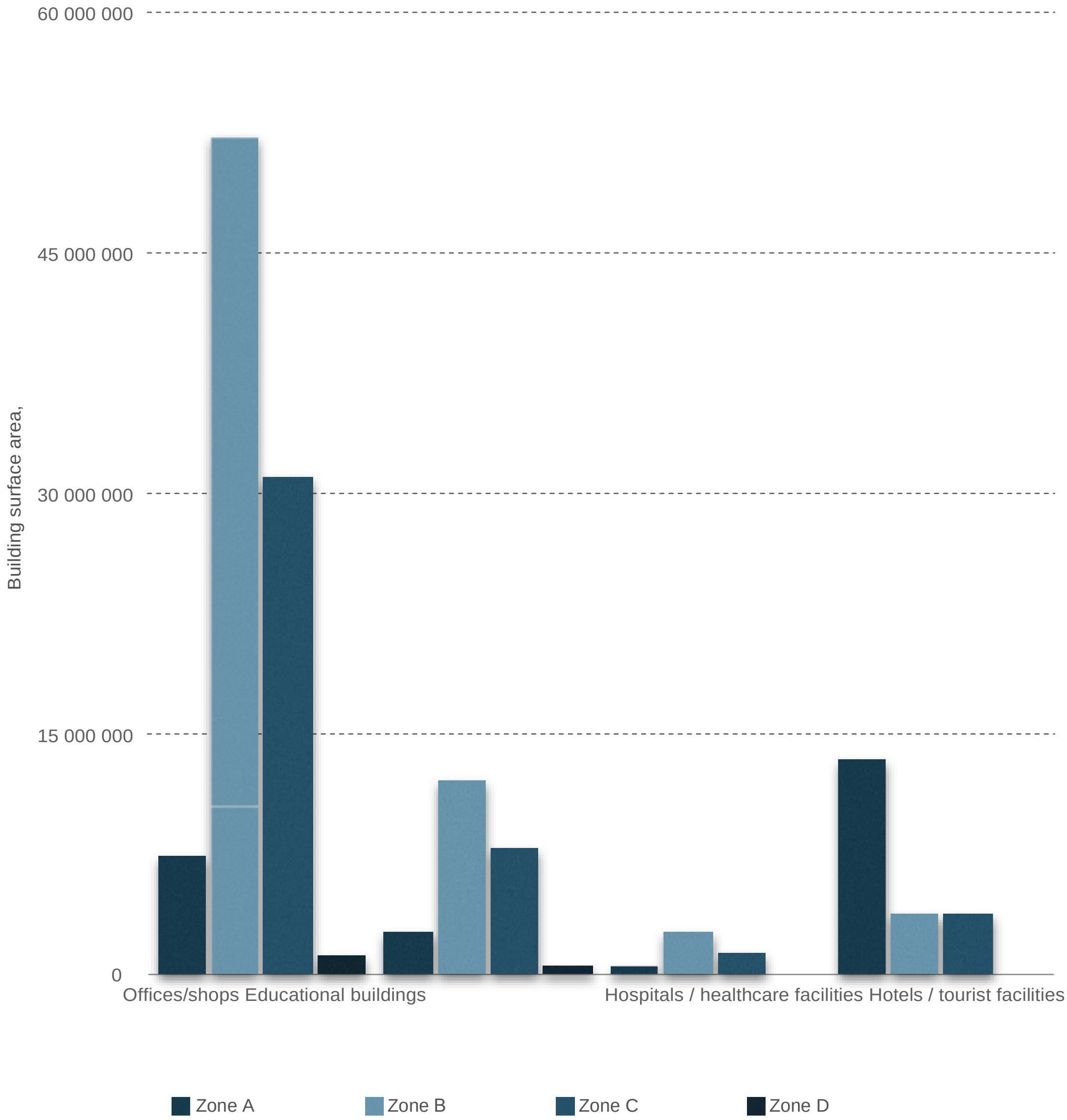
	A	B	C	D
Single-family residences	53 772 359	108 614 398	84 559 451	10 852 335
Apartments / blocks of flats	15 415 882	126 243 020	56 537 733	2 921 396

Figure 19: Breakdown of residences per climatic zone, in terms of surface area (m^2) [15]



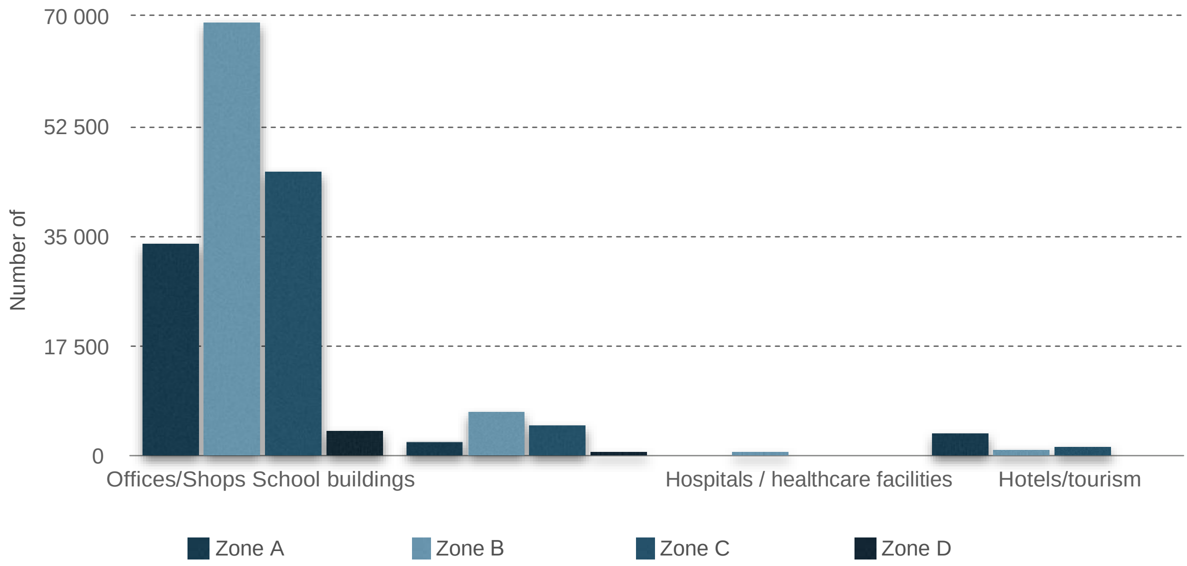
	A	B	C	D
Single-family residences	433 681	873 056	701 706	89 273
Apartments / bloc flats	35 257	230 524	95 373	6 253

Figure 20: Breakdown of residences per climatic zone, in terms of number of buildings [15]



	Offices/shops	Educational buildings	Hospitals / healthcare	Hotels / tourist
Zone A	7 472 079	2 678 480	640 044	13 583 636
Zone B	52 225 915	12 125 699	2 733 553	3 868 963
Zone C	31 168 252	7 976 887	1 495 458	3 854 819
Zone D	1 215 935	672 283	109 786	27 530

Figure 21: Breakdown of tertiary sector buildings per climatic zone, in terms of surface area (m^2) [15]



	Offices/shop s	Educational buildings	Hospitals / healthcare facilities	Hotels / tourist facilities
Zone A	33 785	2 641	325	3 975
Zone B	68 852	7 036	808	1 334
Zone C	45 378	5 236	564	1 470
Zone D	4 124	663	45	12

Figure 22: Breakdown of tertiary sector buildings per climatic zone, in terms of number of buildings [15]

5.4. ENERGY CONSUMPTION OF BUILDINGS

Based on data from EUROSTAT (2014) [1], in 2012 Greek households consumed 5.042 Mtoe (Mtoe: million tons of oil equivalent), compared to 3.058 Mtoe in 1990, which corresponds to a total increase of 64.8% in the consumption of energy. The tertiary sector is the fastest growing sector in terms of energy consumption, as the energy it consumes has almost tripled since 1990, following an average increase trend of 6.7% per year. It consumed 0.652 Mtoe in 1990, but reached 2.233 Mtoe in 2012. It should be stressed that the energy consumption of buildings (residences and tertiary sector buildings) rose by 24% in the period 2000-2005, reaching 8.607 Mtoe, one of the sharpest increase rates in Europe. Besides, based on the 2012 energy balance, energy consumption in the building sector (residential and commercial sector buildings, etc.) in Greece stands at 7 751 ktoe, representing 45% of the total energy consumption, while consumption in the residential sector represents 29%. These data prove firstly the increased significance of the building sector for the energy balance, while also highlighting the huge potential (margin) for reducing the energy consumption of buildings and improving their energy performance.

In the years 2008-2010, however, there was a drop in the consumption of electricity, in the industrial, residential and tertiary sectors in particular, as these were the sectors affected most by the economic recession in terms of energy consumption, which is further decreased on account of the rising prices of heating fuel, electricity, etc.

The energy consumption of commercial buildings is also extremely high and, based on statistics, the energy consumption of offices in Greece is comparatively one of the highest among European countries (ODYSSEE-MURE-2012)[22].

As regards residential buildings in particular, an energy consumption survey was conducted (2011-2012) by the Hellenic Statistical Authority, which found that each household in Greece consumes an average of 10 244 kWh of thermal energy and 3 750 kWh of electricity annually to meet its energy needs (Figure 23).

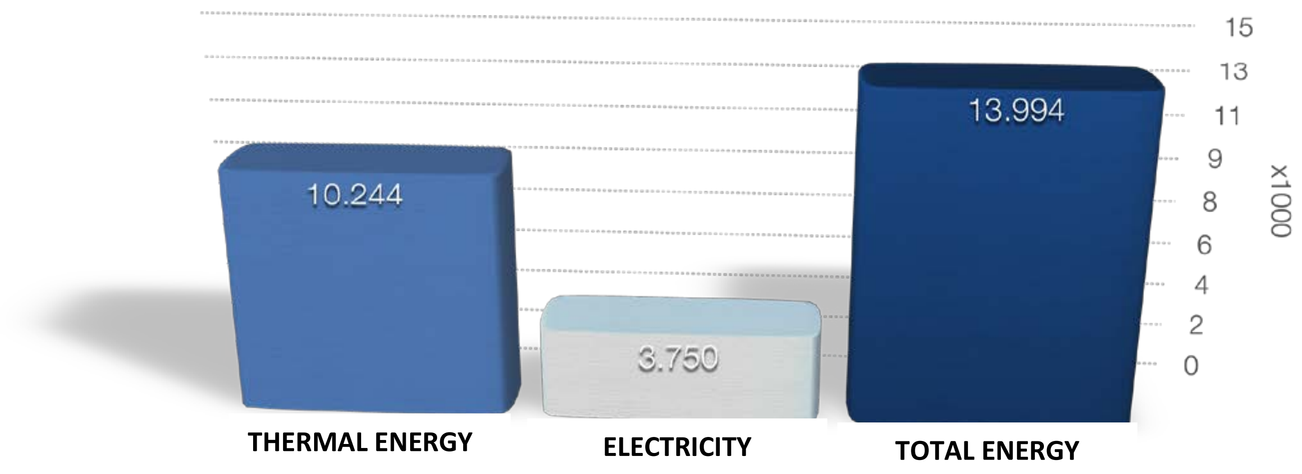
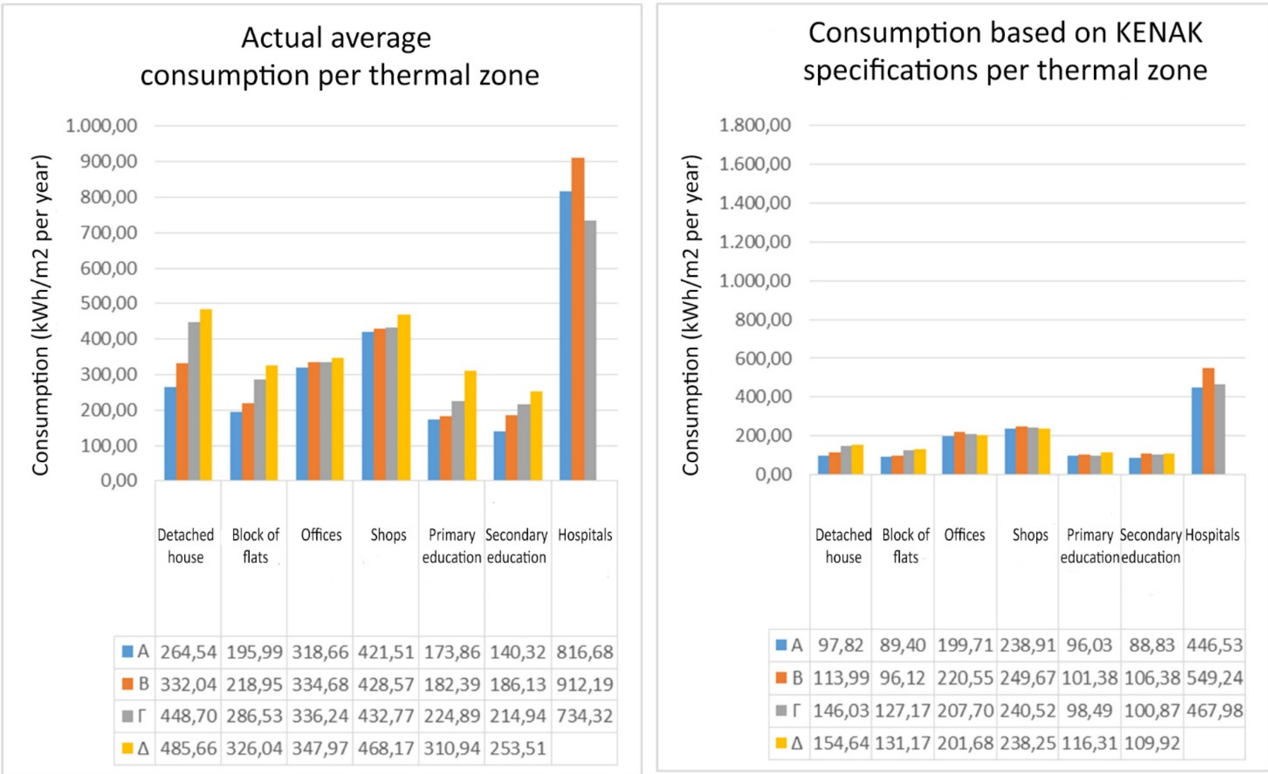


Figure 23: Average annual energy consumption per household 2011-2012 (ELSTAT, 2013) [18]

Also based on the statistics from the energy efficiency certificates (EECs) issued so far, one can identify the different consumption levels for each building use in each climatic zone. In particular, Figure 24 shows the average energy consumption[5] per building use in each climatic zone, as well as the average energy consumption of an equivalent reference building[6] in each climatic zone.



	Detached house	Block of flats	Offices	Shops	Primary education	Secondary education	Hospitals
A	264,54	195,99	318,66	421,51	173,86	140,32	816,68
B	332,04	218,95	334,68	428,57	182,39	186,13	912,19
Γ	448,70	286,53	336,24	432,77	224,89	214,94	734,32
Δ	485,66	326,04	347,97	468,17	310,94	253,51	

	Detached house	Block of flats	Offices	Shops	Primary education	Secondary education	Hospitals
A	97,82	89,40	199,71	238,91	96,03	88,83	446,53
B	113,99	96,12	220,55	249,67	101,38	106,38	549,24
Γ	146,03	127,17	207,70	240,52	98,49	100,87	467,98
Δ	154,64	131,17	201,68	238,25	116,31	109,92	

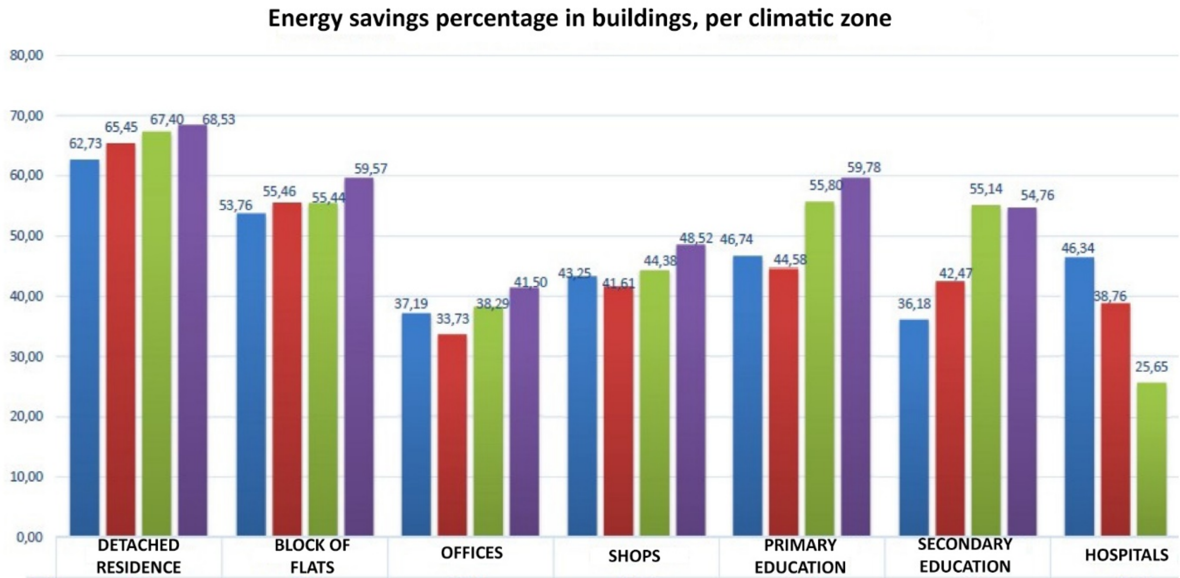
Figure 24: Average consumption per building use and per climatic zone (MEECC, 2014)

Figure 24 above shows that the energy consumption of residences and educational buildings increases in colder zones (due to heating needs), the energy consumption of offices and shops is not affected significantly by the climate zone, and the energy consumption of hospitals and healthcare facilities is higher in warmer zones (due to their need for air conditioning).

5 It should be stressed that the consumption by buildings is theoretical and is calculated based on the features of the buildings
(asset method), not based on how users operate the buildings.

6 A theoretical building with the same geometric characteristics, location, orientation, use and functional features as the building under inspection, which meets the minimum requirements set out in the Regulation on the efficiency of buildings (KENAK) concerning its design, shell and electromechanical installations, which is rated under category B.

A further comparison of the consumption levels of buildings against those of reference buildings helps draw important conclusions on the energy saving potential of the existing building stock (Figure 25).

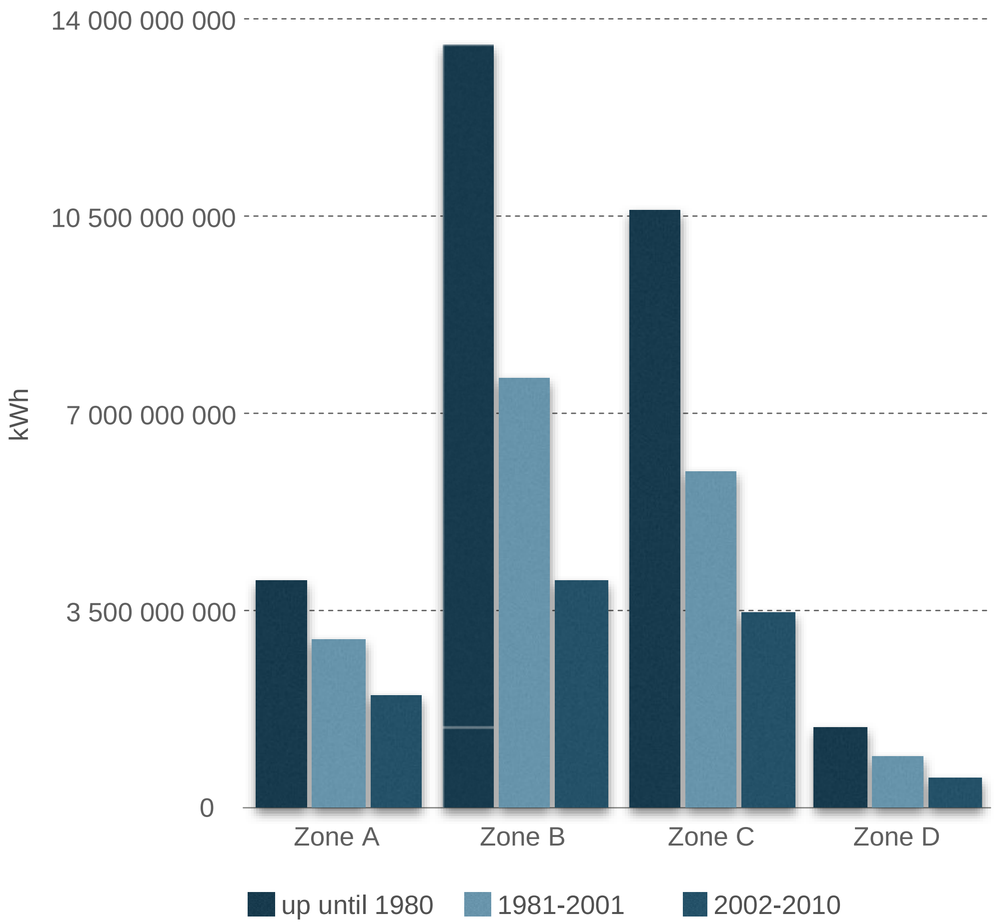


	DETACHED RESIDENCE	BLOCK OF FLATS	OFFICES	SHOPS	PRIMARY EDUCATION	SECONDARY EDUCATION	HOSPITALS
A	62,73	53,76	37,19	43,25	46,74	36,18	46,34
B	65,45	55,46	33,73	41,61	44,58	42,47	38,76
Γ	67,40	55,44	38,29	44,38	55,80	55,14	25,65
Δ	68,53	59,57	41,50	48,52	59,78	54,76	

Figure 25: Energy savings percentage per building use and per climatic zone (MEECC, 2014)

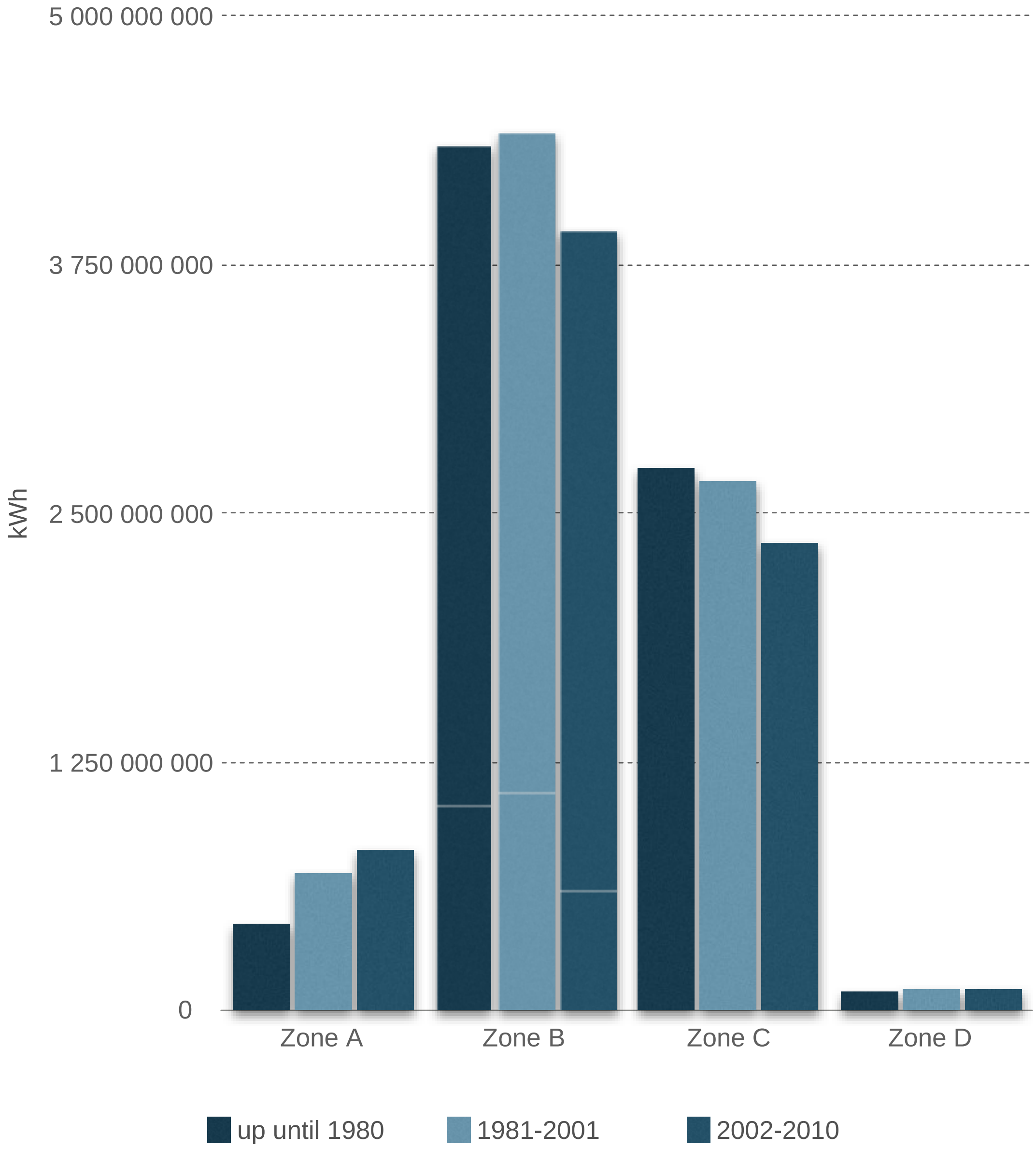
Based on Figure 25, if the building stock was renovated to meet the minimum requirements set out in the Regulation on the efficiency of buildings (KENAK) (energy category B), we would ensure an average energy saving of 66% for detached residences, 56% for blocks of flats, 38% for offices and shops, 48% for educational institutes and 37% for hospitals and healthcare facilities.

Figures 26 to 30 above show the total energy consumption levels for different types of buildings (single-family residences, blocks of flats, offices/shops, educational buildings, hospitals / healthcare facilities and hotels) in the three age categories (before 1980, 1981-2000 and 2001-2010) for all four climatic zones. Annex II includes tables with complete consumption data (thermal energy, electricity and total energy). The data are derived from the research programme TABULA and are based on combining a calculation method (TCG_KENAK) and actual empirical measurements taken in the context of research tasks carried out by the laboratories of educational and research centres.



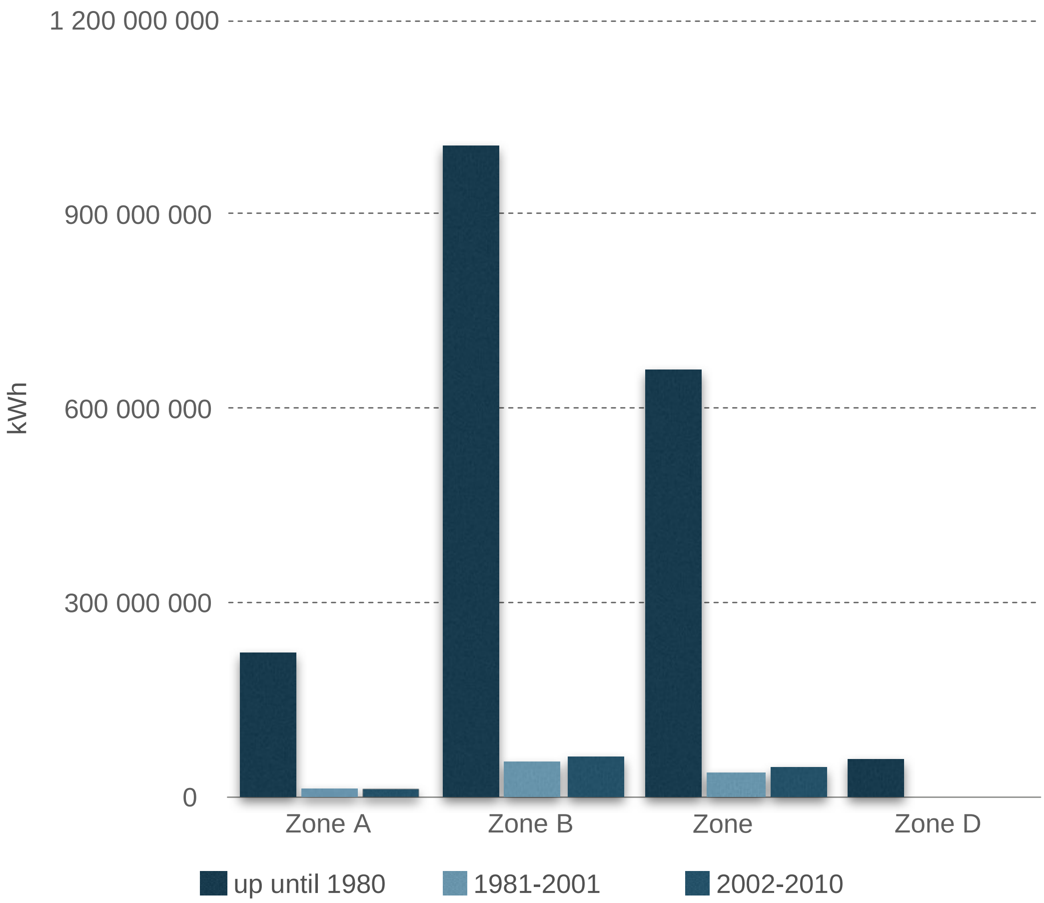
	up until 1980	1981-2001	2002-2010
Zone A	4 049 410 964	3 038 228 360	2 021 880 786
Zone B	13 589 727 642	7 641 030 276	4 077 260 969
Zone C	10 628 887 361	6 016 367 898	3 520 289 308
Zone D	1 450 717 597	935 992 848	585 196 566

Figure 26: Total primary energy consumption per age category and per climatic zone



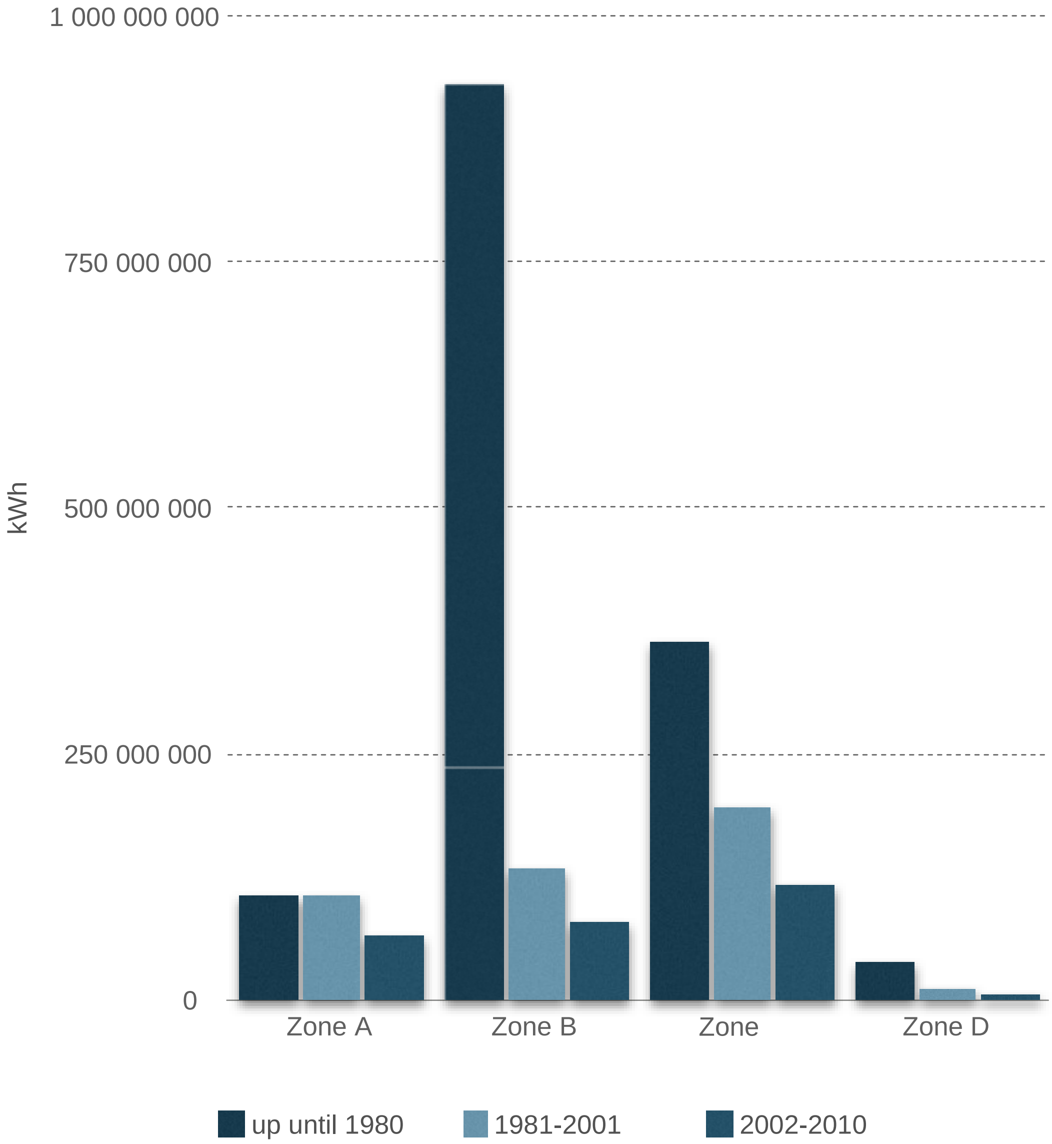
	up until 1980	1981-2001	2002-2010
Zone A	438 147 774	697 426 099	813 432 620
Zone B	4 344 068 085	4 417 123 338	3 925 362 404
Zone C	2 723 505 778	2 668 054 535	2 357 358 245
Zone D	103 167 748	109 448 707	114 131 976

Figure 27: Primary energy consumption of offices/shops per age category and per climatic zone



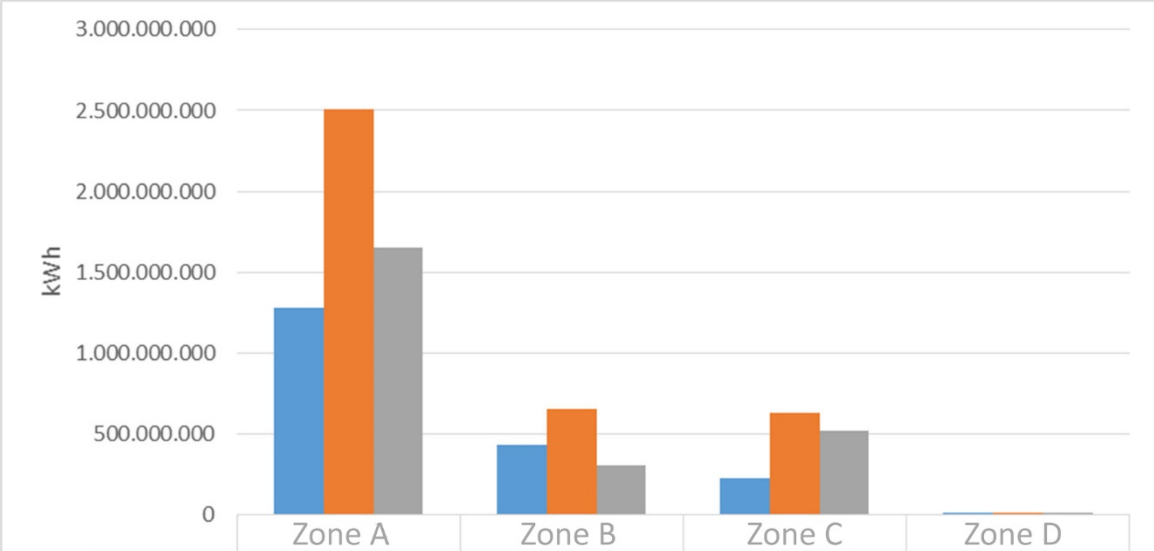
	up until 1980	1981-2001	2002-2010
Zone A	223 002 709	12 012 164	14 482 689
Zone B	1 006 635 843	55 751 456	64 097 176
Zone C	661 729 023	37 883 599	44 293 222
Zone D	60 060 679	3 273 823	3 895 517

Figure 28: Primary energy consumption of educational buildings per age category and per climatic zone



	up until 1980	1981-2001	2002-2010
Zone A	105 787 766	105 514 681	66 020 570
Zone B	930 592 789	133 787 486	79 307 105
Zone C	364 512 868	195 889 326	118 121 942
Zone D	38 104 567	10 758 232	6 381 760

Figure 29: Primary energy consumption of hospitals / healthcare facilities per age category and per climatic zone



	Zone A	Zone B	Zone C	Zone D
up until 1980	1.275.962.734	430.380.931	224.712.416	2.538.344
1981-2001	2.504.994.532	654.268.238	624.878.066	3.903.593
2002-2010	1.653.485.921	305.054.405	520.402.686	2.860.319

Figure 30: Primary energy consumption of hotels per age category and per climatic zone

5.5. OWNERSHIP OF BUILDINGS

Another important parameter that needs to be taken into account, as it affects the decision to be made concerning the renovation of a building, is how the building is used by its owner or lessee.

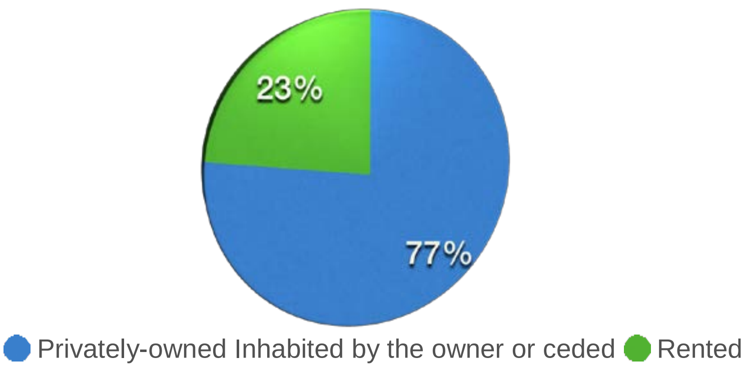


Figure 31: Ownership status of properties in Greece based on user (owner or lessee) [24]

Figure 31 confirms the large percentage of buildings inhabited-used by their owners, as only 23% of the buildings are rented [24]. This parameter is very important and is deemed to constitute a deterrent to the implementation of interventions. Besides, it is to that end that Directive 2012/27/EU on energy efficiency requires that Member States should remove such barriers by the use of appropriate, mainly institutional, incentives.

5.6. URBANISATION OF BUILDINGS

Buildings can be rated on a case-by-case basis depending on location, i.e. whether they are located in an urban or rural environment, as the consumption of energy is directly affected by the level of urbanisation of the area in which a building is located. As regards households in particular, an analysis of the energy consumed per level of urbanisation led to the conclusion that households in urban areas consume more energy and, to a certain degree, heating oil, compared to those in rural areas, where the use of fuel wood is higher.

Based on a survey conducted in 2009 by the Laboratory of Steam Boilers and Thermal Plants of the School of Mechanical Engineering of National Technical University of Athens entitled ‘Looking into and recording the standards used to describe the energy consumption patterns of Greek families’, 74% of the residences are located in urban areas and 26% are located in rural areas.

Figures 32 and 33 also show a breakdown of the final use of energy and of the fuel types for households based on the level of urbanisation, as recorded in the energy consumption survey (2011-2012) conducted by the Hellenic Statistical Authority [18].

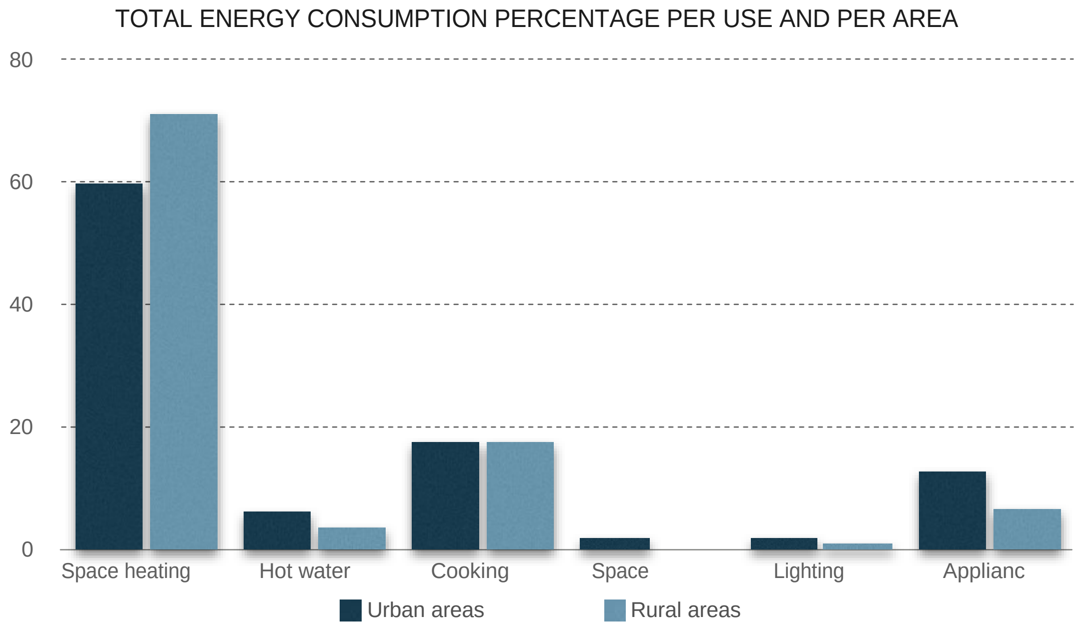


Figure 32: Percentage breakdown of the total energy consumption of households per end use and degree of urbanisation [18]

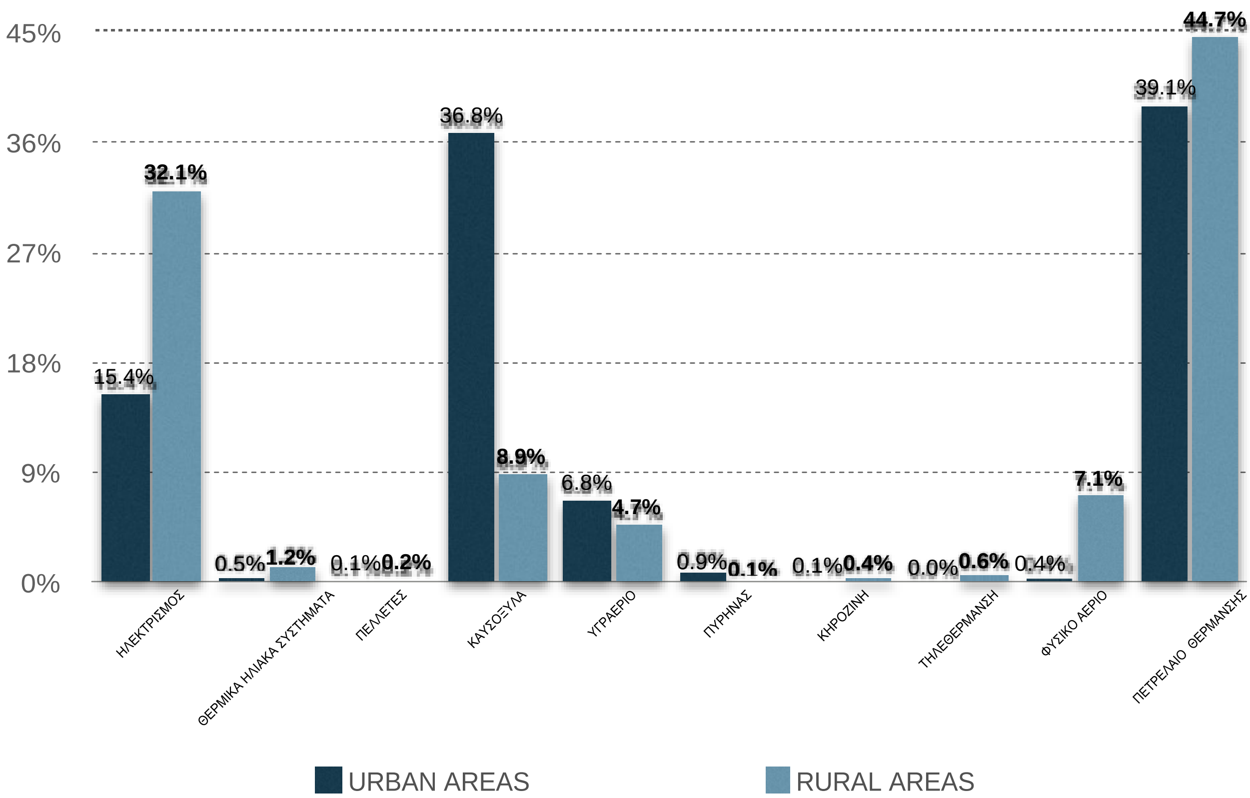


Figure 33: Percentage breakdown of the total energy consumption of households per fuel type and degree of urbanisation [18]

5.7. ENERGY CHARACTERISTICS OF BUILDINGS

Based on the results of the energy consumption survey (2011-2012) conducted by the Hellenic Statistical Authority [18], a breakdown of the average annual total energy consumption per type of fuel used and per type of use was determined (Tables 3 and 4).

Heating oil	44.1
Natural gas	5.4
District heating	0.5
Kerosene	0.3
Olive kernels	0.3
LPG	1.8
Fuel wood	17.4
Wood pellets	0.5
Thermal energy (from thermal solar systems)	2.9
Electricity	26.8
Total	100.0

Table 3: Percentage breakdown of the total energy consumption of households per fuel type used [18]

Space heating	63.7
Hot water production	5.7
Cooking	17.3
Space cooling	1.3
Lighting	1.7
Appliances (electric and electronic)	10.2
Total	100.0

Table 4: Percentage breakdown of the total energy consumption of households per end use [18]

As regards thermal energy, 85.9% is consumed for heating purposes in residences, 9.7% is consumed for cooking and 4.4% is consumed for the production of hot water, and the average annual consumption of thermal energy per fuel type is shown in Figure 34:

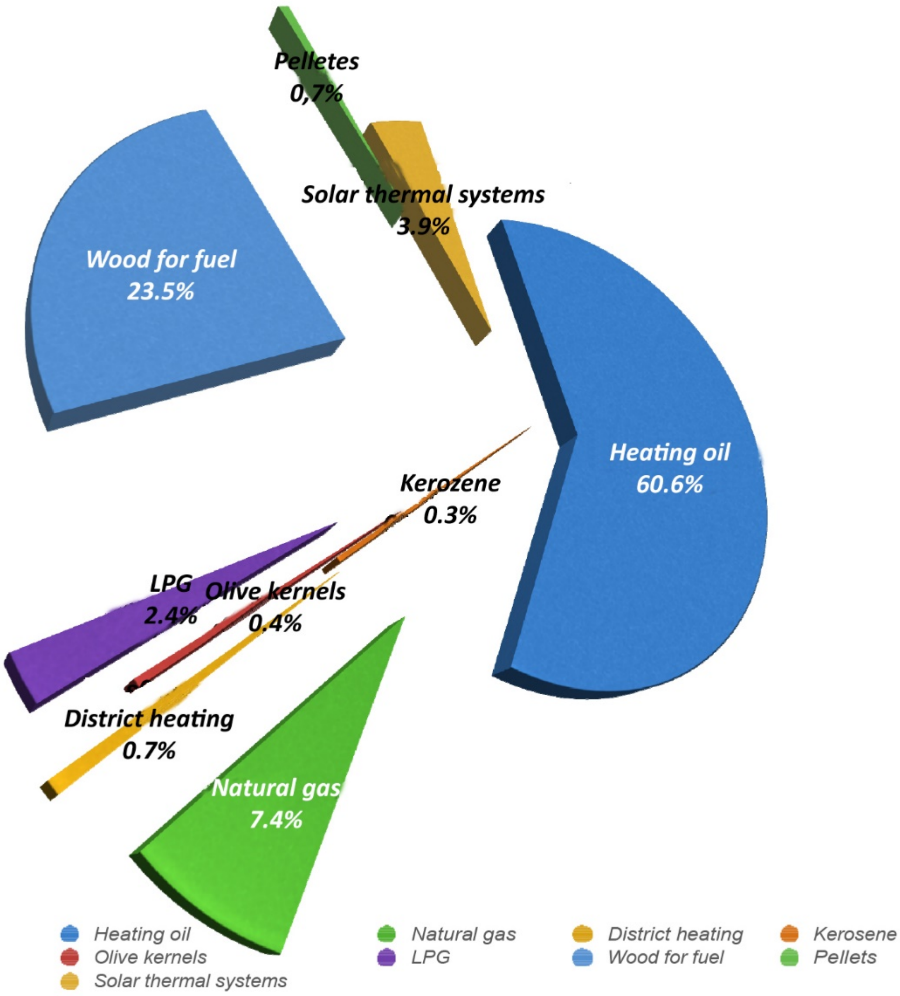


Figure 34: Percentage breakdown of thermal energy consumption of households per fuel type [18]

Based on the survey results, the fuel type used most extensively to generate thermal energy is oil (60.3%), followed by wood for fuel (12.4%). The use of natural gas is still limited (7.4%). In particular, Table 5 below lists information on the heating modalities used by households.

<table>
<tr><th></th><th>2004</th><th>2008</th><th>2009</th><th>2010</th><th colspan="2">2012</th></tr>
<tr><td>Central heating</td><td>68.8</td><td>68.2</td><td>66.9</td><td>65.9</td><td>60.3</td><td rowspan="2">63.8</td></tr>
<tr><td>Diesel heater</td><td>8.3</td><td>5.3</td><td>5.2</td><td>5.0</td><td>3.5</td></tr>
<tr><td>Gas heating</td><td>0.7</td><td>5.0</td><td>6.6</td><td>7.2</td><td>7.4</td><td rowspan="2">8.7</td></tr>
<tr><td>LGP heater</td><td>1.4</td><td>0.6</td><td>0.8</td><td>1.4</td><td>1.3</td></tr>
<tr><td>Storage heater</td><td>2.8</td><td>2.8</td><td>2.7</td><td>2.6</td><td colspan="2" rowspan="3">12.4</td></tr>
<tr><td>Electrical appliances</td><td>4.4</td><td>4.4</td><td>4.7</td><td>4.7</td></tr>
<tr><td>Air conditioners</td><td>3.2</td><td>4.0</td><td>4.3</td><td>4.8</td></tr>
<tr><td>Wood-biomass heater</td><td>6.9</td><td>6.1</td><td>5.9</td><td>5.4</td><td colspan="2">12</td></tr>
<tr><td>Other</td><td>3.06</td><td>2.6</td><td>3.2</td><td>2.3</td><td colspan="2">2.5</td></tr>
<tr><td>No heating</td><td>0.5</td><td>0.4</td><td>0.4</td><td>0.5</td><td colspan="2">0.6</td></tr>
</table>

Table 5: Residential heating modes [18]

In respect of electricity, as shown in Figure 35, an average 38.4% of the total electricity consumed by a household is for cooking, 14.7% is for the fridge, 10.6% is for the washing machine, and only 6.6% and 4.9% are for lighting and cooling in the residence, respectively.

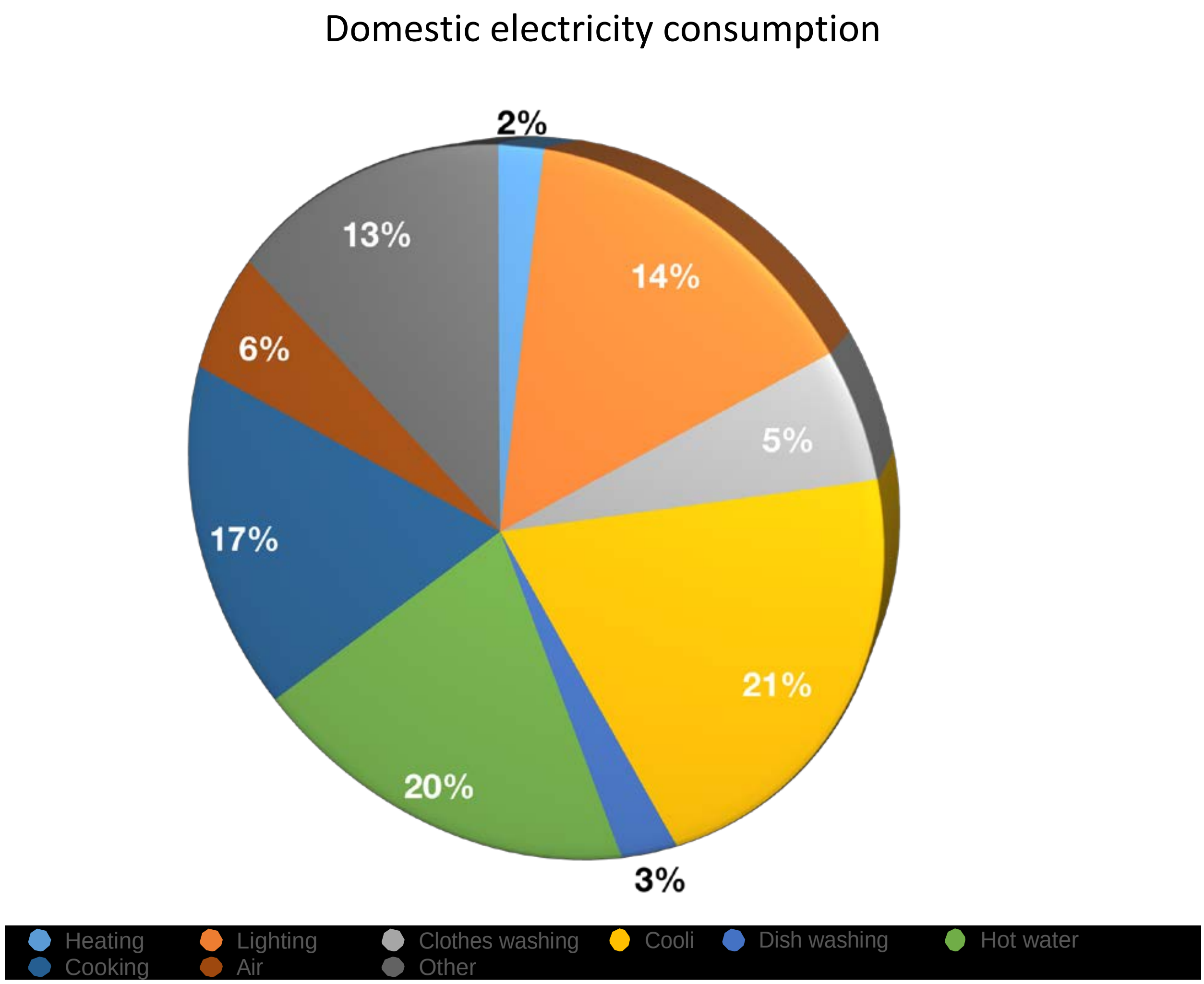


Figure 35: Percentage breakdown of electricity consumption per end use [18]

Some very important conclusions were reached based on the above survey and on statistics from other studies and surveys, concerning the energy characteristics of Greek households:

- 50% of residences have thermal insulation.
- 98.9% of residences have a heating system/equipment.
- 50.8% of households use a central heating system, 48.6% use an independent (standalone) heating system and 0.6% use district heating.
- The fuel used for the main heating system in residences is:
    - heating oil in 63.8% of the residences;
    - electricity in 12.4% of the residences;

- biomass (fuel wood, pellets, briquettes, agricultural and forestry residues) in 12.0%
- of the residences; and
- natural gas in 8.7% of the residences.

- 33% of households use a complementary system too, in addition to the main heating system, that is:
  - a fireplace in 32.3% of residences;
  - independent air conditioning units in 28.2% of residences;
  - portable electrical appliances (electrical heater, electrical air heater, etc.) in 26.5% of residences;
- 98.6% of households have a system/equipment for producing hot water, as follows:
  - 74.5% of households use an electrical water heater;
  - 37.6% of households use a solar water heater;
  - 25.2% of households use a system connected to the central heating system (boiler).
- 60% of households use some cooling system in the warm months of the year, as follows:
  - 99.7% of residences use independent air conditioning units;
  - 0.3% of residences use central cooling systems.

Table 6 below lists the characteristics of the shells of residential buildings (U-value: $kWh/m^2.K$, etc.) as determined from existing structures and based on weighted averages:

	Detached			Apartments / blocks of flats		
	-1980	1980-2000	2000-	-1980	1980-2000	2000-2010
CLIMATIC ZONE A						
WALL U-values	2.36	1.28	1.01	2.13	1.11	0.81
ROOF U-values	3.12	1.68	0.91	2.96	1.33	0.72
FLOOR U-values	3.07	2.95	2.94	3.07	2.21	2.08
WINDOWS U-values	4.89	4.82	3.33	5.14	4.88	4.40
WINDOWS g-values	0.60	0.57	0.54	0.62	0.58	0.55
CLIMATIC ZONE B						
WALL U-values	2.02	0.96	0.86	2.06	1.09	0.75
ROOF U-values	2.72	1.09	0.70	2.85	1.28	0.62
FLOOR U-values	2.60	2.02	1.93	2.13	1.52	1.00
WINDOWS U-values	4.71	4.51	3.33	4.99	4.25	3.55
WINDOWS g-values	0.59	0.56	0.54	0.61	0.51	0.55
CLIMATIC ZONE C						
WALL U-values	2.02	0.96	0.86	2.06	1.09	0.75
ROOF U-values	2.72	1.09	0.70	2.85	1.28	0.62
FLOOR U-values	2.28	1.01	0.79	2.68	1.21	0.74
WINDOWS U-values	4.71	4.51	3.33	4.99	4.25	3.55
WINDOWS g-values	0.59	0.56	0.54	0.61	0.51	0.55
CLIMATIC ZONE D						
WALL U-values	2.61	1.02	0.86	2.00	1.02	0.75

ROOF U-values	3.06	1.15	0.71	2.76	1.20	0.62
FLOOR U-values	2.47	1.00	0.79	2.10	1.06	0.66
WINDOWS U-values	4.63	4.33	3.33	4.92	4.52	3.53
WINDOWS g-values	0.60	0.56	0.54	0.61	0.56	0.55

Table 6 : Construction characteristics of residential buildings [26]

It should be noted that there are no sufficient available data on the energy characteristics of other types of buildings and, therefore, it was deemed appropriate not to proceed with a further analysis of them.

6. ENERGY RENOVATION SCENARIOS

6.1. COST-OPTIMAL RENOVATION SCENARIOS

Pursuant to Article 5 of Law 4122/2013 (Government Gazette, Series I, No 42) on the energy performance of buildings – transposition in Greek legislation of Directive 2010/31/EU of the European Parliament and of the Council, and other provisions, which transposed Directive 2010/31/EU on the energy performance of buildings into national legislation, it is necessary to prepare a report to calculate cost-optimal levels of minimum energy performance requirements for buildings and building elements. The results of the report will, *inter alia,* set out the energy interventions that can be implemented in a building, combined with a cost-benefit analysis, to determine the cost-optimal energy performance interventions. The report is currently being prepared and, therefore, its results are not yet available to assess the assumptions and analyse the scenarios for the strategy's cost-optimal renovations.

Based on a significant number of surveys conducted and on practice in the renovation market, a number of energy-saving measures have been recorded in the existing building stock relating to the building shell, electromechanical heating and cooling systems, hot water systems, etc. The most important energy-saving measures are listed in Table 7 below:

No	Energy-saving measures in the building stock	Savings percentage (%)	
		Thermal energy	Electricity
1	Exterior wall thermal insulation	33-60	
2	Thermal insulation on roofs - floors	2-14	
3	Restoration of glazed units (windows, doors and frames)	14-20	
4	Maintenance of central heating systems	10-12	
5	Installation of new high-efficiency, oil-fired central heating systems	Up to 17	
6	Installation of a gas-fired central heating system	up to	
7	Installation of compensating thermostats	3-6	
8	Installation of space thermostats	3-6	
9	Installation of external shading	10-20	

No	Energy-saving measures in the building stock	Savings percentage (%)	
		Thermal energy	Electricity
10	Installation of ceiling fans		Up to 60
11	Night ventilation		Up to 10
12	Installation of solar collectors for hot water		50-80
13	Installation of high-efficiency lighting systems		Up to 60
14	Installation of a building management system (BMS)	Up to	Up to 30
15	Airtightness	16-21	
16	Replacement of air conditioners with high-efficiency heat pumps		65-75
17	Use of geothermal pumps	Up to	
18	Installation of a planted roof	Up to	Up to 30
19	Use of cool materials	Up to	

Table 7: Energy-saving measures for the building stock in Greece (Gaglia et al., 2010, LSEA&EO of the Technological Education Institute of Piraeus, 2012, 2013, 2014 [25], [26], [27], [28])

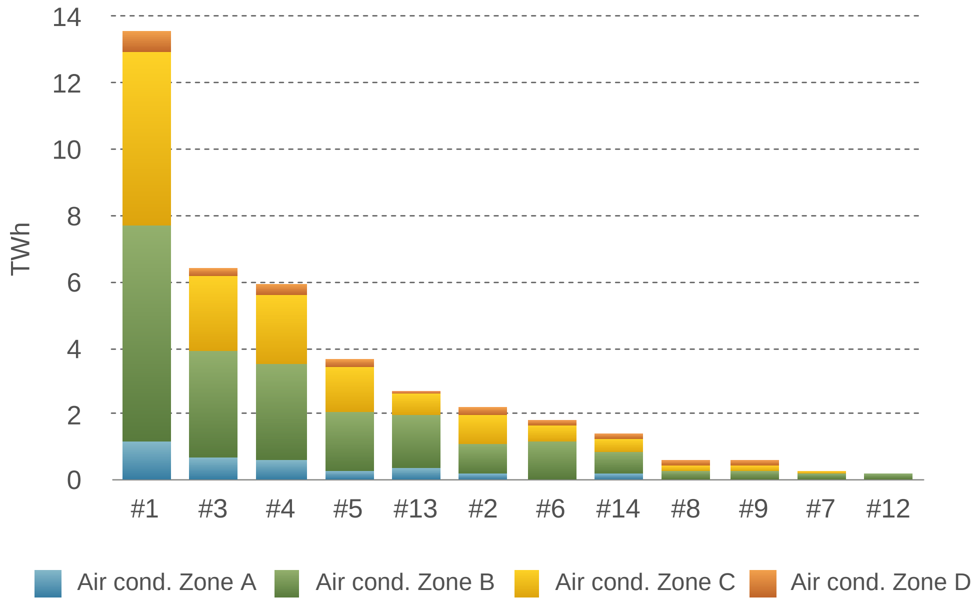
The measures are implemented depending on the type of building and account must be taken of the maximum energy savings possible based on cost. Naturally, there are other parameters too (locally produced or imported products, increase in jobs, etc.) which must be taken into account in drawing up an overall strategy for implementing energy-saving measures. The critical choices that need to be considered relate primarily to the following energy-saving measures:

- External insulation of opaque structural elements according to the specifications set out in the Regulation on the efficiency of buildings (KENAK), to prevent loss in the first place.
- Replacement of single glazing with other glazing complying with high thermal insulation specifications and with low thermal emissivity (low-e).
- Replacement of window and door frames with energy-efficient ones, fitted with a thermal break system,

  according to the specifications set out in the Regulation on the efficiency of buildings (KENAK).
- Use of solar thermal systems to produce hot water (instead of electrical water heaters).
- Redesigning of the heating system and installation of a high-efficiency boiler based on a new thermal loss study.
- Redesigning of the lighting system and installation of high energy efficiency lighting systems utilising natural light too (in tertiary sector buildings in particular).

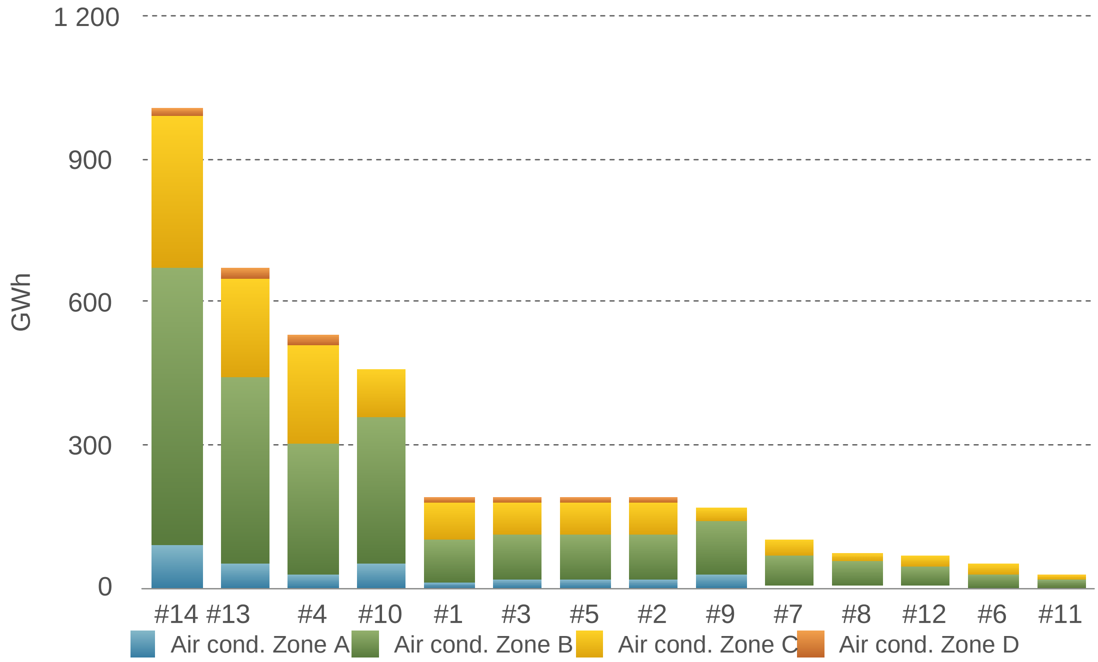
- Use of BMS systems to ensure better functioning of building installations (mainly in office buildings, shops and tertiary sector buildings in general).
- Installation of cool materials on the terrace and in the yard (if any), to mitigate the urban heat island effect.

Figures 36 to 40 below show the total energy-saving potential based on the most appropriate measures per building use category and per climatic zone for the entire building stock. It should be stressed, however, that the approach used is based on the existing practice and on references, instead of the cost-optimal energy saving measures methodology.



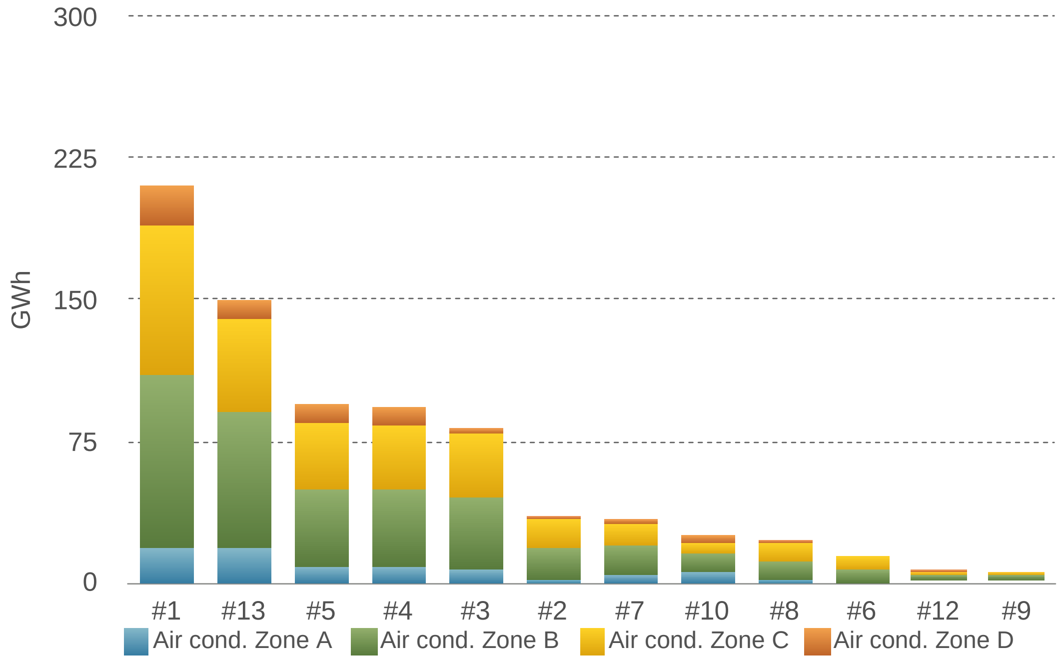
	Air cond. Zone A	Air cond. Zone B	Air cond. Zone C	Air cond. Zone D
#1	1.2	6.5	5.2	0.7
#3	0.7	3.2	2.3	0.2
#4	0.6	2.9	2.1	0.3
#5	0.3	1.8	1.3	0.3
#13	0.4	1.6	0.6	0.1
#2	0.2	0.9	0.9	0.2
#6	0.1	1.1	0.5	0.1
#14	0.2	0.7	0.4	0.1
#8	0	0.3	0.2	0.1
#9	0	0.3	0.2	0.1
#7	0	0.2	0.1	0
#12	0.05	0.2	0.02	0

Figure 36: Assessment of the energy savings per energy-saving measure for all buildings used for residential purposes [15], [22], [25]



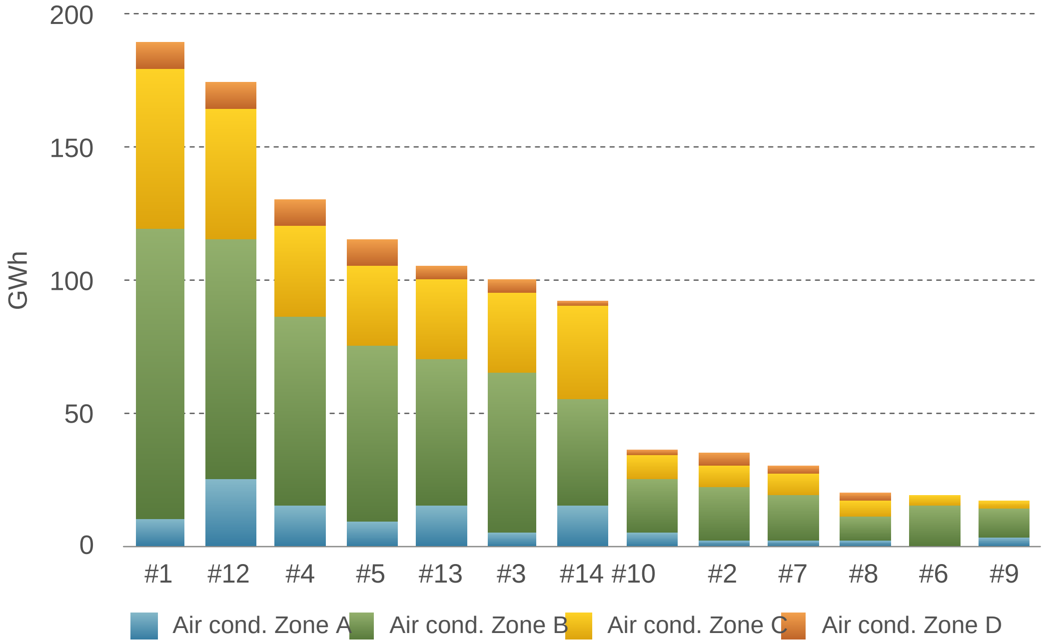
	Air cond. Zone A	Air cond. Zone B	Air cond. Zone C	Air cond. Zone D
#14	90	580	320	20
#13	50	390	210	20
#4	30	270	210	20
#10	50	310	100	2
#1	10	90	80	10
#3	20	90	70	10
#5	20	90	70	10
#2	20	90	70	10
#9	30	110	30	0
#7	5	65	30	0
#8	5	50	20	0
#12	5	40	20	0
#6	0	30	20	0
#11	0	20	10	0

Figure 37: Assessment of energy savings per energy-saving measure for buildings used as offices and shops [15], [22], [25]



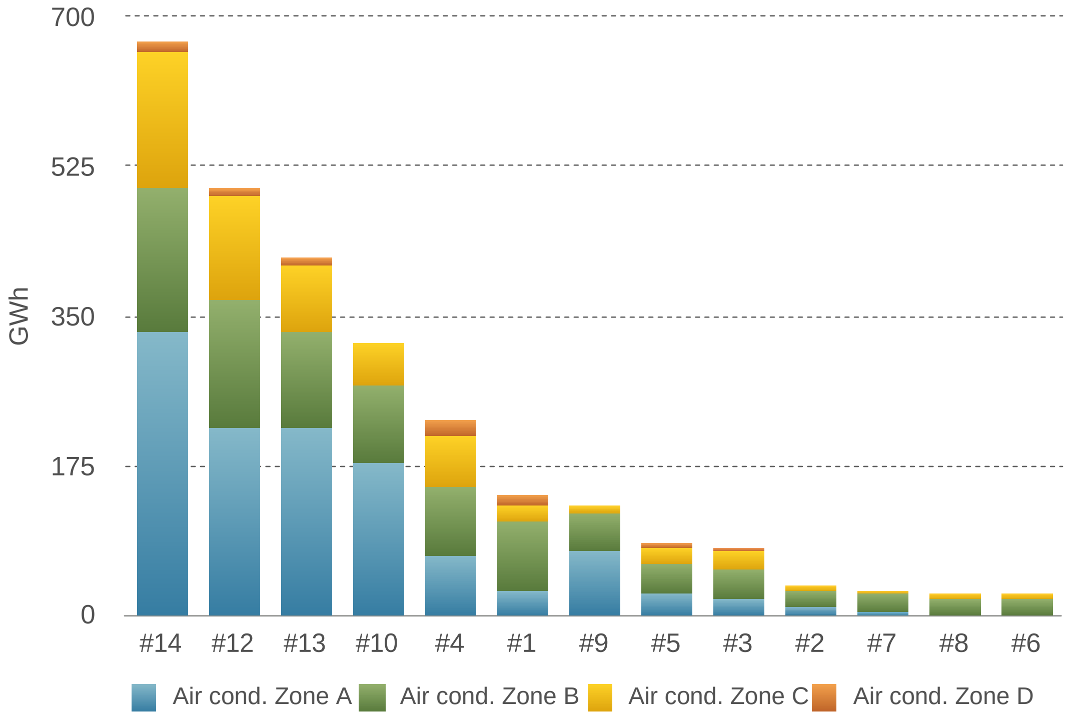
	Air cond. Zone A	Air cond. Zone B	Air cond. Zone C	Air cond. Zone D
#1	18	92	80	20
#13	18	72	50	10
#5	9	41	35	10
#4	9	41	34	10
#3	7	39	34	2
#2	2	16	16	2
#7	4	16	12	2
#10	5.5	10.5	6	3
#8	2	10	10	1
#6	0	8	6	0
#12	1	3	2	1
#9	1	4	1	0

Figure 38: Assessment of energy savings per energy-saving measure for educational buildings [15], [22], [25]



	Air cond. Zone A	Air cond. Zone B	Air cond. Zone C	Air cond. Zone D
#1	10	110	60	10
#12	25	90	50	10
#4	15	71	35	10
#5	9	66	30	10
#13	15	55	30	5
#3	5	60	30	5
#14	15	40	35	2
#10	5	20	9	2
#2	2	20	8	5
#7	2	17	8	3
#8	2	9	6	3
#6	0	15	4	0
#9	3	11	3	0

Figure 39: Assessment of energy savings per energy-saving measure for buildings used as hospitals [15], [22], [25]



	Air cond. Zone A	Air cond. Zone B	Air cond. Zone C	Air cond. Zone D
#14	330	170	160	10
#12	220	150	120	10
#13	220	110	80	10
#10	180	90	50	0
#4	70	80	60	20
#1	30	80	20	10
#9	75	45	10	0
#5	25	35	20	5
#3	20	35	20	5
#2	10	20	5	0
#7	5	20	5	0
#8	0	20	5	0
#6	0	20	5	0

Figure 40: Assessment of energy savings per energy-saving measure for hotels [15], [22], [25]

Based on the above, specific sets of measures can be determined to achieve significant energy savings at least in compliance with the energy performance requirements in force for new buildings of the same category, as described in the different types of renovation.

It is also important to stress the energy savings which can be achieved by the use of passive systems and through application of bioclimatic design principles._The new buildings designed according to the specifications set out in the Regulation on the efficiency of buildings (KENAK) must incorporate at least one passive solar system, such as direct solar gains (southern openings), mass wall, Trombe wall, sun room (greenhouse) etc.

6.2. USE OF RENEWABLE ENERGY SOURCES (RES)

The RES Action Plan has estimated the share of RES in the building sector by 2020, as set out in Table 8 below [55].

Percentage (%)	2005	2010	2015	2020
Residential sector	15	17	22	27
Tertiary sector	10	14	27	39
Industrial sector	-	-	-	-
Total	14	16	24	30

Table 8: Estimated share of RES in the building sector (RES Action Plan [55])

It should also be noted that, pursuant to Article 9 of Law 4122/2013, which transposed Directive 2010/31/EU into national legislation, by 1 January 2021 all new buildings must be nearly zero-energy buildings, and the almost zero or very low amount of energy required to meet the energy needs of the building must be obtained mostly from renewable energy sources, including energy generated in or near the building.
For new buildings where government and public services are housed, this obligation should enter into force no later than 1 January 2019.

The following is an analysis of the key renewable energy sources used in Greek buildings, mostly involving the utilisation of solar energy.

Solar hot water supply systems

In respect of the use of RES in buildings, and the supply of hot water by the use of solar systems in particular, it is required that new buildings and those undergoing major renovation must meet part of their hot water needs by the use of solar thermal systems, based on the Regulation on the efficiency of buildings (KENAK) and Article 10(3) of Law 3851/2010 (Government Gazette, Series I, No 85) on speeding up the development of renewable energy sources with a view to dealing with climate change, and other provisions falling within the remit of the Ministry of the Environment, Energy and Climate Change. The minimum percentage of the solar share on an annual basis is set at 60%.

This obligation does not apply to the uses that are exempt from the application of the Regulation on the efficiency of buildings (KENAK) and when hot water needs are met by the use of other decentralised energy systems based on RES, CHP, district heating for an entire area or building block, and for heat pumps with a seasonal efficiency factor (SPF) greater than 3.3.

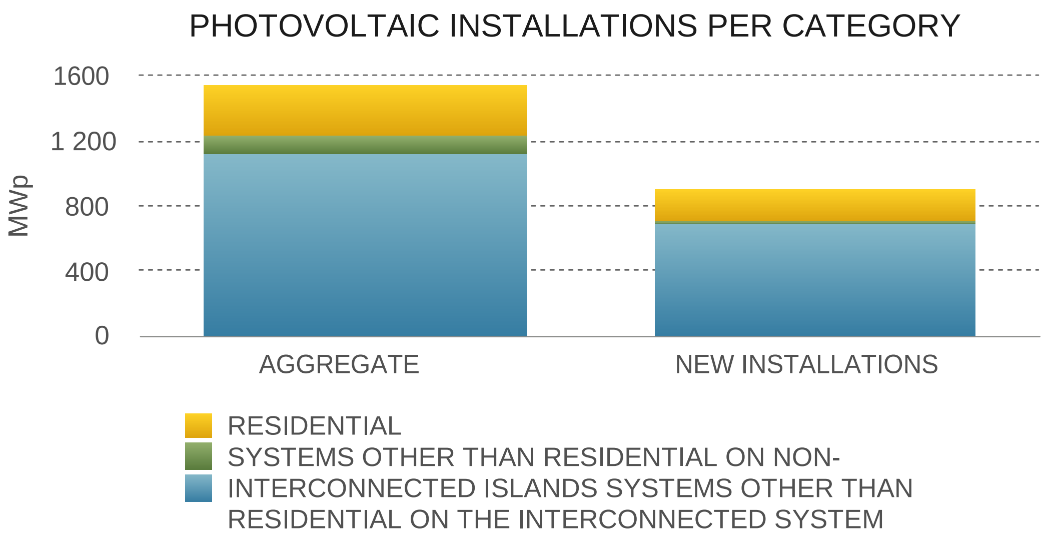
Based on records from the sector (ESTIF, 2013 [29]) Greece has achieved an annual production level ranging between 200 000 and 250 000 m^2, and there are 4 119 200 m^2 in operation in Greece, covering 2.88 GWh (th). The sector's exports are also significant.

Photovoltaic energy

As regards the installation of photovoltaic (PV) systems in buildings and the use of the energy generated by them, a special scheme has been in place since 2009 for the deployment of photovoltaic systems of up to 10 kWp, which applies to residential buildings or premises of very small undertakings.

The scheme relates to PV systems intended to generate energy to feed into the national grid, which are installed on the terrace or roof of a building, including balcony canopies, facades and shades, as well as auxiliary areas in a building, such as storage rooms and car parks, as defined in the building regulation. The scheme will remain in force up until 31 December 2019 for the entire territory of Greece.

INTERCONNECTED SYSTEMS PER CATEGORY	ROOFTOPS <10 KWp	<20 KWp	20-150 KWp	150 KWp - 2 MWp	>2 MWp
Total installed capacity (MWp)	298.7	62.5	582.6	395.2	198.2



	AGGREGATE	NEW INSTALLATIONS
SYSTEMS OTHER THAN RESIDENTIAL ON THE INTERCONNECTED SYSTEM	1 126.1	687
SYSTEMS OTHER THAN RESIDENTIAL ON NON-INTERCONNECTED ISLANDS	112.4	29.7
RESIDENTIAL	297.8	195.3

Figure 41: Photovoltaic plants per category (Hellenic Association of Photovoltaic Companies (SEF), 2013 [30])

6.3. CONNECTION WITH A DISTRICT HEATING SYSTEM

The use of district heating started out in Greece in early 1990, utilising the heat generated by power plants. The thermal energy used to feed district heating installations is derived from heat and power cogeneration plants and high-efficiency heat and power cogeneration plants.

The district heating networks already in operation or under construction relate to the networks and installations of the following undertakings:

1) Municipal District Heating Undertaking of Ptolemaida (DETHP)
2) Municipal Water Supply and Sewerage Undertaking of Kozani (DEYAK)
3) Municipal District Heating Undertaking of the Broader Area of Amyntaion (DETEPA)
4) District Heating of Megalopolis
5) Municipal Water Supply and Sewerage Undertaking of Florina (DEYAF) *(under construction);* and
6) 'Thermi Serron' - District Heating of Serres (private network).

In particular, the district heating system of Serres has been in use since 2007, providing services to more than 10 000 apartments and other buildings which are connected to its network, representing a surface area of 800 000 m^2.The district heating system of Amyntaion has been in use since 2004. By early 2013 it was connected to 1 330 supply points, and there were 600 supply points pending connection. The district heating system of Megalopolis has been in use since 2000, providing services to 500 houses, which are connected to its network.

Directive 2012/27/EU has placed particular emphasis on the utilisation of high-efficiency cogeneration and efficient district heating/cooling systems, requiring Member States to carry out potential assessments and cost- benefit analyses to identify the most resource- and cost-effective solutions for meeting heating and cooling needs.

Moreover, an effort is being made to utilise waste heat from power plants or industrial facilities by carrying out a cost-benefit analysis aimed at utilising waste energy in the case of new units or networks or ones undergoing renovation.

Pursuant to Article 14 of Directive 2012/27/EE, setting out the above obligations, the MEECC submitted the criteria used to exempt facilities from the above obligation to carry out the cost-benefit analysis to the European Commission, as required by the above article, if utilisation of their waste energy would under no circumstances be cost-effective.

6.4. CONSTRUCTION OF SCENARIOS

Based on the above review of Greek building stock, buildings in Greece can be categorised based on use, construction period and climatic zone, to facilitate an analysis of the long-term energy-saving strategy scenarios.

In particular, as referred to above, the parameters which could affect the energy behaviour of buildings are:

- the type of the building (single-family residences, blocks of flats, offices/shops, educational institutes, hospitals and hotels);
- the age of the building (different legislation-construction technologies);
- the location of the building (climatic zone-urbanisation).

The following analysis at this stage, however, does not take into account either the construction period or the location of buildings. For the purposes of this long-term strategy, only the rating based on the type of building is used, i.e. residential and non-residential buildings. Based on that breakdown, the long-term strategy makes the following distinctions in order to develop the final scenarios.

Moreover, for the purposes of this report in particular and with a view to facilitating calculations, the building stock is rated according to Table 9 below.

Use of building	Number of residences and tertiary sector buildings
Normal residences (households)	4 000 000
Hotels	9 000
Schools - educational buildings	16 000
Offices - shops	161 000
Hospitals - clinics	1 700

Table 9: Number of buildings per use for the purpose of making calculations for this study.

6.4.1. RENOVATION RATE OF BUILDINGS

A key parameter for looking into the options available and developing the long-term strategy is the renovation rate of the building stock. Based on current international experience, the renovation rates recorded are between 0.36% to 2,6% for sustained renovations, which are not just individual and isolated actions [31]. Based on surveys on how to choose the key parameters in connection with energy savings in the building sector [31], [32], it was finally decided to study three different renovation rate intensity levels:

- a basic rate, with fixed annual quantities, representing essentially the renovation rate under current practice, without any additional measures implemented;
- a slowly increasing rate, with a fixed annual increased rate; and
- a medium intensity rate, with a direct significant increase, which is meant to remain at fixed levels afterwards.

Obviously, there are numerous renovation rate combinations. However, account must be taken each time of the number of buildings in the stock, the country's financial situation, the investors' maturity level, the funds available, etc. That is why other renovation rate types were rejected, e.g. a high intensity renovation rate which, based on a survey [31], requires significant investment, thus being impossible to adopt in Greece at the present time. The three different rates concerned were chosen with a view to assessing the required investment against the resulting energy and parallel socioeconomic benefits, in respect of residences in particular. In respect of other categories of buildings, given the small number of those buildings, only the basic rate is analysed relating to a fixed number of buildings per year and using the slowly increasing rate.

Based on statistics and estimates, an estimated average of 25 000 to 30 000 energy interventions are carried out on residences annually. The slowly increasing and medium intensity rates were chosen as they allow for covering a high percentage of buildings in the total stock, i.e. 70-80%. The renovation rates are shown graphically in Figure 42 below.

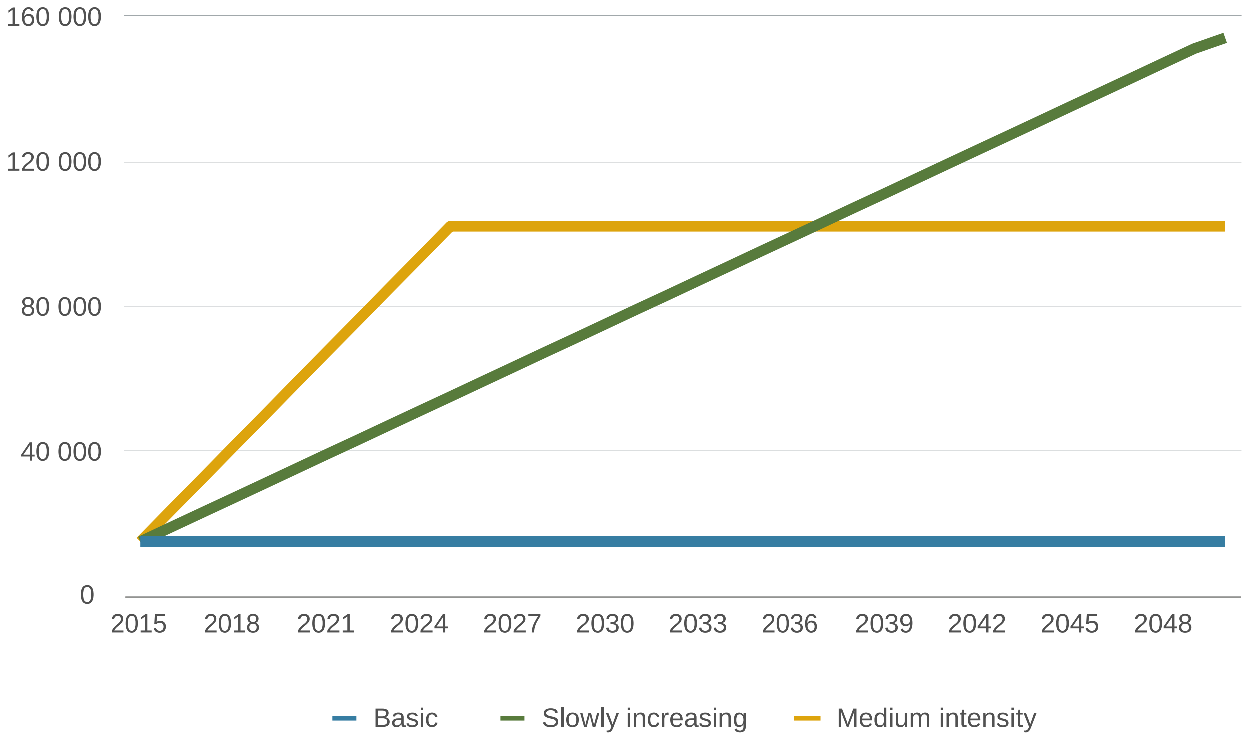


Figure 42: Renovation rate of residences

Table 10 below provides detailed renovation rate examples for residences.

	RENOVATION RATE	2015	2020	2025	2030	2040	2050	TOTAL NUMBER OF RENOVATED RESIDENCES
		NUMBER OF BUILDINGS						
1	**BASIC**	25 000	25 000	25 000	25 000	22 000	25 000	900 000
2	**SLOWLY INCREASING**	28 000	65 200	78 000	90 000	108 000	160 000	3 408 800
3	**MEDIUM INTENSITY**	25 000	68 800	116 000	116 000	116 000	116 000	3 686 000

Table 10: Renovation rate of residences

As regards buildings used for other purposes (non-residential tertiary sector buildings), given the size of the stock (which is relatively small compared to residences), no breakdown per individual rate is provided.

6.4.2. TYPE OF RENOVATION OF BUILDINGS

In the context of this analysis, four different types of renovation will be studied relating to the renovation percentage, i.e. the expected reduction in energy consumption, which affects the investment costs accordingly. Table 11 below describes the four types of renovation:

TYPE OF RENOVATION	SAVINGS PERCENTAGE
Minor	20%
Medium	40%
Major	60%
Nearly zero energy	80%

Table 11: Type of renovation of buildings

Minor renovation essentially involves individual interventions ensuring small savings percentages of the order of 20%. Medium renovation, which ensures a savings percentage of 40%, utilises the current experience from the savings at home programme, as implemented by the MEECC, based on which the average interventions ensure energy savings of 40%. These interventions, though, do not involve major renovation. Respectively, based on the experience from the energy efficiency certificates issued, major renovation (i.e. upgrading buildings to category B) would lead to energy savings of the order of 60% for residences. Finally, it should be noted that, although no nearly zero-energy building scheme has been adopted in Greece and its individual characteristics have not been determined, it is assumed for the purposes hereof that a nearly zero-energy building will ensure energy savings of the order of 80%, which is close to the EU consumption target of 40-50 kWh/m^2 annually for residences[7].

7 Although the above renovation types do not fully correspond to non-residential buildings, the same percentages have been used for the purposes of this study concerning shops and offices, educational and school buildings, hospitals and hotels.

Typically, the energy savings percentage is linked to the renovation costs, which are measured respectively in comparison to the cost of the property's value. Table 12 below lists renovation examples, with indicative costs, based on market practice:

No	Intervention-renovation measures for energy savings	Cost
1	External thermal insulation	EUR 50 / m^2
2	Glazed units - window/door frames and glazing	EUR 200-250 / m^2
3	Solar water heater	EUR 1 000 - 1 300 for a typical residence
4	More efficient heating installations -	EUR 8 000 - 10 000
5	High energy-efficiency lighting systems	EUR 2 / m^2
6	Green/planted roofs	EUR 90 - 120 / m^2

Table 12: Energy saving measures and indicative costs (MEECC, Savings at Home, estimates based on market price research)

The cost per energy savings unit is estimated based on a combination of different intervention measures for typical domestic residences and, respectively, for buildings used for other purposes[8]. The values recorded in relevant references for Greece are between EUR 0.7 and 2.2 kWh, the maximum value being achieved where the materials used and works carried out are of high value (whose application requires specialised technical knowledge). Based on the analysis set out herein, the cost of typical renovations is estimated at EUR 1 / kWh for residences, EUR 1.2 / kWh for schools, and approximately at EUR 1.5 / kWh for offices, shops, hospitals and hotels.

An analysis of different renovation scenarios for typical buildings shows that the implementation of individual low-cost actions (e.g. only installation of a solar water heater) ensures a small percentage of energy savings, respectively. It is therefore desirable that renovations are more in-depth, combining energy saving measures that improve the building as a whole, including both its shell and functional systems (heating, air conditioning, lighting).

8 Case studies have been carried out concerning the savings potential and typology of the Greek building stock as part of the project TABULA (2012) [15], as implemented in the context of the European intelligent energy Europe programme (IEE).

Based on the savings at home programme implemented by the MEECC, the average savings percentage ensured is of the order of 40%, with an average renovation cost of EUR 10 000.00. However, where a renovation includes only measures ensuring energy savings of 40%, the functioning of the building is locked in at a relatively high consumption level, which is actually rather far from the EU low consumption target of 40-50 kWh/m^2 annually. Only the major renovation scenarios are able to achieve the energy savings targets set by the EU (BPIE 2011, [33]).

6.4.3. BUILDING RENOVATION SCENARIOS

Based on the two above parameters, there are 5 scenarios developed finally, combining the type of renovation and renovation rate, as follows:

- (a) The **basic scenario (S1)** includes a fixed division of the renovation rate, i.e. of the 25 000 buildings per year to be upgraded most will be upgraded by 20% (minor renovation) and fewer by 40% (medium renovation) or a 60% (major renovation). This is essentially a scenario that describes the situation that would prevail without implementing any additional favourable measures. This is the current practice in the Greek market, as estimated based on the recent renovation permits issued (ELSTAT) and the market itself (suppliers and renovation crews), as well as the current practice that resulted from the energy-saving programmes for buildings (‘Savings at home’, bank programmes, etc.)

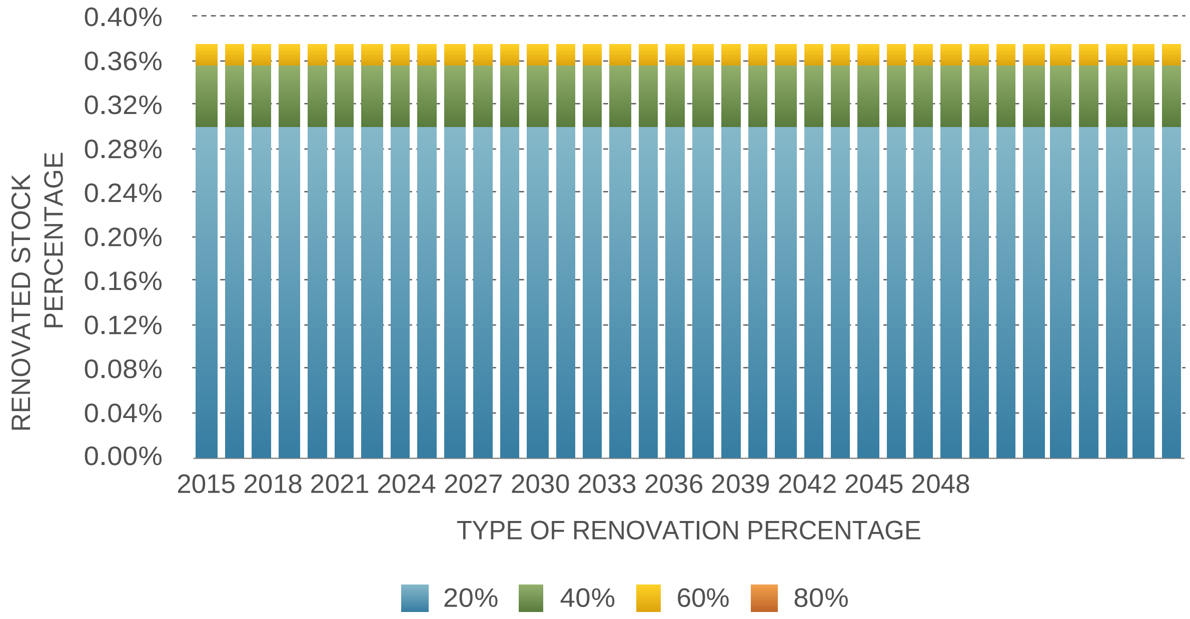


Figure 43: Basic residence renovation scenario

- Under the **medium scenario (S2)** the renovation rate changes slowly, combining different types of renovation. The medium scenario ensures higher energy savings, as a significant part of the stock achieves savings of the order of 60%. However, at the end of the period (2050), although a significant part of the building stock is actually functioning with increased energy efficiency, this is still far from achieving the target of 40-50 kWh/m^2 annually.

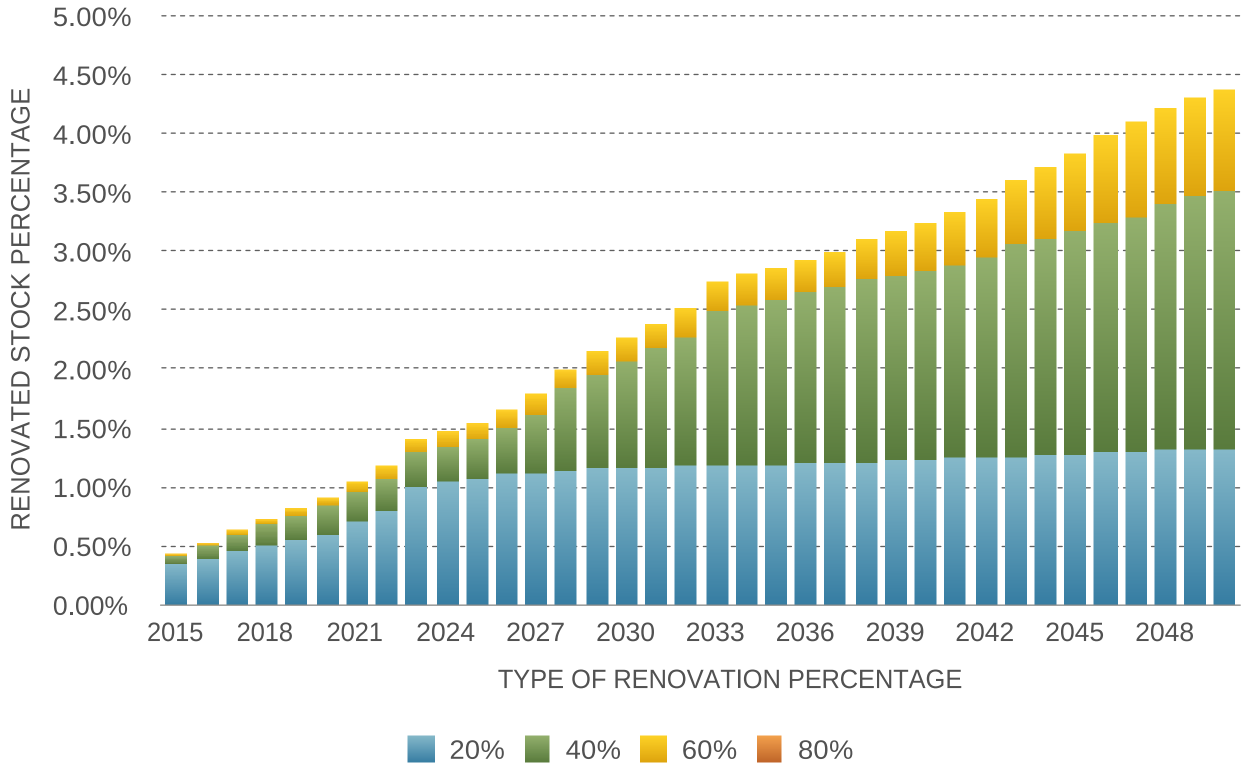


Figure 44: Average residence renovation scenario

(c) The **strong scenario (S3)** is based on a medium intensity renovation rate and includes more in-depth renovations. Under this scenario, it is possible to achieve (in the years 2018-2020) a building stock with a good energy behaviour relatively quickly, and a large percentage of the building stock will have achieved a 60% renovation level (major renovation) by the end of the period (in 2050), starting from 2025.

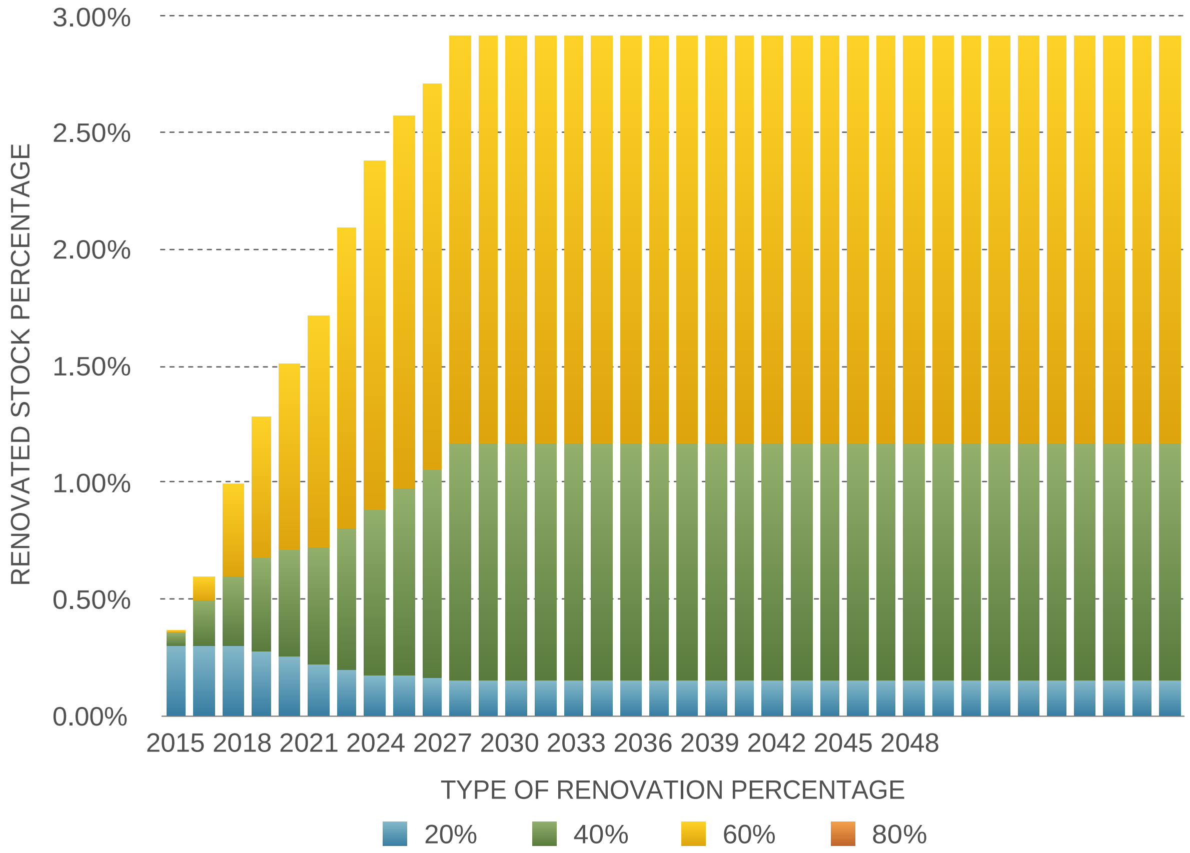


Figure 45: Strong residence renovation scenario

(d) The **ambitious scenario (S4)** describes a medium intensity rate too, involving different types of renovation, which has also included nearly zero-energy buildings (nZEBs) in recent years. In terms of energy, this is the scenario that ensures the highest energy savings percentages for a very large part of the building stock, whereas some of those buildings will function on a nearly zero-energy basis.

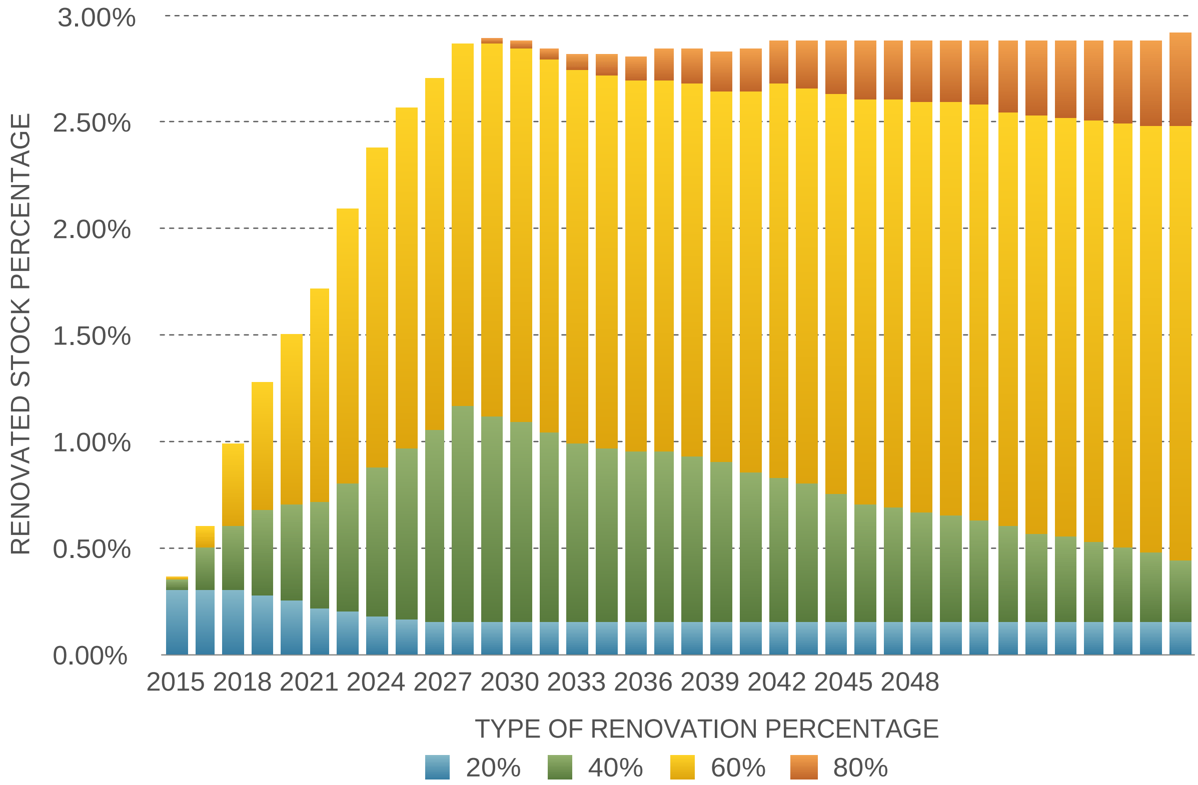


Figure 46: Ambitious residence renovation scenario

(e) The **targets scenario (S5)** also describes a medium intensity rate, involving different types of renovation and ensuring high savings percentages for a very large part of the building stock. Under this scenario, consideration is given to the achievement of the targets set for the renovation of buildings through the national energy efficiency action plan, ensuring a type 'S' renovation rate, i.e. the renovation rate increases initially (up until 2020), is then kept at a fixed level, and obtains a significant value in the end.

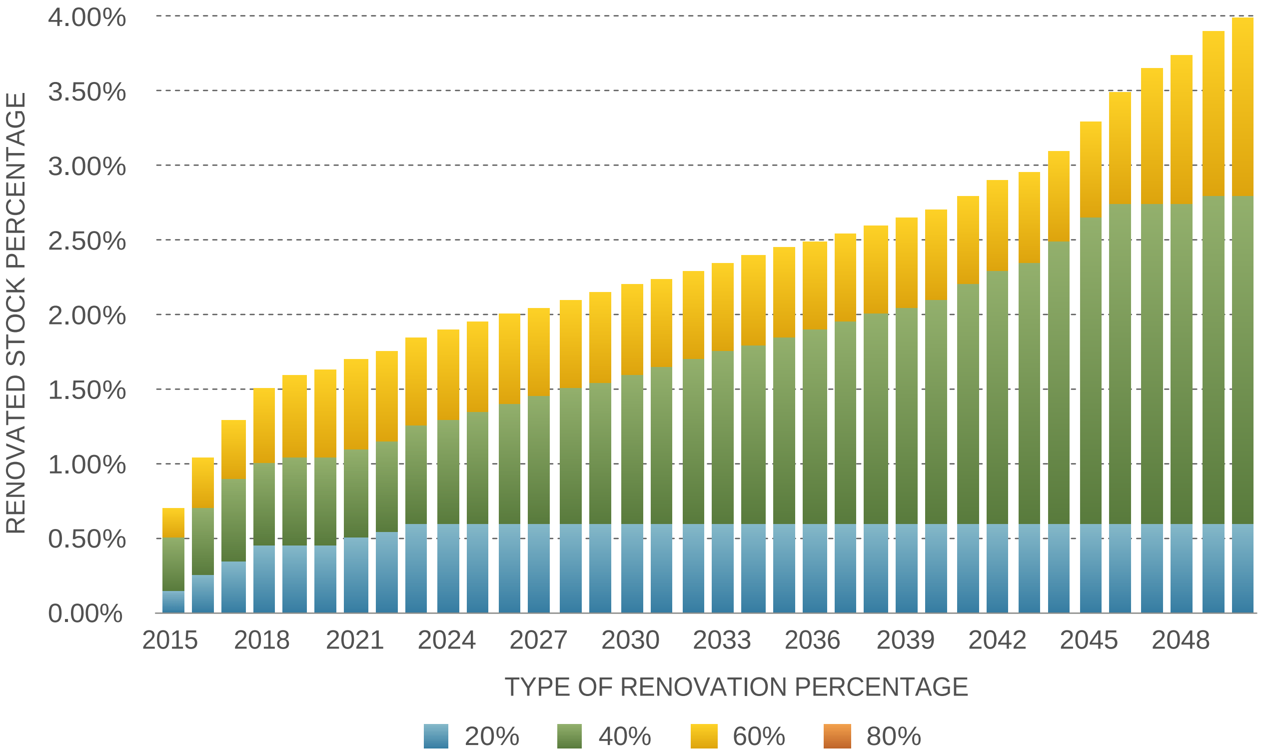


Figure 47: Residence renovation targets scenario

Table 13 below shows the key renovation scenarios examined for typical domestic residential buildings:

CHANGES OF RENOVATION DEPTH OVER TIME (2015-2050) - HOUSEHOLD RESIDENCES										
	RENOVATION RATE			RENOVATION PERCENTAGE - START YEAR 2015			RENOVATION PERCENTAGE - END YEAR 2050			
Scenarios	2015	2025	2050	Minor 20%	Medium 40%	Major 60%	Minor 20%	Medium 40%	Major 60%	nZEB 80%
S1 - BASIC	25 000	25 000	62 000	12 000	2 250	750	12 000	2 250	750	0
S2 - MEDIUM	25 000	62 000	176 000	12 000	2 200	800	52 800	88 000	34 800	0
S3 - STRONG	25 000	62 000	176 000	12 000	2 240	760	6 000	40 800	70 00	0
S4 - AMBITIOUS	25 000	62 000	176 000	12 000	2 100	900	6 000	11 600	81 600	17 600
S5-TARGETS	28 000	62 000	160 000	6 000	14 000	8 000	24 000	88 000	48 000	0

Table 13: Residence renovation scenarios

According to the above analysis, both major renovation and renovation that leads to nearly zero-energy buildings (nZEBs) are handled progressively and intensified as time goes by. In particular, nZEBs are mentioned under the ambitious scenario only after 2025, as the relevant obligation relates mainly to new buildings, which are not included in the existing stock.

As regards tertiary sector buildings, it should be noted that their number is significantly lower than the number of residences and they have a different energy consumption mix and function profile. Consequently, it was not deemed appropriate to analyse all the above scenarios during the current phase, but a decision was made to analyse, concerning all types of tertiary sector buildings, only the basic scenario (S1) and the targets scenario (S5), which will also help achieve the targets set in the context of the national energy efficiency action plan.

Table 14 below shows the key renovation scenarios examined for offices/shops, schools, hospitals and hotels:

TYPE OF TERTIARY SECTOR	SCENARIOS	RENOVATION RATE			RENOVATION PERCENTAGE - START YEAR 2015			RENOVATION PERCENTAGE - END YEAR 2050			
		2015	2025	2050	Minor 20%	Medium 40%	Major 60%	Minor 20%	Medium 40%	Major 60%	nZEB 80%
Offices - Shops	S1 - BASIC	1 085	1 085	1 085	868	162	55	868	162	55	-
	S5 – TARGETS	1 006	4 071	4 071	805	150	52	242	1 642	2 818	-
Hospitals	S1 - BASIC	47	47	47	37	17	3	37	7	3	-
	S5 – TARGETS	11	50	50	8	2	1	30	17	3	-
Hotels	S1 - BASIC	250	250	250	200	37	13	200	37	13	-
	S5 – TARGETS	56	263	263	45	8	3	14	91	158	-
Schools – Educational buildings	S1 - BASIC	444	444	444	356	66	22	356	66	22	-
	S5 – TARGETS	100	467	467	80	15	5	24	163	280	-

Table 14: Tertiary sector building renovation scenarios

6.5. ECONOMIC MODEL - ASSUMPTIONS

Pursuant to Article 4 of Directive 2012/27/EU on energy efficiency, Member States must establish a long-term strategy for mobilising investments in the renovation of their national building stock [1]. The cost analysis and optimal solutions are determined by considering the size of the building stock to be at the levels shown in Table 2 of Section 5.1, and the energy characteristics of the five building stock categories (residences, offices/shops, schools, hotels and hospitals) are used as data for the cost-benefit calculation model.

The approach of not including the entire building stock in one category is a result of promoting the strategy of gathering and mobilising different forms of investment around the individual building use categories. The difference in the size and characteristics of the individual stocks (e.g. very large for residences, and relatively small for shops/offices, and small – though with particular energy characteristics – for hospitals and hotels) allows for the identification of different groups of investment interest, which requires that the individual cases are looked into separately with a view to speeding up the implementation of the strategy for the energy upgrade of buildings.

Table 15 below cites the financial figures and assumptions used for making the calculations and analysing the energy-saving scenarios. The surface area of the buildings was estimated on the basis of both the building inspection archive database (i.e. data from the energy efficiency certificates issued) and the related census reports. The information from the building inspection archive was also used to determine the data for typical average annual total primary energy consumption and the corresponding electricity and thermal energy consumption. This data collection and processing method (asset method) was preferred over the use of data from the actual consumption levels (operational method) as the aim was to estimate the energy-saving potential of the building stock as real estate. The calculations that are based on the actual consumption levels – under the current situation in particular, which are marked with significantly lower prices – relate to indoor operating conditions that do not meet the minimum requirements for thermal and energy comfort and may lead to erroneous conclusions as to the potential for improving the energy upgrade of a building.

KEY ASSUMPTIONS OF THE CALCULATION MODEL					
	Residences	**Offices/shops**	**Schools**	**Hospitals**	**Hotels**
Number of buildings in the stock	4 000 000	161 000	16 000	1 700	9 000
Total surface area of the building stock (million m^2)	360	93	23	5	21
Typical building surface area (m^2)	90	580	1 440	2 940	2 330
Typical primary energy consumption ($kWh/m^2/year$)	360 = (56*2.9+170*1.1)	400 = (95*2.9+113*1.1)	146 = (20*2.9+80*1.1)	550 = (80*2.9+290*1.1)	277 = (50*2.9+120*1.1)
Electricity to final thermal energy consumption ratio (kWhe/ kWhth)	56/170	95/113	20/80	80/290	50/120
Renovation cost - reference year 2015 (EUR/kWh)	1	1.5	1.2	1.5	1.5
Discount rate	8%				
Annual inflation rate of electricity	0.5%				
Annual inflation rate of heat	0.55%				
Cost of electricity (p)	EUR 0.10/kWh				
Cost of heat (h)	EUR 0.14/kWh				
Lifecycle of energy interventions tmax	10-30 years				
Annual inflation rate of the economy	The model may be changed to take inflation into account. In this case, the calculations made are net of inflation.				

Table 15: Assumptions used for the calculation model.

Annex III describes the key parameters of the calculation model, the financial details and the other assumptions and the results on an annual basis up until 2050, to make an economic estimate of the interventions. Certain assumptions are then listed which were taken into account in when developing the specific strategy and relate to more specific matters referred to in Annex B to Commission staff working document SWD(2013)180final/22.5.2013. In particular:

- An estimate of the renovation cost for buildings used for various purposes, as already presented in Section 6.4.2, is between EUR 1/kWh and EUR 1.5/kWh.
- The cost of electricity and thermal energy before taxes is estimated to keep rising (inflation rates for electricity and thermal energy of 0.5% and 0.55%, respectively), based on estimates from the report 'EU Trends 2050' [48].
- The life-cycles of energy interventions are determined on the basis of the applicable legislation, i.e. Ministerial Decision No Δ6/7094/2011 (Government Gazette, Series II, No 918/2011) [49], ranging between 10 and 30 years.
- The calculations made are net of inflation.
- The cost-efficiency of the different sets of measures has not been determined using the cost optimisation methodology, as the study required under Article 5 of Directive 2010/31/EU has not been prepared.
- The intervention cost did include the cost of additional transactions, such as the cost of relocation of the tenants.
- No specific set of information measures for each building category and no implementation timeframe were determined in the current phase of the study. It is deemed appropriate, however, to enhance the measures aiming at informing would-be investors and other stakeholders of the relevant costs and benefits, as provided for in the long-term strategy for the renovation of buildings.
- No specific care was taken in the current phase of the study concerning the exemplary role to be played by the State at all central government levels and in the provision of public services.
- The lowest energy efficiency level per capital invested was not taken into account as a sole priority factor in respect of the renovation of the building stock, but the calculation model also took account of other factors.
- Different scenarios were examined in respect of the rate of change of key parameters. The resulting key parameters for making cost-benefit projections were analysed for the different scenarios presented.
- The size of the stock of residential buildings was changed from
  3.5 million to 4.0 million, to determine the sensitivity of the economic model. This

resulted in shifting the repayment date from 2023 to 2028.

- The change in renovation cost, which is also a key parameter in the model, was checked. The cost was doubled and tripled, respectively, and the internal rate of return (IRR) resulting for the relevant cases was examined. The doubled cost leads to an IRR that is a fraction, usually lower than 5-6%.
- Major renovations are presented as a single set, as it is estimated that it is not easy for somebody to invest often in building renovation, energy upgrade in particular. Besides, the period covered by the study (2015-2050) is 35 years, and it is difficult for somebody to invest in energy upgrade more than once, given that the payoff period is approximately 20 years.
- The progressive change of renovation depth is accompanied by a simultaneous drop in expenses, as there are also corresponding developments in the renovation market, too (energy intervention learning curve).

6.6. ADDITIONAL BENEFITS

Typically, the effectiveness of energy efficiency and energy-saving measures is assessed on a short-term basis, taking into account only technical-economic parameters and variables with immediate financial value, such as the cost of the energy savings, the payoff of the funds used, the mid-term profit of the proposed action.

However, the indirect and long-term benefits of energy savings are of equal or even higher value and have a multiplier effect. Given their non-market value, most of these benefits are examined and referred to at a second level of decision-making.

6.6.1. ADDITIONAL BENEFITS FOR THE ENVIRONMENT AND PUBLIC HEALTH

(a) **Environmental benefits:** The building sector accounts for 40% of final energy consumption and makes a significant contribution towards greenhouse gas emissions. Therefore, its share in climate change and the formation of the microclimate in each area is high. The energy upgrade of buildings will certainly reduce the emissions of greenhouse gases and other polluting gases which cause environmental impact, such as sulphur oxides (SOx), nitrogen oxides (NOx), particle matter (PM10), produced both by the fuel burnt to produce electricity for buildings (lighting, air conditioning, etc.) and indirectly by the fossil fuels burnt in heating systems (e.g. central heating systems). Moreover, in addition to improving the quality of ambient air, there is also a visible short-term improvement of the quality of indoor air and environment, which has a positive effect on productivity and health. A recent survey [34] carried out as part of the ExternE and NEEDS projects estimated and measured the effect of various pollutants in EUR per ton of pollutant produced, based on the producing sources (fuel mix used to generate energy). Those pollutants were then linked to health effects, respectively. Estimates have also been made to measure environmental impact costs [35] and translate them into a percentage of the electricity price.

The environmental benefit of the renovation of buildings represents approximately 10% of the cost of energy savings (Table 16).

(b) **Health benefits:** Energy efficiency renovation entails direct health benefits and, therefore, reduces healthcare costs. These benefits are actually quite close to the energy savings value, based on an estimate made by Copenhagen Economics (2012) [36]. More specifically, renovation works such as improved insulation, more efficient heating and systems, better indoor lighting and ventilation, help reduce the occurrence rates of connected diseases and improve the quality of the indoor environment, which affects both the individual’s wellbeing and productivity at work (Santamouris and Papaglastra, 2007, [37]). It is important that buildings with energy functioning problems are improved to avoid being included in the ‘sick building’ category, in particular where they house a large number of workers or are used for socially sensitive purposes, e.g. offices, schools and educational buildings, and hospitals.

Health effects are also caused by the inability of low-income households to meet the energy needs of their residences (electricity, heating). As already examined in Section 5.2, the Greek building stock includes a significant number of buildings constructed before 1980, which entails a lack of thermal insulation and efficient heating systems and a degradation of the indoor environment quality and of the relevant comfort conditions. There are often energy poverty conditions prevailing in those energy-intensive buildings, which are typically owned by low-income families that are incapable of carrying out renovation works and accessing state-of-the-art energy services. The EU has provided for lower rates to be charged on vulnerable consumers, which is also true in Greece both for electricity (social tariffs) and thermal energy (allowance granted). As they are incapable of improving the buildings they use, these vulnerable households spend a large part of their income on restoring sustainable comfort and indoor environment quality conditions by resorting to actions that do not pay off. Investment and incentives for renovation can help reduce energy poverty and prevent the associated social exclusion.

The values of the health impact multiplier have been estimated by the International Energy Agency (IEA) to be four times the investment and benefit in terms of energy savings [46].

6.6.2. ADDITIONAL BENEFITS FOR THE ECONOMY AND SOCIETY

(a) **Impact on employment:** An increase in economic activity due to the new jobs created and the resulting investments generates an additional result that is equal to 1.5 times the value of the energy savings costs ([38], [36]). The investments and long-term strategy aimed at the major renovation of buildings also leads to the creation of new markets centred on energy services, renovation, energy-saving and RES technologies, which require specialised staff, new specialisations and, therefore, new jobs. More specifically, the strategy that focuses on large-scale major renovation facilitates the promotion of energy service companies (ESCOs). The development of such markets may, depending on the increase in activities and skills, also lead to exports to markets outside Greece. Investment in the energy efficiency and major renovation of the building stock must be accompanied by new training programmes aiming to support the new market with executives, technicians and specialists in financial and investment matters for buildings and RES, thus creating new jobs and increasing the productivity factor of human resources.

Based on an analysis of the different types of saving interventions, using the input-output tables (Mirasgedis et al 2014, [39]), an estimate was made of the number of jobs created and of the contribution of savings towards employment. For example, each investment of one million euro creates

21.1 jobs in basic building insulation, 13.9 jobs in using state-of-the-art glazed units and 24 jobs in equipment replacement (boilers, etc.). These values lead to a multiplier of the order of 0.3 (Table 16).

(b) **Energy security:** The improved energy efficiency of the building stock through major, or gradual major, renovation operations can lead in the long run to reduced demand for energy and imports of related energy products. Reduced demand for energy actually leads to improved security of the supply of energy, thus eliminating the risks associated with energy systems and such factors as fuel supply costs and territorial and quantitative availability of fuel. Efforts are being made recently to increase awareness, both at political and individual levels, of the fact that ensuring energy savings is the first step towards making Greece independent in terms of energy.

In addition to energy security, improving the energy efficiency of buildings and, therefore, reducing consumption levels, helps prevent peaks and makes consumption demand smoother. Consequently, energy producers will not have to make large investments to meet small peak load demand. Where RES (photovoltaics, solar thermal and geothermal systems, etc.), high-efficiency cogeneration of heat and power (HECHP) or district heating measures are included too, the national energy system taps into several diversified supply sources, which makes it more secure and reduces its dependence on conventional thermoelectric plants. At the national level, reduced demand may also affect how fossil energy resources are handled, which will have a direct impact on the cost of supply and on the security of supply itself. Ensuring energy security would also require maintenance of stocks of fuel in warehouses, which entails certain costs, i.e. sums that are not invested in growth and prosperity for society.

Moreover, energy prices tend to be aligned with demand and, therefore, when demand drops (due to lower consumption levels), the related prices tend to follow a smoother trajectory in the supply market, thus preventing local peaks and the associated consequences (peak charges and black-outs).

In terms of security, the multiplier is of the order of 0.6 of the investment responsible for the energy-saving benefit [Tsani, 47].

(c) **Property value increase** (leasing and/or selling value): It is a fact that, a property's market value is directly linked to its energy identity. Besides, the indoor environment quality and enhanced energy costs are included in the criteria used by buyers/tenants in making choices. Renovating a building, as well as ensuring energy benefits and improving the quality of the indoor environment will also help enhance its outward appearance and, therefore, its market value. Actually, this is a typical example of the classic economic paradigm of supply and demand, as energy efficient buildings are more expensive due to increased demand, whereas old-fashioned buildings are sold at very low prices due to limited demand. More specifically, there a new property market appears to emerge in which the final level of the rent is determined primarily by its energy efficiency rather than the objective value of the local area, given the current situation in particular, in which the operating costs of a building are increased due to the high cost of energy.

As explained in the section on the building stock, implementing energy saving measures leads to lower consumption bills in terms of both the energy used for heating/cooling and electricity used for other day-to-day needs of a household. Users of offices or other tertiary sector buildings may cut down on their operating expenses by reducing the energy costs of the services or products they supply to the market. Increasing energy costs in the near future are included in the risks that threaten to compromise the profitability of an undertaking. The set of direct economic benefits also includes improving the value of a building that is renovated, as it entails a rise in the rent and/or resale price, where the owner uses the building to generate revenue. The requirement for an energy efficiency certificate to be issued where a building is to be leased out or sold has led to the better functioning of the property market (residences and shops).

An analysis of the property market, carried out by the Bank of Greece (BoG, 2012, [40]) using the hedonic pricing method, took account of a number of parameters affecting property values and rent levels. The indicator did not take account of the effect of a building's energy efficiency directly, only indirectly (age of the building). It would be advisable to use that parameter, too, in the future (Figure 48).

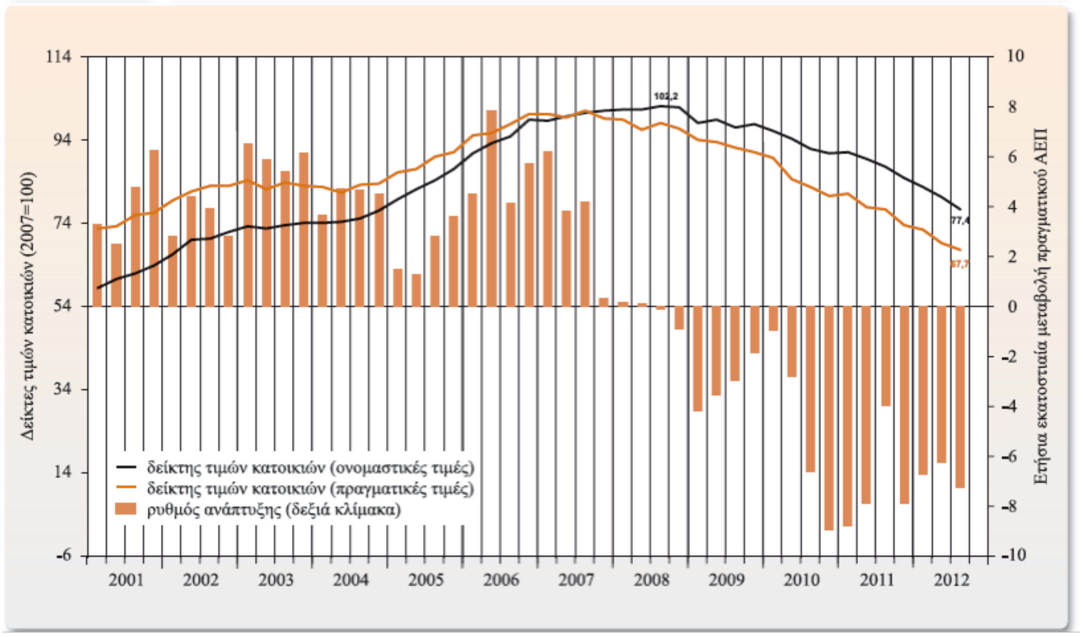


Figure 48: Residence price index and growth rate (BoG, 2012, [40])

Similar analyses and the use of indicators looking into the energy efficiency of buildings (Kholodilin et al, 2014 [41], DECC, 2013 [42]) have not established a clear and unequivocal trend, but have indicated that the energy features of buildings property market will help to shape the property market in the near future. In presenting the results of a European research project (Hellenic Property Federation - TRAINREBUILD, 2012, [43]), the Hellenic Property Federation explained that the selling price of high energy-efficiency buildings is rising by an average of 2% to 7% in Europe.

The above analysis helps measure the additional energy savings benefits through coefficients/multipliers which demonstrate the magnitude of the benefits ensured in terms of sustainable development (social, economic, environmental benefits). More specifically, a combination of energy savings and mobilisation of investment for the renovation of energy-intensive buildings can provide multiplied benefits at individual, sectoral and national levels and, therefore, these need to be taken into account both at state and personal initiative levels. The additional benefits also determine the social return on investment [44].

For example, the benefits resulting from energy savings in buildings and the corresponding multipliers, if aggregated, can represent at least double the cost of the savings, using conservative estimates. The benefits are also multiplied from the perspective of the owner/investor of the building that undergoes energy investment. Table 16 below lists the multipliers taken into account, on a conservative basis, in the context of this study:

ADDITIONAL BENEFIT	MULTIPLIER
Employment	0.3
Public health	1.0
Environment	0.1
Energy security	0.6
TOTAL	2.0

Table 16: Additional benefits and impact multipliers [36] [44]

7. POLICIES AND MEASURES FOR BOOSTING RENOVATION

7.1. EXISTING MEASURES AND POLICIES

Despite high subsidy levels, the national strategic policy on building renovation targeted primarily single-family residences and individual consumers and focused on individual-pilot actions in the public Sector. This section presents the most important existing measures implemented in recent years that affect the mobilisation of investment in the renovation of residential and tertiary sector buildings. Specifically, the following measures should be stressed:

1. **The Regulation on the efficiency of buildings (KENAK)**

KENAK established integrated energy planning in the building sector, aiming to improve the energy efficiency of buildings, ensure energy savings and protect the environment through:

- preparation of a study on the energy performance of buildings when new ones are erected; major renovation of existing buildings;
- establishment of minimum requirements for the energy efficiency of buildings;
- energy rating of buildings by issuing energy performance certificates;
- energy inspections on heating and air conditioning systems.

KENAK is essentially a regulation that combines all the parameters affecting the energy efficiency of a building, i.e. its design, envelope and electromechanical installations, and establishes a specific methodology for calculating the energy efficiency and the rating of buildings under energy categories.

Energy inspection is an important tool for identifying the energy condition of existing buildings and its potential for improvement. Adopting the measure that involves the carrying out of energy inspections and issuance of EECs is a key tool in our national energy policy, as it has provided the property market, firstly, with new qualitative criteria which are directly linked to the value of properties and, secondly, with measurable data on the annual operating costs incurred for heating and cooling, hot water, lighting, etc. It has proved that the energy inspections carried out on, and the EECs issued for, buildings ensure significant added value for the property market as a whole and for each individual building that acquires an ‘energy identity’, which sets out its energy characteristics along with useful tips on how to improve its energy performance [33].

2. The ‘Savings at Home Programme’

The savings at home programme started in 2011 with a budget of EUR 548 million, aiming to promote interventions for improving the energy efficiency of the shell and of the heating and hot water systems of residential buildings. After about four years of implementation of the programme, approximately 100 000 applications have been submitted for participation, and approximately 50 000 of them have already been accepted and in 40 000 cases the energy efficiency enhancement interventions have been completed, with a total eligible budget of EUR 400 million, ensuring an average energy saving of 41%, as most of the interventions related to older, energy-intensive buildings. The implementation of the programme is expected to result in total annual primary energy savings of approximately 60 ktoe.

The programme is deemed to be one of the most growth-oriented, ensuring direct benefits for people and also boosting employment, as it directly creates turnover for businesses and professionals, small- and medium-sized ones in particular, in Greek economic sectors that have a good standing and prospects. As regards the construction sector in particular, which is currently undergoing a prolonged recession due to the economic crisis, the programme is a real boost as it guarantees employment and promotes the sale of construction and other energy-saving materials, which have increased added value, as most of them are produced in Greece.

It should be stressed that approximately 3 000 jobs have been created thanks to the programme, and a total of EUR 700 million has been invested in the actual economy so far.

3. Mandatory installation of solar thermal systems in new buildings

KENAK makes the use of solar thermal systems to meet part of the hot water needs mandatory. The minimum percentage of the solar share on an annual basis is set at 60%.

4. ‘Allazo KLIMAtistiko’ [changing air conditioning].

Under the programme implemented in the period 2007-2013, subsidies were granted for replacing and recycling older, energy-intensive household air conditioners. Through the use of more energy-efficient air conditioners in the residential sector, the ‘Allazo KLIMAtistiko’ action aimed to reduce the amounts of energy consumed (energy savings) and the amounts of pollutants emitted (mainly CO_2) to generate electricity.

The recycling of withdrawn air conditioners helps reduce the amount of waste taken to final disposal and utilises/re-uses some of them, thus ensuring environmental benefits.

5. Upgrade of public buildings

As regards the public sector, a number of calls have been issued and are currently under implementation for enhancing the energy efficiency of public buildings, with a total budget of the order of EUR 500 million, with a view to ensuring energy savings, also recognising that the State's role is strategic and exemplary. The EXOIKONOMO OTA I and II [SAVE for local authorities I and II'] programmes involve energy-saving interventions in existing municipal buildings and local authority infrastructures, including open building facilities.

The programmes started in 2009 with a total budget of EUR 150 million. Furthermore, through the Operational Programme 'Environment and Sustainable Development' implemented by the MEECC, a number of calls have been issued for the renovation of public buildings, including the programmes 'Bioclimatic upgrade of public open spaces' and 'Green roofs', the pilot programmes 'Green neighbourhood' and 'Green island', etc., aiming to enhance energy efficiency, promote sustainable development locally, improve the quality of life of people and also create new jobs, thus maximising the added value of the programmes and strengthening local economic prospects.

As part of preparing the 3rd national energy efficiency action plan, measures were included concerning the renovation of residential, public and professional buildings which are currently being implemented or are to be implemented (in the period 2011 – 2020). Table 17 below lists measures relating to building uses:

No	Policy measure to save energy	Number of interventions	Calculated final energy savings (ktoe)
1	'Savings at home' programme	70 000 residences	83.8
2	'Save' programme for Local Authorities	104 municipalities	3.7
3	'Save II' programme for local authorities	139 municipalities	8.3
4	Energy upgrade of residences	200 000 residences	239.5

No	Policy measure to save energy	Number of interventions	Calculated final energy savings (ktoe)
5	Energy upgrade of public buildings	280 public buildings	12.8
6	Energy upgrading of commercial buildings	3 500 buildings	31.6
7	Implementing an energy management system in public sector and general government agencies according to the ISO 50001 standard	4 000 buildings	28.1
8	Energy upgrading of commercial buildings through energy service companies	3 000 buildings	50.8
9	Education and training actions for tertiary sector staff	40 000 individuals	76.8
10	Developing smart metering systems	5 760 000 meters	96.8
11	OPESD operations		14.2
12	Offset of fines on illegal buildings against energy upgrades	90 000 dwellings	107.8
13	Energy managers in public sector and general government buildings	15 000 buildings	52.6

Table 17: Energy savings policy measures for buildings (report pursuant to Article 7)

6. Tax incentives

Tax incentives were adopted in 1994 to deduct the sums spent on energy upgrade interventions and RES installations from the taxpayer's total income by up to 20% of the expenditure incurred, with a ceiling of EUR 700. A change was made in 2010 to the effect that 10% of the expenditure could be deducted for a maximum expenditure of EUR 6 000 (i.e. a deduction ceiling of EUR 600) concerning energy upgrade interventions and RES installations, and the maximum expenditure was further reduced to EUR 3 000 (i.e. a deduction ceiling of EUR 300.00) in 2011. However, most tax exemptions, including energy efficiency interventions, were abolished in 2013. It should be noted, however, that new legislation is about to be adopted which introduces a reduction in income tax at a specific percentage of the expenditure incurred for energy upgrade interventions in buildings which are implemented following energy inspection.

7. Town planning incentives

Under Article 25 of Law 4067/2012 (Government Gazette, Series I, No 79, 2012) setting out the new building regulation, incentives have been provided for constructing minimum energy consumption buildings. More specifically, incentives are granted for increasing the plot building ratio to 5% for buildings that receive an A+ rating, or 10% for buildings with a very high energy efficiency (primary energy consumption below 10kWh/^{m2}/year) and environmental performance.

8. Offset of fines on illegal buildings against energy upgrades

The measure stems from the application of Article 20 of Law 4178/2013 (Government Gazette, Series I, No 174/2013), which provides that the amounts paid for services, works and materials intended for the energy upgrade of buildings can be offset against the sums of the special fine imposed, even up to 50% of that fine. Offsetting is possible if the interventions allow for upgrading the building by at least one energy category, or achieves annual primary energy savings greater than 30% of the consumption of the reference building.

9. Replacement of oil-fired installations with gas-fired ones

An action has been implemented in the context of energy upgrades and energy savings for buildings relating to the replacement of oil-fired heating systems with gas-fired ones in residences (Government Gazette, Series II, No 3071/2014). The action aims to subsidise the cost incurred for the internal installation of natural gas systems in residences, in replacement of existing oil-fired heating systems, to reduce pollutants and save energy. The action budget is EUR 15 million in terms of total public expenditure, with funds derived from the NSRF 2007-2013, which are to be spent as follows: EUR 10 million in Attica, EUR 3 million in Thessaly and EUR 2 million in Macedonia.

The subsidy covers 60% of the total eligible cost incurred for the internal installation of the gas-fired system. This action is estimated to subsidise approximately 50 000 households, and the intervention aims to reduce the energy costs for residences, enhance the energy performance of heating systems and reduce atmospheric pollution in the cities where the action is implemented, thanks to the use of a cleaner source of energy.

7.2. ANALYSIS OF OBSTACLES

Implementing the long-term plan for the renovation of the building stock in Greece is faced by, and must overcome, a number of obstacles and barriers, as usually arise when social and technical changes are made. Respectively, attracting investment aimed at ensuring the cost-optimal renovation of residences and buildings used for other purposes (offices, shops, hospitals, educational centres, etc.) is prevented by a number of barriers, which are actually interconnected and need to be overcome.

The policy that aims to renovate existing buildings in Greece needs to take into account various critical factors such as:

- the fact that the building stock in Greece consists of numerous older buildings, which were constructed on the basis of outdated operating regulations and often lack any thermal insulation, thus requiring large amounts of energy to ensure acceptable comfort conditions in winter, according to current standards;
- the fact that the current condition of heating systems leads to lower performance rates and, therefore, to increased energy consumption and environmental pollution levels;
- the fact that the payoff period for energy efficiency interventions is typically quite long;
- the fact that the interventions must comply with specific rules for the protection of cultural and architectural heritage, as these apply to many settlements in Greece;
- the fact that the implementation of external interventions in individual apartments in blocks of flats is wrought with practical difficulties, thus entailing very long implementation times;
- the fact that the energy savings benefit and the capital payoff rate of the appropriate renovation are often low;
- the fact that the implementation of energy interventions in residences in many properties is often difficult due to XXX and is linked to outdated decision-making regulations;
- the fact that the economic and social pressure on low-income classes has increased energy poverty in Greece; and
- the ever-increasing demand for improved living and working conditions, in terms of thermal comfort in the summer in particular, which, combined with a drop in the cost of the appliances concerned, has led to the installation of over 3 000 000 air conditioners in the last 25 years.

The energy consumption of buildings is directly linked to social and economic factors, as both the thermal quality and energy consumption of buildings are directly linked to people’s income. It should be noted that only 8% of low-income individuals reside in homes with double glazing and insulation, while the percentage is

64% among those with a high income. Given the differences in the quality of buildings, it was found that there is high thermal energy consumption per square meter among those with very low- and very high-incomes. The cost of heating and air conditioning per person and surface area unit is higher by 127% among the low-income group than among those with high income.

It should also be noted that no **energy awareness** has been established in Greece yet, either at national or individual levels. The benefits for society from improving the energy efficiency of buildings are not directly felt by investors and owners, thus creating a 'benefit gap', which leads to reduced levels of investment in the energy upgrade of buildings, as made by the owners themselves.

Respectively, the energy upgrade of public sector buildings is not yet implemented in a holistic manner, which could serve as an example both for users of and visitors to public buildings.

The following is an analysis of various obstacles, aiming to identify the challenges involved and how to mobilise investment for renovating the building stock.

7.2.1. IMMATURE MARKET - TECHNICAL OBSTACLES

The new market for the energy upgrade of buildings is rather immature, essentially undergoing an initial development phase and is thus faced with the problems associated with the creation of any new market. The market concerned was the result of the strong decline in construction activity, which had flourished in Greece in the period 2000-2007.

The market is faced with various technical obstacles, such as:

- technical restrictions concerning interventions on the building shell and the provision of renovation services, such as architectural, infrastructure accessibility and common heating infrastructure issues;
- difficulty in making decisions for blocks of flats due to outdated regulations;
- lack of a sufficient renovation services chain;

- lack of energy labelling, energy standards and certification for the materials used in construction;
- lack of technical support and of reliability of energy services;
- lack of measurement/direct devices (e.g. smart meters), which would indicate clearly and directly the energy savings ensured by the renovation implemented.

An additional weakness may be the fact that sometimes the person making the decisions (and bearing the related costs) concerning the level of the energy efficiency of a building is not the same as the one bearing the cost of the energy consumed in the building. A typical example of that is rented buildings, where the cost of the energy upgrade is borne by the owner, but the benefit of the energy savings is enjoyed by the lessee. This weakness can be corrected by transferring the energy upgrade cost to the lessee by integrating the cost in the rent paid, as a payoff for the reduced energy consumption costs.

Is should also be noted that a typical characteristic of the Greek construction sector is that the materials used (insulating materials, lighting units, glazing, window and door frames, electrical materials, etc.) often have a glaring lack of sufficient certification in terms of characteristics. The same applies to building system installation and maintenance operators, who often have no certification.

7.2.2. INSTITUTIONAL OBSTACLES

The legislation on the energy efficiency of the building stock is rather recent, as it entered into force in 2010, and numerous amendments to the legislation in force have been adopted in recent years which are accompanied by a large number of ministerial decisions and implementing circulars with which technicians are not yet acquainted. It should be noted at this point that no cost-optimal levels of minimum energy performance requirements (Article 5 of Directive 2010/31/EU) and no specifications for nearly zero-energy buildings (Article 9 of Directive 2010/31/EU) have been adopted in Greece yet.

Furthermore, the institutional obstacles may also include the fact that no specific national standard has been adopted yet for the taking of adequate and confirmed measurements of the actual energy consumed in buildings. The Regulation on the efficiency of buildings (KENAK) has adopted a calculation method which is not related to the operation of the building (operational method), but is related to the building characteristics (asset method) and, therefore, it cannot be used as a useful standard for recording actual consumption levels. From the beginning of 2000, the international community has been developing a protocol (the International Performance Measurement & Verification Protocol), with a view to establishing a uniform method for taking and verifying measurements both for energy and water savings.

7.2.3. FINANCIAL OBSTACLES

The benefits of the energy upgrade of buildings are often estimated over time and are therefore deemed to be uncertain due to the lack of reliable market data concerning other investments. In Greece in particular, where there is an increased country risk due to the economic crisis and political instability, the uncertainty and risk associated with the return on a long-term investment are increased.

Bank loans, which have been a traditional tool for financing consumer and investment needs in Greece, have fallen off significantly, resulting in a corresponding reduction in investment expenditure for the renovation of buildings. For example, based on recent information from the Bank of Greece, the net flow of financing to households was negative in April 2010 and there will be an estimated drop of EUR 202 million by August 2014, with the rate of change to housing loans standing at -3.0%.

The financial obstacles may also include the drop in income and the change of consumer patterns among the Greek people in recent years due to the economic recession. Under these conditions, investing in renovation is seldom a priority.

7.2.4. LACK OF INFORMATION AND UPDATING

These obstacles are linked to a lack of skills and training among those involved in the application of new techniques and technologies in the field of energy renovation. There are weaknesses also in the fields of energy-saving technologies and renewable energy sources used in international renovation practice.

It has been proved that the lack of reliable and appropriate information on the energy efficiency of major renovation measures has delayed the application of new techniques for improving the building stock. The primary information that exists is general and cannot yet be adapted easily to each investor and/or building user. The information is provided on an occasional basis, and investors, even at an individual user level, are not given an opportunity to assess the benefits of the investment in energy renovation in an integrated and complete manner.

It is high time universities and technological educational institutes adapted their training programmes to include the concepts of energy savings ensured through the renovation of buildings in various scientific and technological disciplines, including all the individual lines of knowledge associated with both the shell of the building and its systems and installations, as well as the behaviour of the building stock users. It is also vital for those institutes to take part in research programmes in the field of buildings, focusing on renovation issues both in terms of the technical and the financial aspects involved.

8. FUTURE-ORIENTED PROSPECTS

8.1. DRAFT NEW POLICY LANDSCAPE - TRANSITION PATH

It is true that the transition to a ‘sustainable building stock’ cannot be realised in the short run. Undoubtedly, there are actions needed at all levels to overcome the obstacles and barriers detailed in the previous chapter. First, this takes the appropriate political will, which must translate into strong initiatives. It is also necessary to take institutional action and grant incentives combined with private sector mobilisation and secure appropriate funds.

A fundamental factor for the new policy to be successful is to make people energy conscious, which can be achieved only gradually and requires constant information and awareness activities as well as significant incentives (in terms of finances, town planning, taxation).

As referred to above, this study focuses on the gradual and coordinated upgrade of the building stock, to ensure that 80% of the existing building stock can be upgraded by 2050. To that end, both energy efficiency improvement policies and measures need to be analysed up until 2050, although the national targets have been set so far primarily for the period up until 2020.

In particular, the policy framework for the energy efficiency of buildings by 2020 consists of institutional actions relating primarily to the implementation of EU Directives, but it is also being promoted by measures already planned for the new programming period 2014-2020. Priorities have been included as part of the new programming period relating to the building stock for the transition to a low carbon dioxide emissions economy, aiming to deal effectively with the challenges involved and achieve Greece’s targets. Particular priority will be given to the following in respect of the building stock:

- Improving the energy efficiency of buildings and using RES in public buildings.
- Implementing interventions to save energy, enhance energy performance and use RES in residences and tertiary sector buildings.
- Developing energy management systems in public and tertiary sector buildings.
- Promoting awareness and information actions to ensure rational use of energy.
- Promoting energy service companies (ESCOs).

- Strengthening research and technological development in technologies relating to RES, energy saving, etc.
- Developing environmentally friendly energy generation and energy saving interventions through more efficient use of energy in agriculture, forestry and food processing, investment in more energy-efficient buildings and facilities, and/or encouragement, at a collective level, of the use of more efficient renewable energy sources, such as biomass.

The social and technological transitions required for the energy upgrade of the building stock can be described in three phases, with the following general characteristics:

- **Initial phase (PI)** for a period of five (5) years (up until 2020): the need to modernise the institutional framework and implement the necessary structures will be determined primarily during this phase, to create the appropriate energy awareness, in addition to the required mechanisms and infrastructure. Information and awareness measures, as well as incentives, pilot programmes, subsidised actions, etc. are also needed in this direction.
- **Speed-up Phase (PII)** for a period of twenty (20) years (2020-2040): further technological and innovation-oriented development of products and techniques should take place during this phase, while expecting a drop in the cost of energy upgrades and the establishment of additional benefits that will make possible a more cost-efficient major renovation of buildings.

  Given the existence of appropriate mechanisms, an effort will be made during this phase to speed up the renovation rate of the building stock.
- **Stabilisation phase (PIII)** for a period of ten (10) years (2040-2050): it is estimated that the energy upgrade market, which is currently immature, will have reached the required level of maturity by that time to implement interventions on almost the entire building stock, based primarily on private investment terms.

These phases were used in the analysis of social and technological transitions in the CRISP project, in conjunction with the corresponding actions required for achieving long-term strategy transition at three levels:

- Governance
- Structure
- Practices

As shown in Figure 49, the transition path to the ‘sustainable building stock’ vision by 2050 is not steady, but follows an S-curve, and Table 18 provides an indicative allocation of the activities required for that transition.

Figure 49: S-curve of the transition path to the 'sustainable building stock' vision by 2050

8.2. REQUIRED ACTIONS

Table 18 below presents an indicative allocation of the activities required to achieve the 'sustainable building stock' vision by 2050. Actions are listed which aim to eliminate those elements that prevent technical and social transition as well as actions that consist of elements that are necessary for the transition to the sustainable functioning of buildings, particularly through streamlined energy management and improved tenant-user behaviour.

2014-2020	
2014-2020	
2040-2050	

	Governance		Structure		Practices
1	Improvement of the legislative framework through cost-optimal minimum energy requirements concerning energy performance	1	Strengthening audit mechanisms for energy inspections	1	Carrying out energy savings campaigns in schools, universities, private workplaces
2	Setting the requirements for nearly zero-energy buildings	2	Strengthening audit mechanisms to make sure that certified products are installed and to prevent the import of illegal products	2	Training consumers to adopt energy-efficient materials in their properties
3	Securing resources for financing energy upgrades in the new programming period	3	Promoting Energy Service Companies (ESCOs)	3	Training of contractors and technicians on the installation and maintenance of energy-efficient technologies and materials in the building stock
4	Encouraging – reducing taxation for – consumers/residential users where they adopt energy-efficient methods and/or carry out renovation works	4	Setting up structures for recording the households classified within the energy poverty category (energy poverty monitor)	4	Implementing pilot renovation programmes for public buildings through ESCOs
5	Encouraging – reducing taxation for – energy services	5	Appointing energy managers in each public building and adopting an incentive ('green bonus') for the achievement of specific targets	5	Utilising financing tools and mechanisms (e.g. Funds for granting subsidies and loans, etc.)
6	Adopting incentives ('green bonus') for public servants - energy managers of public buildings that save energy and resources	6	Setting up databases for the energy mapping of public buildings	6	Green loans with more favourable terms

	Governance		Structure		Practices
7	Adopting incentives for subsidising green materials	7	Including the installation of smart meters in each energy saving intervention	7	Implementing programmes for subsidising energy upgrades in domestic residences, public and tertiary sector buildings
8	Including external costs in the pricing of energy	8	Setting up local smart grids	8	Implementing pilot energy and technological programmes, modernising neighbourhoods and blocks of buildings
9	Adopting policies and measures for speeding up and facilitating the penetration of energy-efficient practices and nearly zero-energy buildings	9	Carrying out research and development for new construction materials (that require less energy and are more environmentally friendly)	9	Linking the energy consumption of a building to its objective value
10	Adopting incentives for renovating buildings with several owners, instead of individual properties/apartments	10	Setting up a market - register of green materials	10	Creating flexible financing - bank products for the energy upgrade of buildings
11	Adopting incentives for renovating building complexes	11	Expanding the natural gas network	11	Upgrading public and tertiary sector buildings through ESCOs and public- private partnerships (PPPs)
12	Providing incentives for purchasing/ leasing energy-efficient buildings	12	Mechanisms for direct measurement of the energy footprint in the area	12	Implementing energy management systems in public buildings and organisations
13	Adopting stricter requirements concerning the energy efficiency of new buildings	13	Promoting RES systems	13	Utilising financing tools and mechanisms (e.g. funds for granting loans, guarantees, etc.)
14	Adopting stricter requirements concerning the energy efficiency of new buildings	14	Expanding geothermal energy and high efficiency cogeneration of heat and power networks	14	The energy upgrade of degraded settlements

	Governance		Structure		Practices
		15	Expanding the natural gas network all over Greece	15	Expanding the ESCOs scheme to include the energy upgrade of
				16	The energy upgrade of all public buildings

Table 18: Temporal breakdown of activities for achieving the 'sustainable building stock' vision by 2050

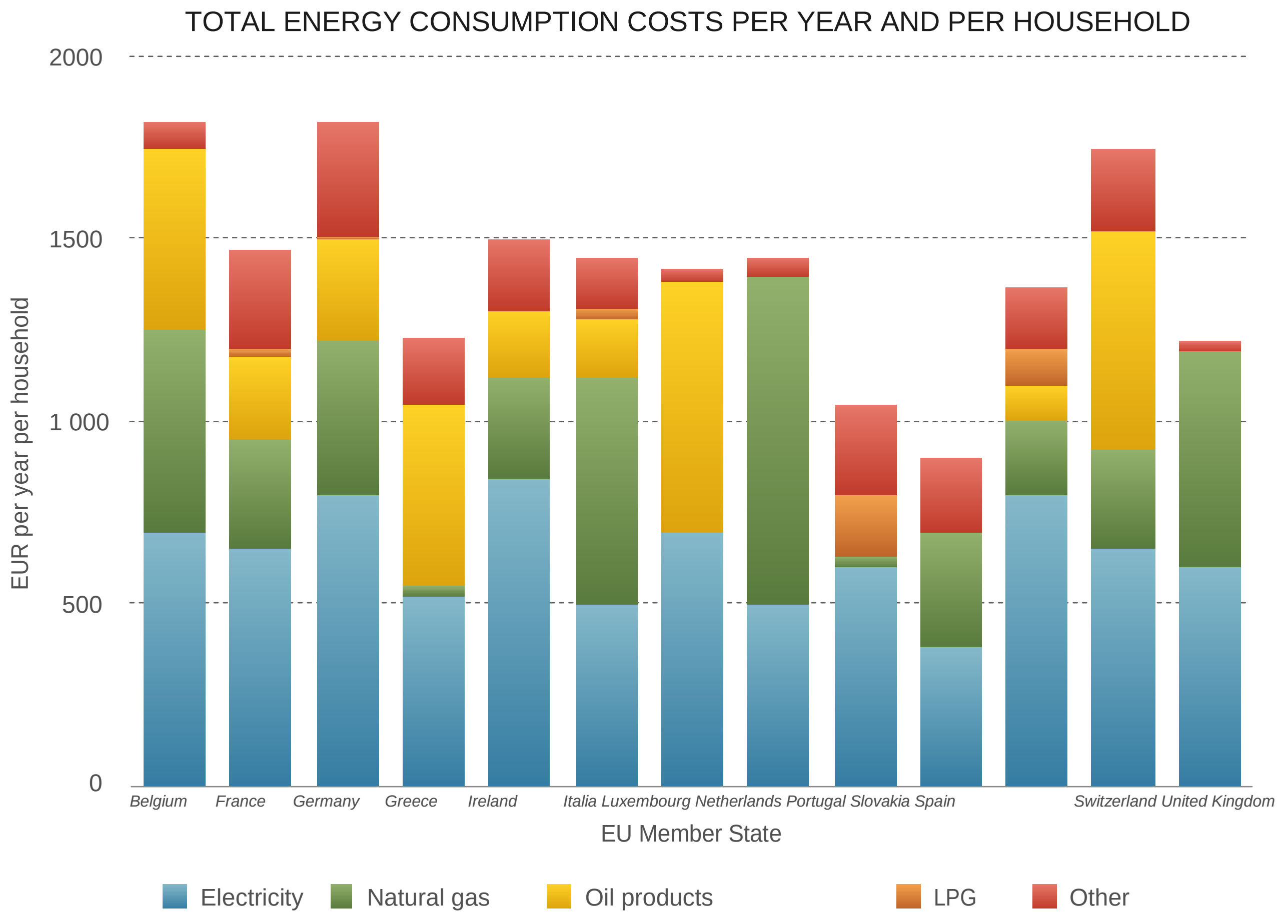
8.3. SOURCES OF FINANCING FOR THE ENERGY RENOVATION OF BUILDINGS

8.3.1. PRIVATE FUNDS

A number of energy upgrades of the building stock are implemented individually, either as part of an overall renovation of the property concerned or aiming specifically to improve its energy performance. However, given that the economic benefit is not felt immediately in this case, as the additional benefits of renovation have not been communicated properly, except for the net economic benefits resulting from the functioning of the buildings, the number of front runners is rather small. Energy projects usually take a long time to pay off (without taking into account the additional benefits), i.e. approximately ten years, while various surveys have shown that owners would wish to see their investment pay off within five years before they would invest in the energy upgrade of their buildings.

Moreover, where energy upgrades are financed using the owners' own funds only, it is not always easy to secure the initial capital needed. In addition to the difficulty of securing the initial capital, it is also hard to obtain loans from financial institutions, given the current state of the economy. This is especially true in Greece, where the need to upgrade buildings in terms of energy is not fully appreciated yet.

Greek households spend a rather significant sum of money to meet their energy needs (EUR 1 230.00), as shown by Figure 50, amounting to a monthly salary per year for an average household. The energy savings resulting from renovation would reduce that sum significantly and would release other resources, respectively. Furthermore, based on this sum, it is possible to assess the sum that individuals would be willing to spend on the energy upgrade of their home. It should be noted, however, that this sum relates to the actual consumption levels of households, which are not always sufficient to ensure thermal comfort conditions, in recent years in particular, which have been marked by high energy prices and reduced income levels for households. As already referred to in this study, the calculations are based on the property and its energy features, as estimated by the methodology provided for in the Regulation on the efficiency of buildings (KENAK) (asset method), which unavoidably leads to higher estimates of consumption levels, i.e., approximately double.



	Electricity	Natural gas	Oil products	LPG	Other
Belgium	700	550	500	0	70
France	650	300	230	20	270
Germany	800	420	280	10	310
Greece	520	30	500	0	180
Ireland	840	280	180	0	200
Italy	500	620	160	30	140
Luxemburg	700	0	680	0	40
Netherlands	500	900	0	0	50
Portugal	600	30	0	170	250
Slovakia	380	320	0	0	200
Spain	800	200	100	100	170
Switzerland	650	270	600	0	230
United Kingdom	600	590	0	0	30

Figure 50: Energy consumption costs in EUR per year and per household [53]

Private capital should also include investments made through energy service companies (ESCOs), i.e. a new mechanism for the promotion, management, financing and monitoring of energy upgrade projects, to remove mainly financial obstacles to the implementation of energy saving interventions. This method used to implement and finance energy projects is expected to play a major role in the upgrade of public buildings and infrastructure in particular, as well as hospitals, hotels and other energy-intensive facilities.

8.3.2. BANK PRODUCTS

In the period from late 2000 to early 2010, the Greek banking system launched bank products aimed at the upgrade of residences which include energy upgrades, too.

Table 19 below lists the key banks and their programmes.

Bank	Bank product
Alpha Bank	Alpha Green Solutions - Energy Saving
National Bank	Energy Ethnostegi
Eurobank EFG Group	Green Housing - Energy Saving Loan
Piraeus Bank	Green Solutions for Individuals

Table 19: Banks and bank products for energy savings

The following is a short description of the bank products described above:

The ‘Energy Saving Home’ housing programme was intended to cover the costs incurred for repair and/or renovation work carried out in residences in order to improve their energy efficiency, such as:

1. Installation of thermal insulating window frames/glazing
2. Replacement of old burner/boiler system
3. Installation of solar water heaters
4. Other thermal insulation applications
5. Installation of photovoltaic systems

The ‘Energy Ethnostegi’ programme enabled owners wishing to energy-upgrade their residences to obtain financing for up to 100% of the approved budget for energy upgrade projects with/without collateral. The interest rate without collateral was lower than the National Bank’s current consumer lending rate.

The ‘Green Housing - Energy Saving Loan’ programme provided financing to cover the repair and/or renovation costs incurred in connection with the energy upgrade of residences and, therefore, with energy savings. Eligible interventions included:

1. Change of window/door frames (including shutters, roll shutters, etc.) and installation of double glazing
2. Thermal insulation of walls, roof insulation and/or installation of an envelope
3. Installation or replacement of burner/boiler with a new oil- or gas-fired one, or of a RES system
4. Other interventions (heat compensation system, insulation of pipes, shades, solar collectors, etc.)

The ‘Green Solutions for Individuals’ programme targeted owners wishing to ‘turn green’ by ensuring substantial savings of energy and natural resources through the enhancement of the energy efficiency of their properties by carrying out repair works, which were covered by up to 100% with a low interest rate and a discount in expenses.

It should be noted that the above programmes implemented by financial institutions are no longer in place, as the institutions currently participate in the ‘Savings at Home’ programme, in which the banks are not just co-investors, but take an active role by undertaking:

· to receive and assess the applications filed by interested parties, checking the supporting documentation required by the programme guide;
· to register the applications in the information system;
· to disburse the loans and pay the grant;
· to make payments to suppliers/crews;
· to certify the implementation of the project through an administrative audit.

Undoubtedly, financial institutions can play a major role in achieving the ‘sustainable building stock’ vision, as they ensure funding leverage. Despite the economic difficulties afflicting Greece, it is expected that the Greek financial system will offer attractive lending interest rates to live up to the expectations of would-be clients/investors. Actually, financial institutions, either in cooperation with the State or independently, are expected to develop new products and set up sales strategies to attract those willing to invest in the energy upgrade of buildings.

8.3.3. ANALYSIS OF BARRIERS TO INVESTMENT

The opportunity cost has always been a factor assessed by investors who are waiting for the ‘right’ opportunity to maximise their benefits. In respect of the energy renovation of buildings, in the form of investment, the sums required for a medium renovation investment amount to approximately to EUR 15 000 for a typical apartment with a surface area of 100 m^2, which may reach EUR 50 000 for major energy performance renovations. These sums are too high to invest for individual minor investors, as they might place their money in more profitable ‘opportunities’. This situation, in conjunction with a lack of knowledge of the additional benefits resulting from energy upgrades, increases the discount rate used to adjust future economic benefits to present values.

Respectively, the internal rate of return of individual investments is between 8% and 10%, precisely because additional benefits, such as the health of users of residences and improved indoor environment quality, are not taken into account and integrated. Finally, the payoff of investments made by owners in the energy upgrade of their residences usually takes long a long time, i.e. approximately ten (10) years, which causes investment insecurity.

Another factor that should be stressed is that the investment made in the improvement of the energy efficiency of buildings is deemed to be ‘irreversible’, i.e. impossible to undo later on. Irreversibility is critical, in particular where private funds are invested in small-scale renovations that do not utilise all the energy saving options available for buildings constructed specifically before 2000. The next renovation will usually take place after 20 years, thus limiting the opportunity for a significant reduction in the energy costs associated with the functioning of buildings.

Due to the current level of financial liquidity and the small size of the market in the energy renovation of buildings, renovation costs are still high where adjusted to energy saving units. The high costs are a deterrent for individual minor investors, as they cannot benefit from scale economies. In Greece in particular, account should also be taken of the fact that a large percentage of buildings are privately-owned, which renders the decision-making process for buildings with many owners extremely difficult.

Attracting larger investments in the energy upgrade of buildings also entails a number of risks. A significant risk taken into account is the macroeconomic environment in the country where the investment is to be made (country risk), which depends on the country’s financial situation, political stability, geopolitical standards and a number of other factors. Investment security can be increased where international economic organisations, such as the European Investment Bank, take part in large-scale projects, as these can secure investment funds and mitigate the risk. The Greek economy, despite having been ranked 78th by the World Bank for the year 2011/2012 (Doing Business 2013, World Bank, [45]), is also one of the 10 economies that improved at least in three areas linked to the development of business activity (Table 20).

	Economy	Ease of doing business rank	Reforms making it easier to do business									
			Starting a business	Dealing with construction permits	Getting electricity	Registering property	Getting credit	Protecting investors	Paying taxes	Trading across borders	Enforcing contracts	Resolving insolvency
1	Poland	55				✔			✔		✔	✔
2	Sri Lanka	81	✔			✔	✔			✔		
2	Ukraine	137	✔			✔			✔			
4	Uzbekistan	154	✔				✔			✔		✔
5	Burundi	159	✔	✔		✔				✔		
6	Costa Rica	110	✔	✔			✔		✔			
6	Mongolia	76	✔				✔	✔				
8	Greece	78		✔				✔				✔
9	Serbia	86	✔								✔	✔
10	Kazakhstan	49	✔				✔					✔

Table 20: Ten economies that improved, in 2011/2012, at least 3 factors affecting the development of entrepreneurship [45]

8.3.4. DETERMINATION OF POTENTIAL SOURCES AND MECHANISMS OF FINANCING

Experience from recent years has shown, firstly, that EU Member States have kept increasing the use of cohesion policy financing for energy performance purposes, in buildings in particular, and, secondly, that there has been an increase in the use of financing schemes. There are no complete data, however, concerning the impact of this financing on energy savings in the building sector.

It should be stressed that the European Investment Bank (EIB) has provided specifically for support for investment for energy savings in the building sector. The EIB has set a number of criteria to be used for choosing the projects to be supported, including *inter alia:*

- cost-optimal renovations;
- small-scale projects eligible under national regional development programmes;
- projects for the creation of nearly zero-energy buildings;
- innovative technologies relating to energy savings.

The EIB has already participated in the effort made to renovate the building stock with a number of bank products intended for public organisations (ELENA, JESSICA programmes) and ESCOs, by offering technical and financial assistance.

Table 21 below lists a number of possible financing mechanisms which can secure the (public and private) funds required for the energy upgrade of buildings.

Source of financing	Schemes/mechanisms	Total available financing	Financing for energy efficiency (EE)
Financing under the cohesion policy	Operational programmes, including financing schemes (e.g. JESSICA)	EUR 9.4 billion intended for sustainable energy (RES & EE)	EUR 4.6 billion intended for EE, cogeneration and energy management
Financing of research	HORIZON 2020 programme	EUR 6.5 billion for 'Safe, clean and efficient energy' in the period 2014-2020	EUR 100 million for buildings from programmes in the years 2014 and 2015
Financing under the enlargement policy	Facilities from IFIs (SMEFF, MFF, EEFF)	EUR 552.3 million (381.5 + 117.8 + 53 respectively)	Approximately one third of the total financing for projects in the industrial and building sector
European energy programme for recovery (EEPR)	European Energy Efficiency Fund (EEEF)	EUR 265 million	70% of the financing will be spent on energy efficiency
Financing granted to local bodies (local authorities, etc.) for the provision of technical assistance under the competitiveness and innovation programme	ELENA programme, with support from the European Investment Bank (EIB)	Financing granted based on the project leverage coefficient Aid financing of the order of EUR 2 million, with funds available amounting	Mobilisation of investments with a leverage coefficient of more than 20.
Financing under the section of the new LIFE programme -action for the environment and the climate	Private financing for energy efficiency instrument (PF4EE)	EUR 80 million available in cooperation with the European Investment Bank	Targeted to SMEs as well as larger enterprises and small local authorities

Table 21: Financing programmes for supporting energy upgrade projects for buildings in Europe [50] [51] [52]

The partnership agreement (PA) for the programming period 2014-2020 is broken down into national operational programmes, as well as into regional ones which are classified into categories depending on the actions and financing areas and include actions relating to energy savings. As regards energy-related matters in particular, they have been included in the Operational Programme 'Competitiveness, Entrepreneurship, Innovation' (OP-CEI), in conjunction with the regional operational programmes (ROPs), and cover the entire territory of Greece with a budget of EUR 4.56 billion of public expenditure (EUR 3.65 billion of Union contribution).

More specifically, investment priority 4c of the OP-CEI relates to supporting energy efficiency, smart energy management and the use of renewable energy sources in public infrastructure, including public buildings, and in the housing sector. Energy upgrade projects for residences are to be financed from the OP-CEI, with a lower contribution from the ROPs.

9. ASSESSMENT OF THE EXPECTED ENERGY SAVINGS AND OF THE BROADER BENEFITS

9.1. PRESENTATION OF RESULTS

The renovation and energy savings intervention calculation model, as presented in Section 6.2 and detailed in Annex III, specifies the number of renovated buildings and the required new investments up until 2050, depending on the assumptions used under each energy savings scenario.

Annex IV provides a detailed description of the results for the five scenarios for residences (basic, medium, strong, ambitious and targets) and the two scenarios for other types of tertiary sector buildings (basic and targets). Figures 51, 52 and 53, respectively, show the results for typical residences.

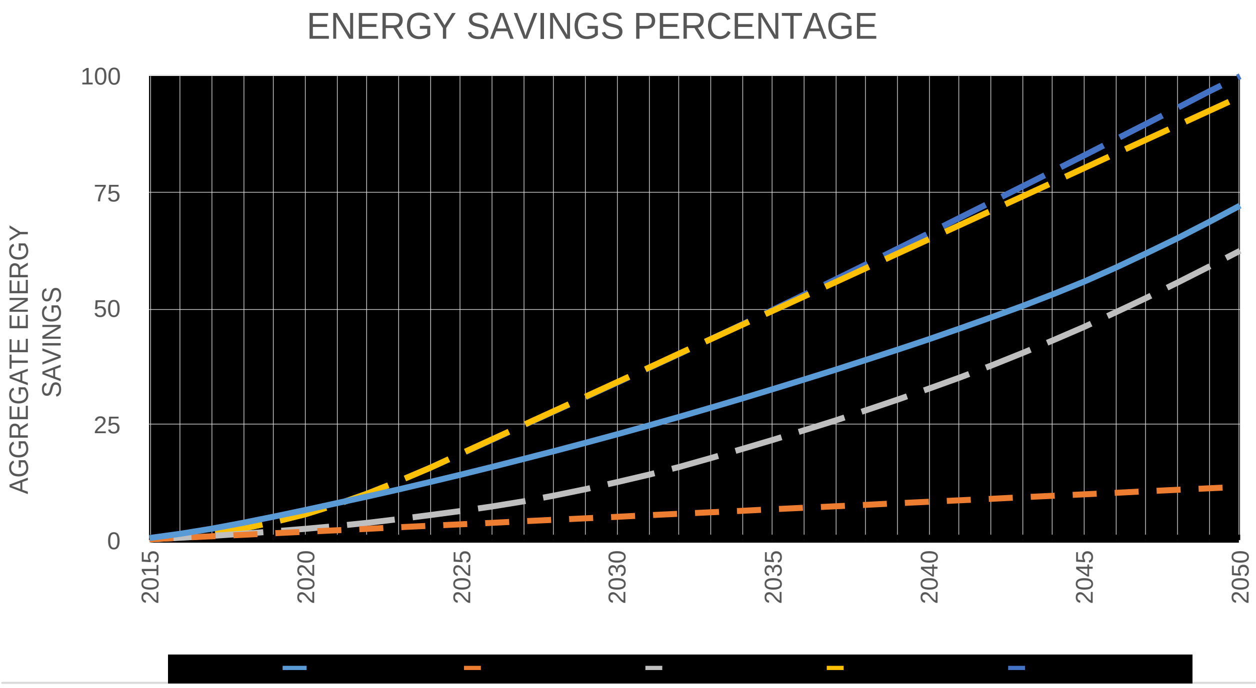


Figure 51: Energy savings percentage (compared to 2011) for typical residences under different renovation scenarios

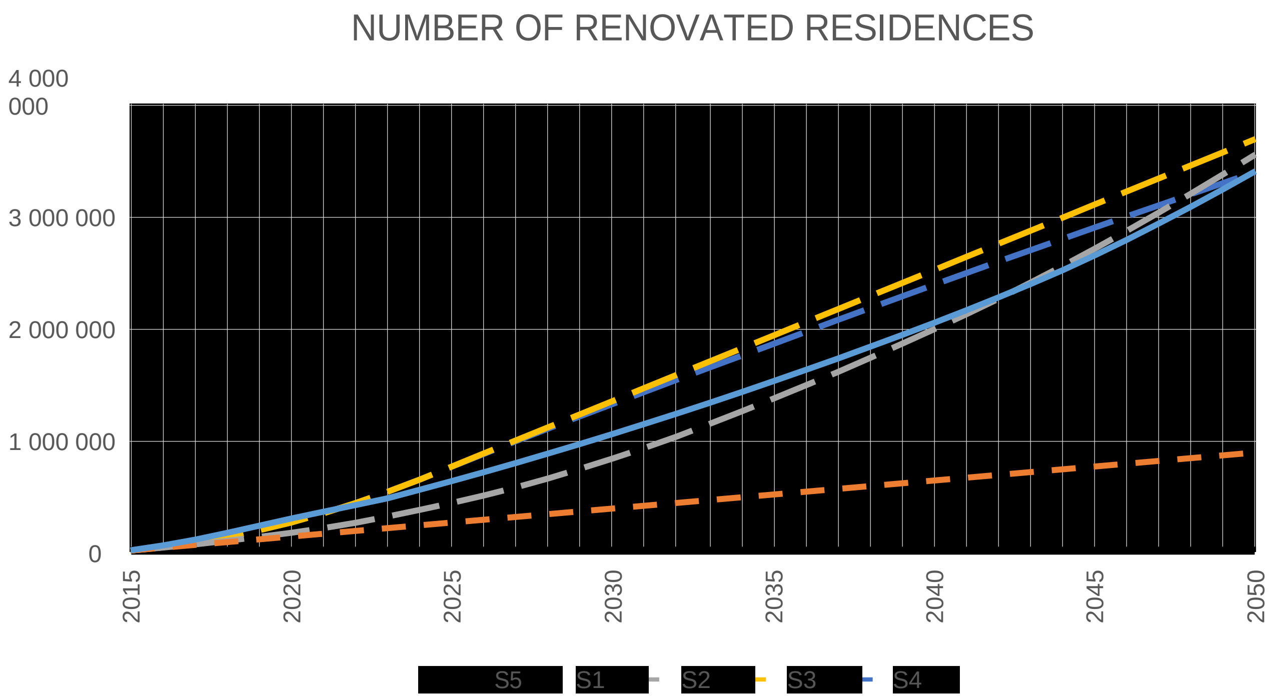


Figure 52: Number of renovated typical residences under different scenarios

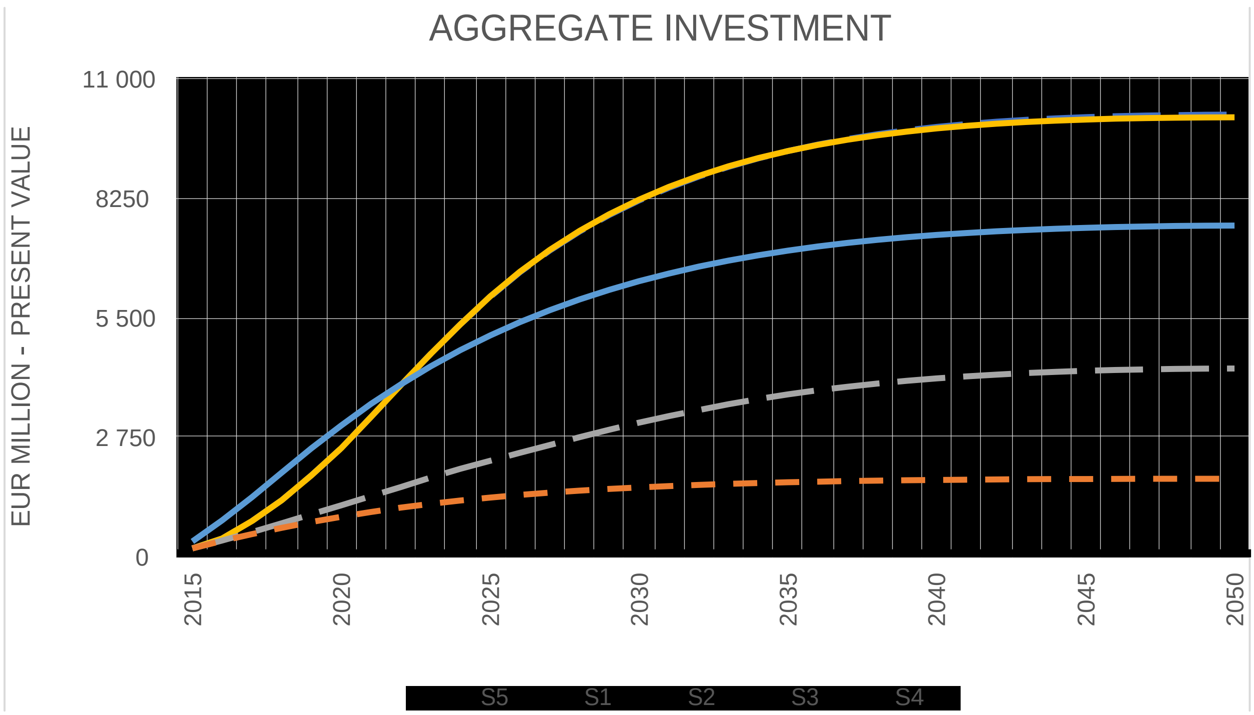


Figure 53: Aggregate investment amount in present values (i=8%) under different typical residence renovation scenarios

As regards the targets scenario (S5) in particular, under which the national targets set through the national energy efficiency action plan for 2020 are also achieved, the aggregate investment amount (present value) required amounts to approximately EUR 7.6 billion up until 2050, to achieve energy savings of the order of 72% compared to the reference year (2011), corresponding to 3 895 ktoe.

Based on the analysis, the targets scenario (S5) will ensure both achievement of the intermediate and final savings targets and the simultaneous creation of an attractive environment for mobilising investment. The internal rate of return on investment (IRR) is approximately 9%. Those values and the expected investment costs both for 2020 and up until 2050 highlight the need for the State to participate in order to make renovation investment more attractive. At the same time, an assessment of parallel additional benefits (health, employment, etc.) demonstrates that the benefit from energy savings renovation in residences has a significant effect on society and secures funds by reducing expenditure in other areas.

Table 22 below describes the energy-related and economic results of the different scenarios, as well as the additional social and environmental parameters used to assess them.

RESULTS OF SCENARIOS - BENEFITS		SCENARIO									
		S1		S2		S3		S4		S5	
		2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
ENERGY-RELATED	Energy savings (TWh)	0.2	0.2	0.34	2.16	1.04	1.93	1.04	2.23	878	2.29
	Aggregate energy savings (ktoe)	105	628	138	3 371	308	5 161	308	5 400	357	3 895
	Energy savings percentage compared to 2011	1.9%	11.6%	2.6%	62.4%	5.7%	95.6%	6%	100%	6.6%	72%
FINANCIAL	Aggregate cost (million)	1 185	6 017	1 563	30 043	3 460	48 107	3 460	50 197	4 036	35 820
	Aggregate benefit (million)	356	9 917	427	42 083	846	78 116	996	100 257	7 746	53 740

RESULTS OF SCENARIOS - BENEFITS		SCENARIO									
		S1		S2		S3		S4		S5	
	Aggregate profit (million)	-829	3 900	-1 136	12 040	-2 614	30 009	-2 463	50 060	-2 964	17 719
ADDITIONAL PARAMETERS FOR ASSESSING THE SCENARIOS	IRR (%)	8.78		10.15		9.72		13.13		9.39	
	Jobs	3 657	2 502	6 176	26 665	18 855	23 816	18 855	27 562	15 860	27 530
	Aggregate reduction in CO_2 Mt	1.4	8.4	1.8	45	4.1	69	4.1	72	4.77	52
	Total cost per energy savings unit (EUR million / ktoe)	11.3	9.6	11.3	8.9	11.2	9.3	11.2	9.3	11.3	9.19
	Benefit based on the multiplier from additional benefits (health, employment, etc.)	7 800		24 080		60 018		100 120		35 440	

Table 22: Energy-related, economic and additional benefits from the energy upgrade of residences under the different scenarios

Correspondingly, as regards tertiary sector buildings, there are result tables provided in Annex IV, and Table 23 below provides an analysis of the number of buildings in the stock that are renovated, the internal rate of return (IRR), the required cost and the payoff period for the initial investment.

	USE OF THE BUILDING SCENARIO	Number of buildings that		Energy savings (ktoe)		IRR	Renovation cost (EUR/kWh)	Repayment year
		2020	2050	2020	2050			
Offices	BASIC S1	6 510	39 060	32	195	1.47	1.5	2034
	TARGETS S4	6 947	141 439	85	1 450	1.96	1.5	2034
Schools	BASIC S1	2 667	16 000	12	72	7.74	1.2	2023
	TARGETS S4	1 100	14 780	8	134	8.61	1.2	2025
Hotels	BASIC S1	1 500	9 000	21	125	3.62	1.5	2029
	TARGETS S4	619	8 314	14	231	4.21	1.5	2029
Hospitals	BASIC S1	282	1 692	10	58	4.85	1.5	2027
	TARGETS S4	117	1 570	7	109	5.53	1.5	2028

Table 23: Comparing scenarios and key parameters for the stock of tertiary sector buildings

Figures 54, 55 and 56 below show the results for all tertiary sector buildings.

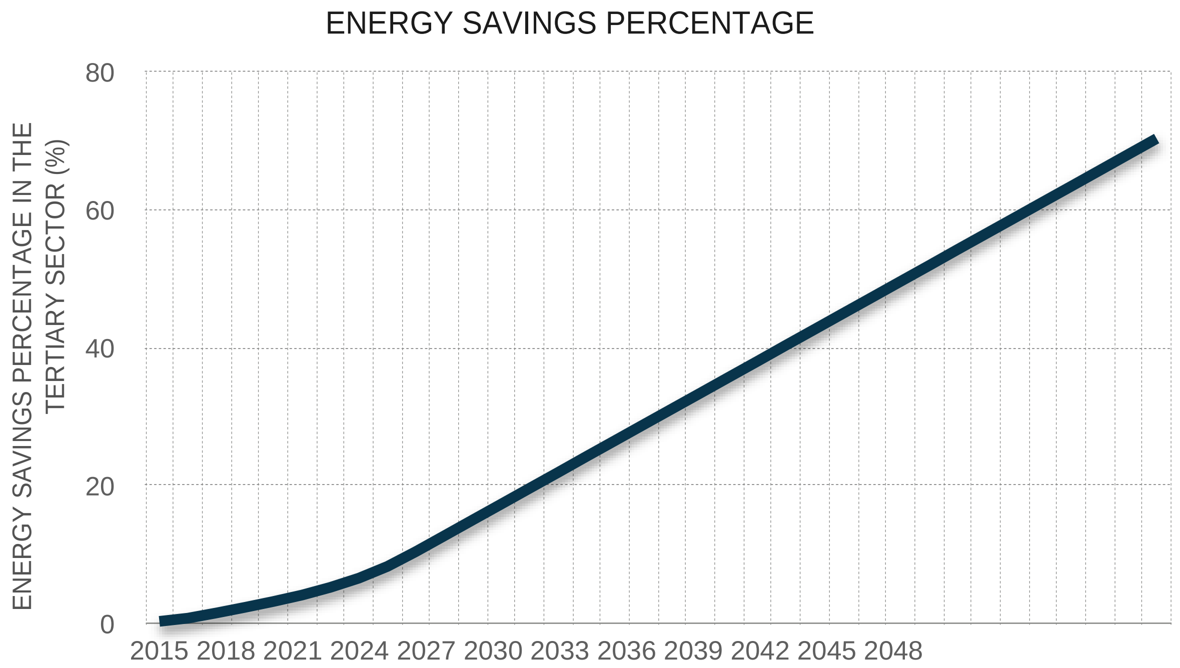


Figure 54. Energy savings percentage for tertiary sector buildings under the renovation targets scenario

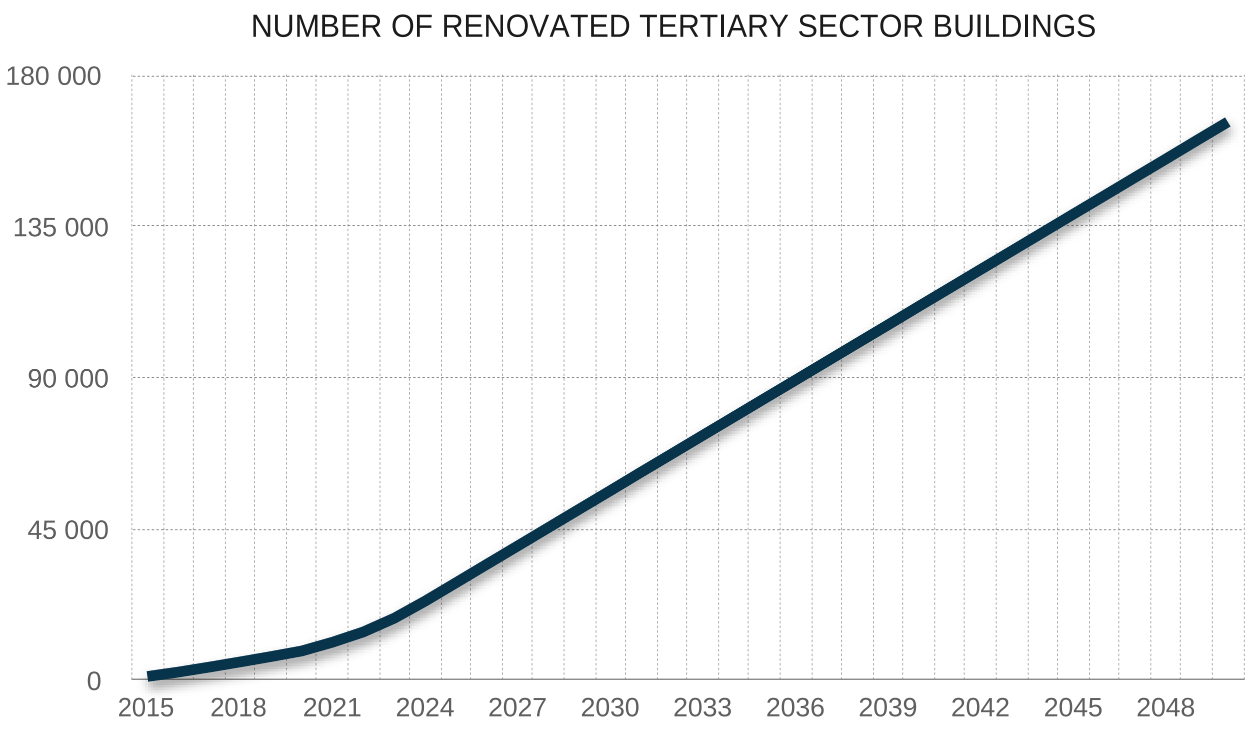


Figure 55: Number of renovated tertiary sector buildings under the renovation targets scenario

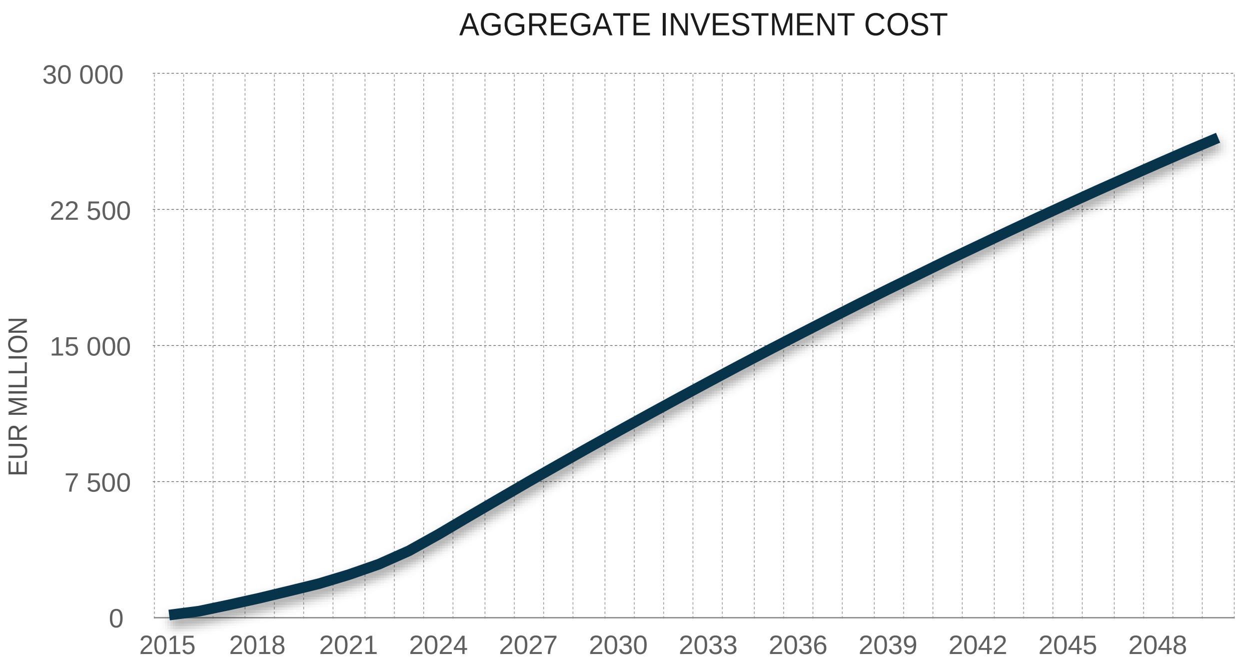


Figure 56 : Aggregate investment amount in present values under the tertiary sector building renovation targets scenario

10. CONCLUSIONS

Renovating the building stock to achieve high energy efficiency is now one of the strategic investment fields in each country, as in addition to ensuring energy savings and reducing carbon dioxide emissions, there are also other economic and social benefits, such as employment, health, energy security and fighting energy poverty.

This long-term strategy report presents primarily Greece's potential for modernising its existing building stock, while at the same time ensuring energy savings, focusing mainly on the large number of typical Greek domestic residences, which number more than 4 million. There are energy savings opportunities in existing tertiary sector buildings too, such as office buildings/shops, schools/educational buildings, hospitals, hotels and public buildings. The report also aims to further analyse the economic and additional social and environmental benefits resulting from the energy upgrade of buildings, to stir the interest among investors in renovating the building stock, recognising that a more holistic, composite social and technical approach is needed, to mitigate the risks and thus ensure future success.

The long-term strategy report sets a clear target for the transition to a sustainable building stock by 2050, i.e. the gradual and coordinated upgrade of the building stock, to ensure that 80% of the existing buildings become energy-efficient by 2050, also taking into account Greece's individual targets and commitments, as well as the prevailing economic conditions, and also provides a reference framework that is necessary for promoting the investments to be mobilised.

The key energy savings targets for the building stock can be achieved by formulating a strategy consisting in the implementation of measures and removal of obstacles emerging at three strategy implementation levels: governance, structure and practice. The strategy aims to meet society's future needs as directly and efficiently as possible. The initial implementation period of the strategy relates to the period up until 2020 and constitutes a critical phase, in which measures need to be taken to boost the creation of a market in improving the energy efficiency of buildings through renovation. This phase includes continuation and strengthening of institutional and non-institutional measures that are linked to the renovation of the building stock. This approach will create the appropriate critical mass and will ensure the mobilisation of the funds needed for private investment, also utilising resources from the coming programming period 2014-2020. In the following phase, developing in the period 2020-2040, further growth is expected in innovative energy products and services, along with a drop in energy renovation costs, to make sure that a mature and stabilised market is established by the final phase, up until 2050, to make possible the implementation of energy renovation projects without any special aid.

In developing the strategy, account was taken of five scenarios (basic, medium, strong, ambitious and targets, as they resulted from combining different rates (basic, slowly increasing and medium intensity) and types of renovation (minor, medium major and nearly zero-energy consumption). The scenarios were analysed based on specific assumptions as regards the size of the building stock, the methodology used to estimate the energy savings, the cost-effectiveness of the interventions, and the energy and financial amounts.

Based on the scenarios examined and presented, energy savings of 11% to 100% resulted for typical residences compared to the energy consumed by those residences in 2011, and the investment costs ranged between EUR 6 billion to EUR 50 billion by 2050 for renovating a stock of 0.9 to 3.7 million typical residences. The internal rate of return for those investments ranged between 8% and 13%, and the resulting additional benefits translated into an average of 23 to 27 thousand jobs per year up until 2050.

As regards tertiary sector buildings (offices, shops, school buildings, hospitals and hotels), the energy savings percentage that could be achieved stood at 72% compared to the energy previously consumed by those buildings, and the relevant investment costs stood at EUR 26 billion up until 2050 for renovating approximately 170 thousand buildings. However, the internal rate of return of those investments is quite low, ranging, depending on the type of building, between 2% and 8.5%, mainly due to the higher renovation costs required for tertiary sector buildings and the rather small number of buildings compared to the stock of typical residences. The resulting additional benefits translate into an average of 10 thousand jobs per year up until 2050.

The indicator of the expected cost per energy savings unit (EUR million / ktoe) is also interesting. In respect of the entire building stock and under all the scenarios considered, the indicator is expected to range between EUR 8.9 to EUR 11.3 million / ktoe. The strong drop in the cost of savings measures, to reduce the values of the cost per energy savings indicator, highlights the need to take measures to strengthen applied research in the field of new and better renovation techniques and technologies aiming to enhance the energy behaviour of buildings and their users, which are to be adopted immediately and are expected to boost the market in energy renovation.

Scenario (S5), which is feasible but ambitious, will ensure both achievement of the intermediate and final energy savings targets and the simultaneous creation of an attractive environment for mobilising investment based on a slowly increasing renovation rate, while at the same time creating a significant number of jobs at the local level to mobilise the national economy.

It should be stressed that the actions carried out for the energy upgrade of buildings also yield additional benefits (health, employment, etc.), which must not be ignored as they offer multiplied advantages at individual, sectoral and national levels. The report aims to provide a conservative assessment of the additional benefits resulting from energy savings, to highlight the magnitude of the advantages ensured in terms of sustainable development (social, economic, environmental), as the benefit from the renovation of buildings has a significant effect on society and secures funds by reducing expenditure in other areas.

The benefits resulting from energy savings in buildings and the relevant multipliers,
if aggregated, can represent at least double the cost of the savings.

There are also significant benefits for the economy from the reactivation of the construction sector, whose decline during the crisis has deprived the national income from a direct contribution of 7% and an indirect contribution of 15%. The energy upgrade of residences and tertiary and public sector buildings can bring about an actual and substantial recovery in the construction and real estate markets, thus increasing employment and promoting construction and other materials with increased added value, many of which are produced in Greece.

The analysis indicates that the prospect of higher energy savings in the building stock requires attracting considerable investments, which can be accelerated if the relevant benefits include more than the purely economic advantages and the direct energy savings relationship in the form of the return on the capital invested.

The mobilisation of private investment requires the incorporation of ambitions and goals into a common awareness among stakeholders and society in general in terms of both economic and additional benefits, such as employment, health, energy security and reduction in the energy dependence. Furthermore, the rates of return on the investment made in the energy upgrade of buildings demonstrate that there is significant potential for energy savings. Taking advantage of the opportunity to invest EUR 4 billion and save 360 ktoe from energy consumption in the building sector has now become a clear priority, in the initial years in particular, when the relevant market is maturing, and requires that the relevant interventions be supported through state participation, to make investment more attractive and ensure payoff periods shorter than ten years.

The method used to implement and finance energy projects is expected to play a major role in the upgrade of public buildings and infrastructures, as well as residences, hospitals, hotels and other energy-intensive facilities, by utilising the experience gained in recent years, which indicates that the EU Member States have kept increasing the use of cohesion policy financing for energy performance purposes. The European Investment Bank has already participated in the effort made to renovate the building stock with a number of bank products intended for public organisations (ELENA, JESSICA programmes) and ESCOs, by offering technical and financial assistance. The national partnership agreement for the programming period 2014-2020 has made available a budget of EUR 4.56 billion for energy programmes under the investment priorities of the Operational Programme ‘Competitiveness, Entrepreneurship, Innovation’ (OP-CEI), also including energy savings and energy efficiency actions. The public sector serves as a role model in the market and has already taken the lead in implementing energy renovations, including energy upgrades, in public buildings used by the central/regional government or local authorities in coordination with other actions implemented under Directive 2012/27/EU, and this national strategy report meets the relevant conditionalities and ensures that financial resources are made available for immediate utilisation.

Moreover, the success of the long-term strategy is also based on the implementation of state actions covering both institutional measures for improving the building stock and ongoing awareness and information actions concerning the resulting benefits as well as the presentation and communication of successful best practices aiming to raise appropriate energy awareness among all stakeholders. In conclusion, the participation and cooperation of all stakeholders will facilitate the successful implementation of the long-term plan for boosting the energy renovation market, to ensure benefits for society as a whole.

It should be stressed, finally, that the long-term strategy will be updated every three years based on data collected and processed from the implementation of the measures, in an ongoing assessment of its success, as well as through sustained dialogue and cooperation with the stakeholders and experts from the public and private sectors.

SOURCES - REFERENCES

1. EUROSTAT, 2014, Energy balance sheets 2011-2012, Statistical Books.

2. MINISTRY OF ENVIRONMENT, ENERGY AND CLIMATE CHANGE, 2014, ANNUAL INVENTORY SUBMISSION OF GREECE UNDER THE CONVENTION AND THE KYOTO PROTOCOL FOR GREENHOUSE AND OTHER GASES FOR THE YEARS 1990-2012

3. PPC SA, 2014, Financial Results for 2013

4. CRES, 2013, BUILD UP Skills – Greece Analysis of the existing situation at the national level and in respect of the Association of Greek Contracting Companies (SATE), 2012, The Greek construction sector

5. CRISP, 2014, Creating Innovative Sustainable Pathways, Final Report, 7th EP Research Project 265310.

6. Klinckenberg F., Pirie M., McAndrew L., 2013, A report by The Policy Partners for Eurima, London, January 2013.

7. Svenfelt A., Engstrom R., Svane O., 2011, Decreasing energy use in buildings by 50% by 2050 — A backcasting study using stakeholder groups, J. Technological Forecasting & Social Change 78, Elsevier.

8. JWG of CA EED, CA EPBD and CA RES, 2013, Towards assisting EU MS on developing long term strategies for mobilising investment in building energy renovation (per EED Article 4)-COMPOSITE DOCUMENT.

9. Central Union of Municipalities and Communes of Greece (KEDKE), 2010, The role of local authorities in the administration and operation of school units.

10. Swan L., Ugursal VI., 2009, Modeling of end-use energy consumption in the residential sector: A review of modeling techniques, Renewable and Sustainable Energy Reviews 13, Elsevier

11. Fracastoro G., Serraino M., 2011, A methodology for assessing the energy performance of large scale building stocks and possible applications, Energy and Buildings, 43, Elsevier

12. EU COM (2014) 520 final, Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy.

13. EU COM (2011) 112 final, A Roadmap for moving to a competitive low carbon economy in 2050.

14. ELSTAT, 2014, POPULATION AND RESIDENCE CENCUS 2011, Characteristics and facilities of residences.

15. TABULA, 2012, Typology Approach for Building Stock Energy Assessment. Main Results of the TABULA project, Final project report.

16. ELSTAT, 2014, POPULATION – RESIDENCE CENSUS 2011, Residences/households comforts.

17. OSK-PPP, 2011, Construction and maintenance of schools using public private partnership (PPP) schemes

18. ELSTAT, 2013, SURVEY ON THE ENERGY CONSUMPTION OF HOUSEHOLDS, 2011-2012

19. National Technical University of Athens, 2009, 'Looking into and recording the standards used to describe the energy consumption patterns of Greek families', Laboratory of Steam Boilers and Thermal Plants of the School of Mechanical Engineering of National Technical University of Athens.

20. MEECC, 2014, Analysis of energy efficiency certificates (EECs), as issued under the 'Savings' programmes and registered as a whole in the database of the MEECC.

21. Government Gazette, Series II, No 407/2010, approval of the Regulation on the energy efficiency of buildings.

22. ODYSSEE-MURE, 2012, Energy Efficiency Trends in Buildings in the EU.

23. OECD, 2012, Greece: Review of the Central Administration.

24. ELSTAT, 2013, LIVING CONDITIONS IN GREECE.

25. A. Gaglia, K. Balaras, S. Moirasgenis, E. Georgopoulos, I. Sarafidis, D. Lalas, 2010, building stock, energy savings potential and reduced pollutants in the residential and tertiary sectors in Greece - Handling measures.

26. Technological Education Institute of Piraeus - LSEA&EO, 2012, Energy mapping survey and actions proposed to ensure energy savings - Phase A, Emporiki Bank, Laboratory of Soft Energy Applications and Environmental Protection (LSEA&EO) Mechanical Engineering Department of the Technological Education Institute of Piraeus.

27. Technological Education Institute of Piraeus - LSEA&EO, 2013, Energy mapping survey and actions proposed to ensure energy savings - School complex of Nikaia, Laboratory of Soft Energy Applications and Environmental Protection (LSEA&EO) Mechanical Engineering Department of the Technological Education Institute of Piraeus.

28. Technological Education Institute of Piraeus - LSEA&EO, 2014, Reconstruction of an industrial building in a cultural municipal centre. Energy mapping survey and actions proposed to ensure energy savings. Laboratory of Soft Energy Applications and Environmental Protection (LSEA&EO) Mechanical Engineering Department of the Technological Education Institute of Piraeus.

29. ESTIF, 2013, Trends and Market Statistics 2012.

30. SEF, 2013, RES statistics for 2012.

31. BPIE, 2011, EUROPE'S BUILDINGS UNDER THE MICROSCOPE, A country-by-country review of the energy performance of buildings.

32. BPIE, 2013, Boosting building renovation. An overview of good practices Renovation requirements, long-term plans and support programmes in the EU and other selected regions

33. BPIE, 2011, Energy Performance Certificates across Europe From design to implementation.

34. Rentizelas, A., Georgakellos, D., 2014, Incorporating lifecycle external cost in optimization of the electricity Generation mix.

35. EEA, 2008, EN35, External costs of electricity production, European Environment Agency, 2008

36. Copenhagen Economics, 2012, Multiple benefits of investing in energy efficient renovation of buildings. Commissioned by Renovate Europe.

37. M. Santamouris, M. Papaglastra, 2007, Pollution and indoor environment quality in buildings. SELKA Publications – 4M.

38. Janssen R., Staniaszek D., 2012, How Many Jobs? A Survey of the Employment Effects of Investment in Energy Efficiency of Buildings. Energy Efficiency Industry Forum (EEIF).

39. Mirasgedis *et al*, 2014, A methodological framework for assessing the employment effects associated with energy efficiency interventions in buildings

40. Bank of Greece, 2012, The real estate market during the recent financial crisis, Bank of Greece Kronenberg, T. *et al*, 2009, The Social Return on Investment in the Energy Efficiency of Buildings: A Case Study of Germany.

41. Kholodilin K., Michelsen C., 2014, The market value of energy efficiency in buildings and the mode of tenure, Dis. Papers, DIW Berlin, No 1398.

42. DECC, 2013, An investigation of the effect of EPC ratings on the house prices, Department of Energy & Climate Change, UK.

43. Hellenic Property Federation - Trainrebuild, 2012, Training for Rebuilding Europe, IEE.

44. Kronenberg, T. etal, 2009, The Social Return on Investment in the Energy Efficiency of Buildings: A Case Study of Germany.

45. World Bank, 2013, Doing Business 2013

46. IEA, 2012, SPREADING THE NET: THE MULTIPLE BENEFITS OF ENERGY EFFICIENCY IMPROVEMENTS.

47. Tsani, 2010, Energy consumption and economic growth: A causality analysis for Greece. Energy Economics, Elsevier.

48. EU, 2014, EU Energy, Transport and GHG Emissions Trends to 2050, Reference Scenario 2013.

49. Ministerial Decision No Δ6/7094/2011 (Government Gazette, Series II, No 918/2011) laying down a methodology framework for measuring and verifying the energy savings, to achieve the indicative end-use national energy savings target

– List of indicative eligible energy performance improvement measures –
Energy content of fuels for end use.

50. EC, 2012, Financial support for energy efficiency in buildings”, consultation paper.

51. EIB, 2014, CSI Europe towards 2014-2020 Financial Instruments for Cities, ELENA Facility.

52. DG Climate, 2014, The new financial instruments under LIFE.

53. BPIE, 2013, DELIVERING ARTICLE 4 OF THE ENERGY EFFICIENCY DIRECTIVE.

54. ELSTAT, 2014, website http://www.statistics.gr/portal/page/portal/ESYE/PAGE-themes?p_param=A1302

55. MEECC, 2010, Action plan for RES.

ANNEX I - CRISP METHODOLOGY

The working group for this study has worked with methodologies in setting targets and policies for the future as part of the European project CRISP[9]. A specific methodology and approach was used for the project, under which future scenarios were developed initially on the specific subject that was of interest in each case, along with a number of structured and specific steps on how to – what steps to take and what path to follow - to realise the above scenarios.

This study looked into energy savings– management in the building sector, and the relevant approach can be very useful and substantial.

To ensure the completeness of the study, the key steps of that interesting approach are cited here, as analysed and presented in the final reference text[10], and there is detailed information posted on www.crisp-futures.eu.

The key idea is to use a bottom-up process in two major phases:

- from now– to the future: the creation of visions/targets for the future in connection with the topic at hand (i.e. what is desirable to happen to a specific topic within 20-30 years from now (envisioning)); and
- from the future to now: the setting of ways/methods/steps and policies that will lead eventually to the achievement of those goals (backcasting).

The reliability of the results of that overall effort is strengthened considerably by the fact that there are, in each step, factors that encourage, support or prevent smooth transition to the future, and therefore, in each step, these factors should either dealt with (in the case of obstacles) or strengthened if they are able to support the future vision and targets.

[9] subsidised research programme, 7th Framework Programme for Research and Technological Development Project Number 265310

[10] TNO report TNO 2014 R10225 Final Report CRISP http://www.crisp-futures.eu/download/attachments/1146943/CRISP-inal+report_2014.pdf?version=1&modificationDate=1397691036000

Creating a common vision for those that participate in sustainable transition is deemed to be critical and quite complex. The tools used, and demonstrate the collective approach of the methodology concerned, are:

- interviews with stakeholders and experts in the matter at hand (energy saving/management in buildings, in the present case), so that they are able to contribute towards the setting of the targets for the future;
- workshops with students to define their visions/desires for what they would like their lives to be like in the future;
- workshops with experts to establish policies/ways to transition from the future to now and creating the conditions necessary for the visions and targets to be achieved.

In particular, the steps of the approach, as implemented under this study, are:

1. The present situation. A detailed examination is initially carried out of the present situation, existing experience, policies already implemented and factors that have affected the topic at hand.
2. The visions and targets. The visions for the future are created-developed. During this step, the method and techniques to be used for creating those visions are very interesting. Initially, also due to the implementation period of the approach, those visions must be created by the stakeholders, who have an interest in the new order of things. The envisioning workshops that can be used to identify these visions require appropriate planning and significant experience in order to be implemented, as this is a totally creative phase that generates, out of nothing, a desirable future that does not currently exist. The participants, coordinator, space, tools and process used are all fundamental planning parameters, which can have a significant effect on, and determine, the success of those workshops.
3. The development of visions and the setting of targets. Different visions are developed during this stage, leading to targets that are quantitative by now.
4. The path from the future to now. The visions and targets are then analysed and specific ‘paths’ and steps are determined to help us get from the future to now, including various parameters and highlighting for each step the obstacles, support factors, difficulties, and differences from the existing situation. This stage utilises the experts’ experience on the topic at hand and the imagination/’

creativity of ordinary stakeholders and parties that are involved in the problem, which is one of the most difficult and innovative approaches to the topic at hand.

5. Groups of specific actions (paths) are created to lead us from the future to now, including the specific steps, policies, positive factors to support these actions and negative factors to be dealt with. The actions relate to society as a whole, government and policy-makers, experts, technology, implementation.
6. Assessment and promotion. The actions are assessed in different ways and are implemented on a trial basis, so that they are tested before being promoted for final implementation.

A very significant advantage of this innovative approach is that it is not just a theoretical projection of the future based on the present, but its key feature is that it stems from the future itself, to which it refers, and is collective, i.e. it is developed by groups of people involved in its different phases.

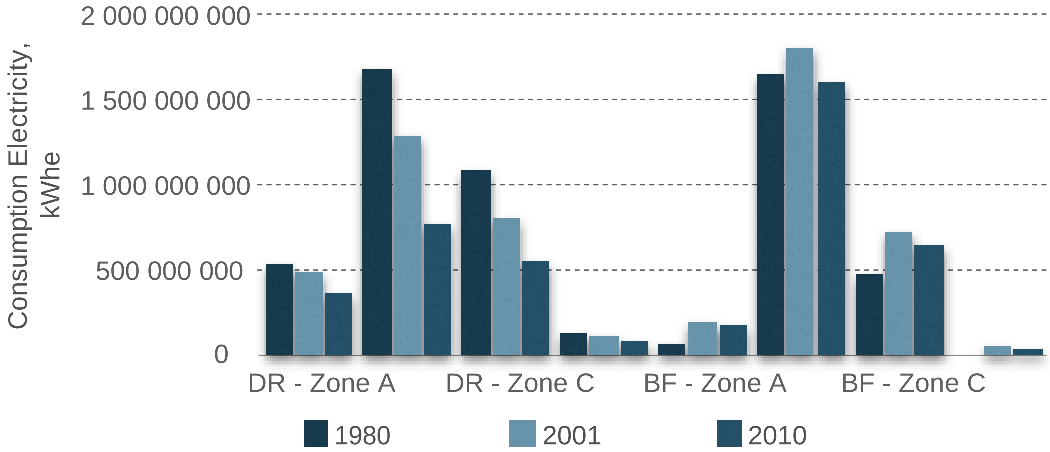
It applies to the specific subject-matter of this project, either as a whole or in individual steps, and is deemed to constitute a reliable way of setting scenarios for the future concerning energy savings and the overall management of energy in the building sector.

ANNEX II – TABLES WITH COMPLETE CONSUMPTION DETAILS

(heat, electricity and total – in terms of primary energy)

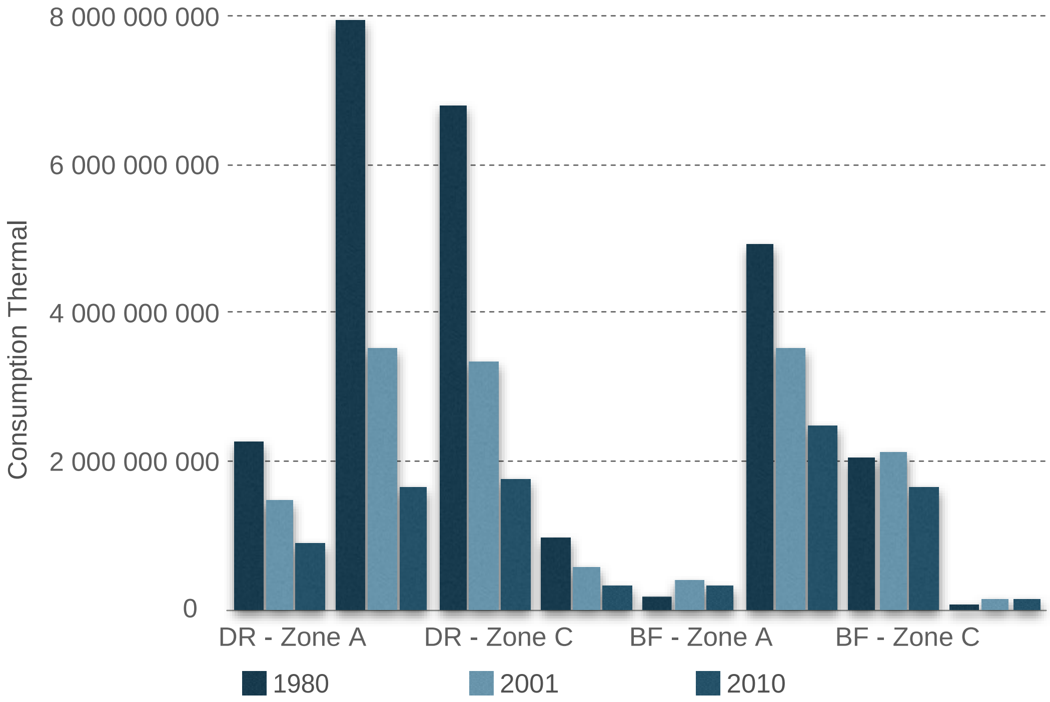
Annex II sets out the total energy consumption of buildings depending on their use, expressed in primary energy (heat and electricity), based on their age (year of construction) and climatic zone. It should be noted that the figures show the energy consumption for the entire building stock of each type of building.

RESIDENCES



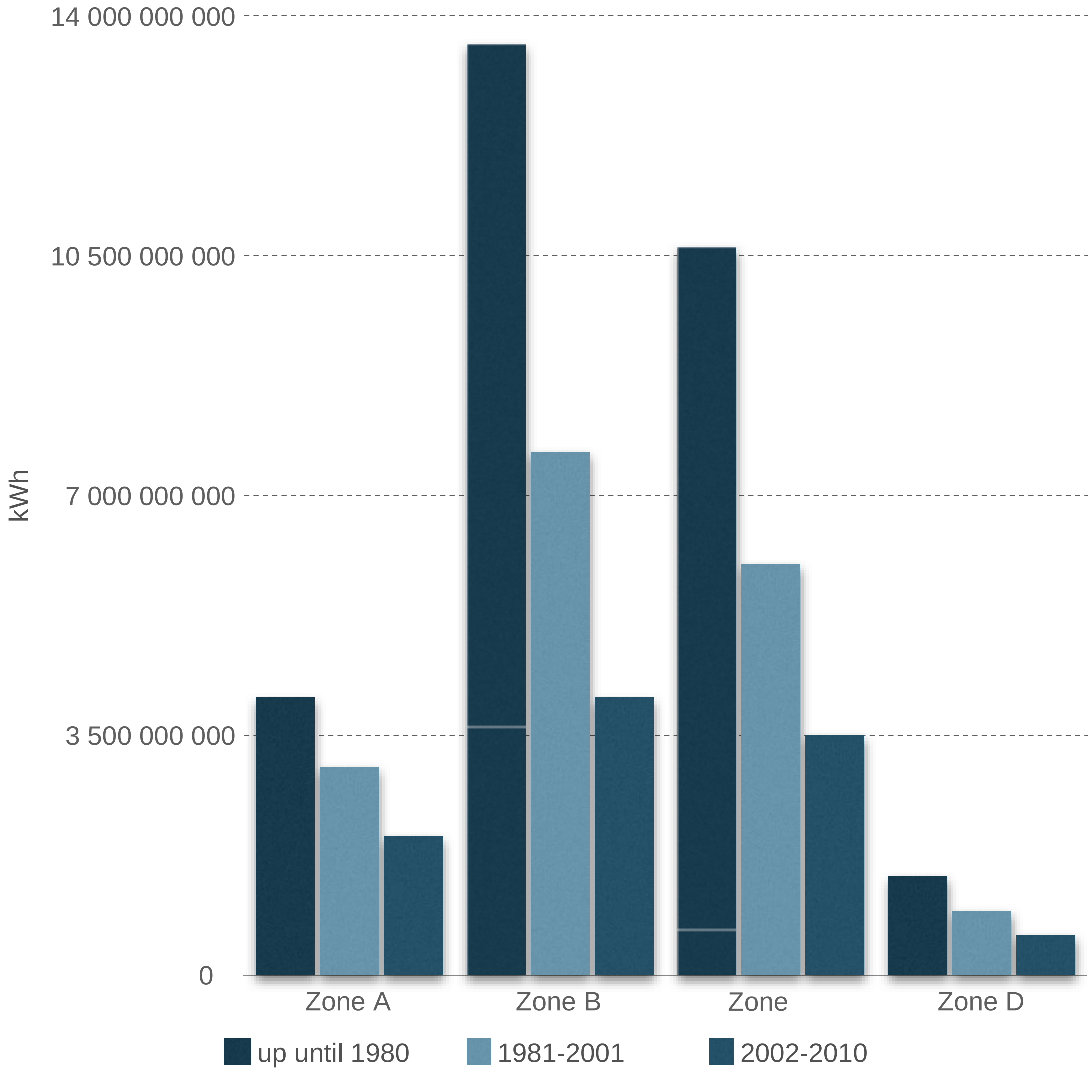
	1980	2001	2010
DR - Zone A	540 241 605	489 450 090	361 073 759
DR - Zone B	1 675 989 420	1 297 168 924	780 883 583
DR - Zone C	1 090 536 785	806 792 630	547 885 973
DR - Zone D	131 902 302	110 176 745	80 686 043
BF - Zone A	73 489 794	196 849 255	174 397 799
BF - Zone B	1 656 636 471	1 807 139 552	1 604 708 019
BF - Zone C	477 302 348	723 498 222	654 320 714
BF - Zone D	14 831 433	45 694 624	39 162 420

Figure BF2-1: Electricity consumption of a detached residence (DR) and a block of flats (BF) per age category and per climatic zone



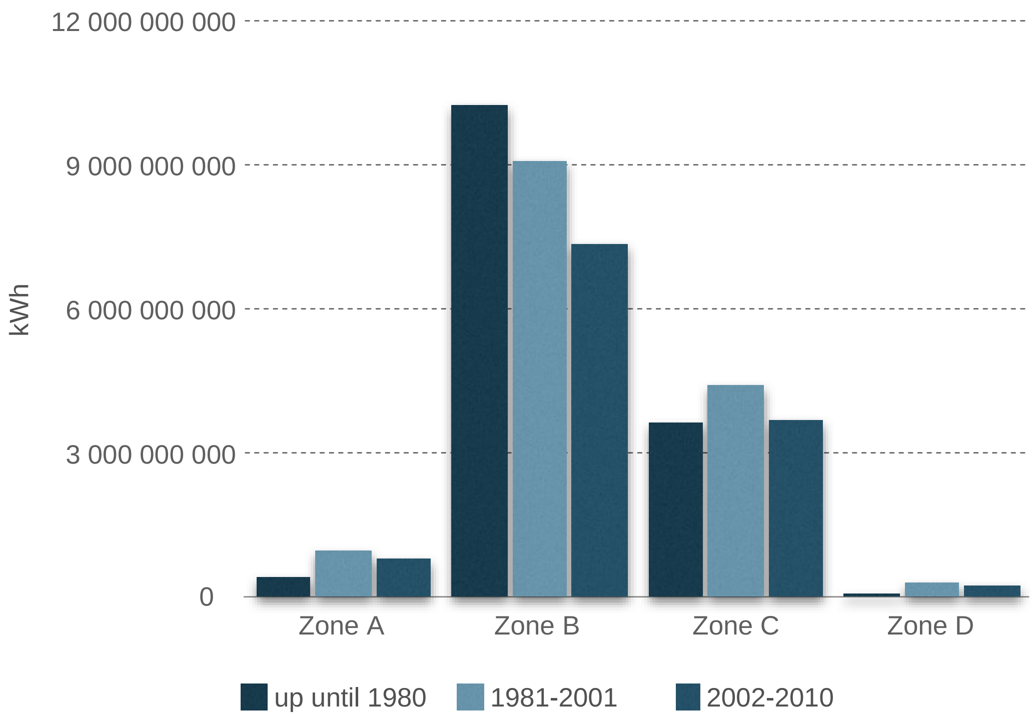
	1980	2001	2010
DR - Zone A	2 257 009 372	1 471 657 364	886 151 715
DR - Zone B	7 935 780 294	3 526 582 180	1 647 907 800
DR - Zone C	6 787 573 350	3 342 426 610	1 755 836 352
DR - Zone D	971 091 748	560 436 624	319 279 128
BF - Zone A	194 180 350	391 174 802	318 199 492
BF - Zone B	4 943 613 596	3 513 882 463	2 487 647 803
BF - Zone C	2 053 510 101	2 131 386 654	1 663 527 240
BF - Zone D	68 615 170	156 060 875	131 686 500

Figure BF2-2: Thermal energy consumption of a detached residence (DR) and a block of flats (BF) per age category and per climatic zone



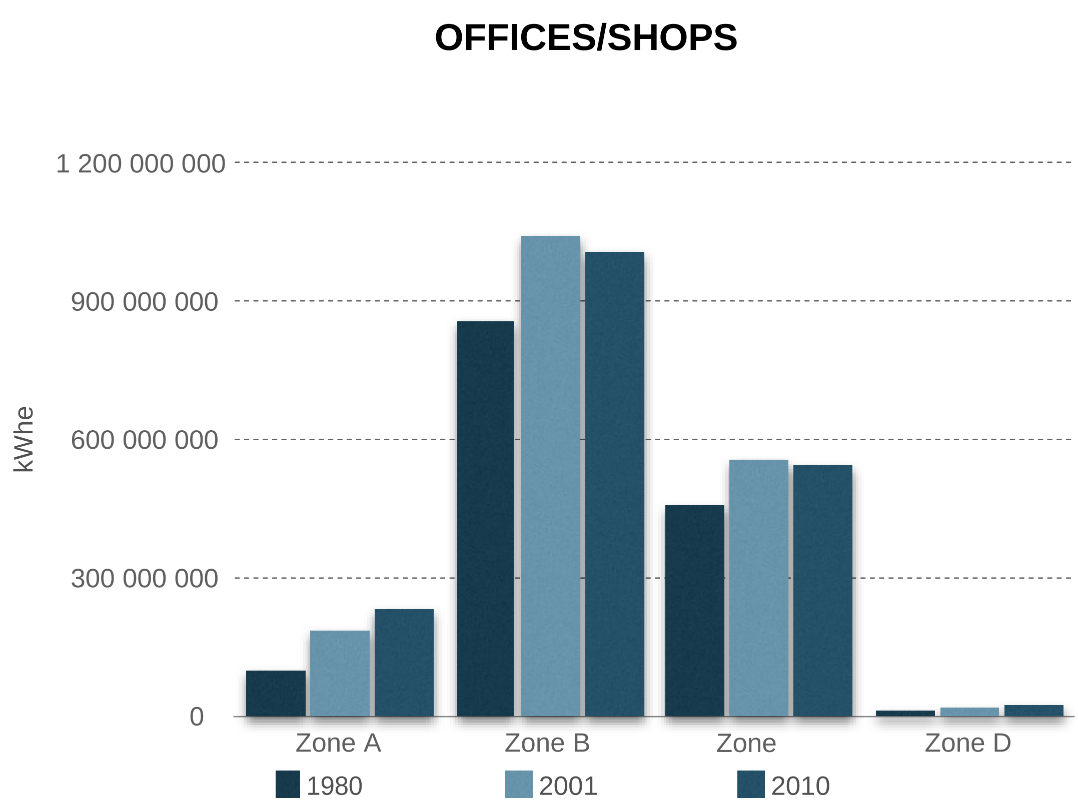
	up until 1980	1981-2001	2002-2010
Zone A	4 049 410 963	3 038 228 360	2 021 880 786
Zone B	13 589 727 642	7 641 030 276	4 077 260 969
Zone C	10 628 887 361	6 016 367 898	3 520 289 308
Zone D	1 450 717 597	935 992 848	585 196 566

Figure BF2-3: Total primary energy consumption of a detached residence (DR) per age category and per climatic zone



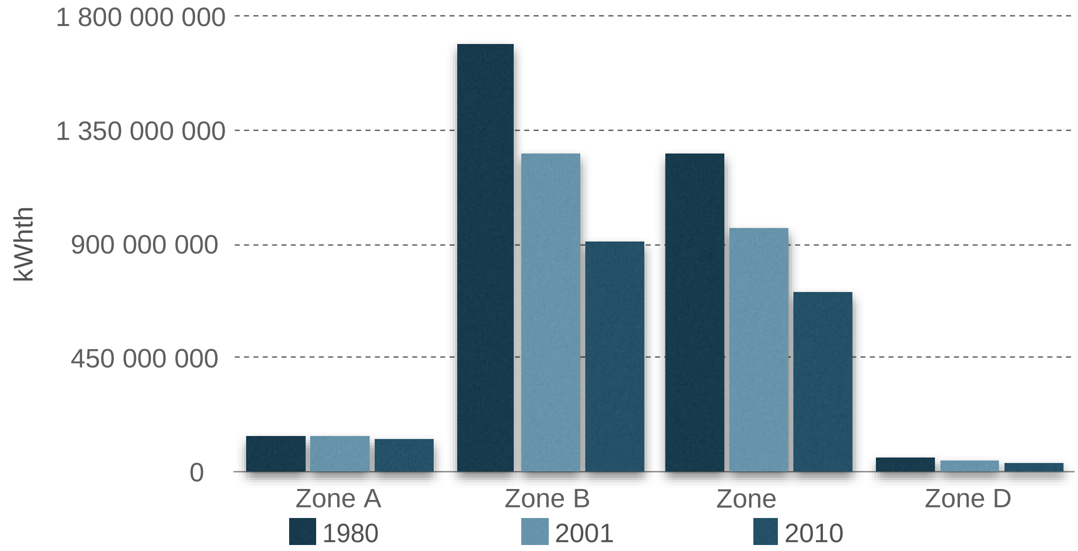
	up until 1980	1981-2001	2002-2010
Zone A	426 718 788	1 001 155 122	855 773 057
Zone B	10 242 220 722	9 105 975 411	7 390 065 840
Zone C	3 643 037 920	4 442 670 163	3 727 410 036
Zone D	118 487 842	304 181 373	258 426 168

Figure BF2-4: Total primary energy consumption of a block of flats (BF) per age category and per climatic zone



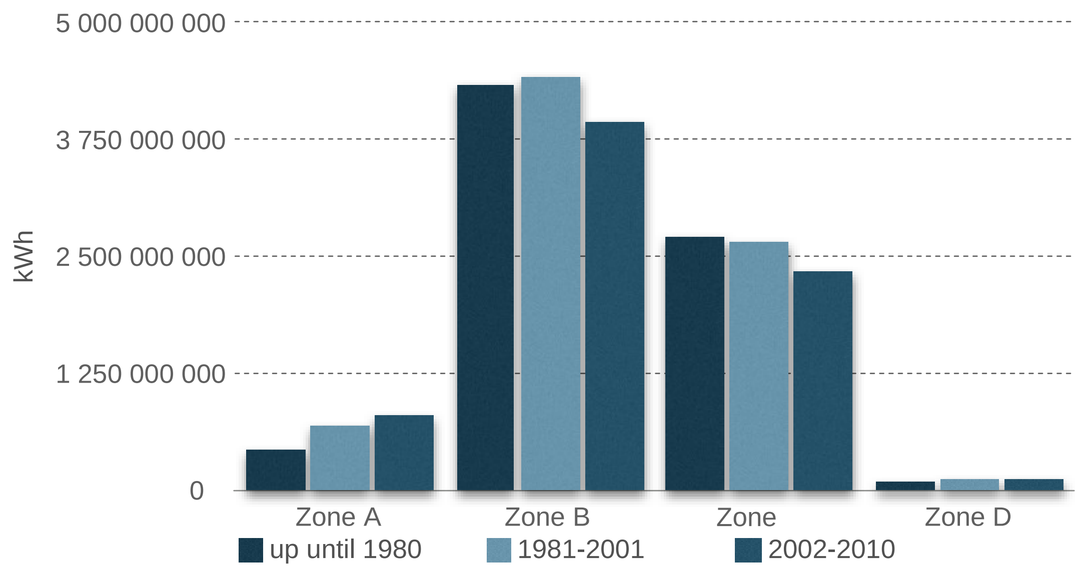
	1980	2001	2010
Zone A	98 783 904	185 795 422	232 409 320
Zone B	856 072 079	1 043 847 555	1 008 298 584
Zone C	460 211 115	553 583 325	544 857 088
Zone D	14 749 956	20 190 384	24 291 603

Figure BF2-5: Electricity consumption of offices/shops per age category and per climatic zone



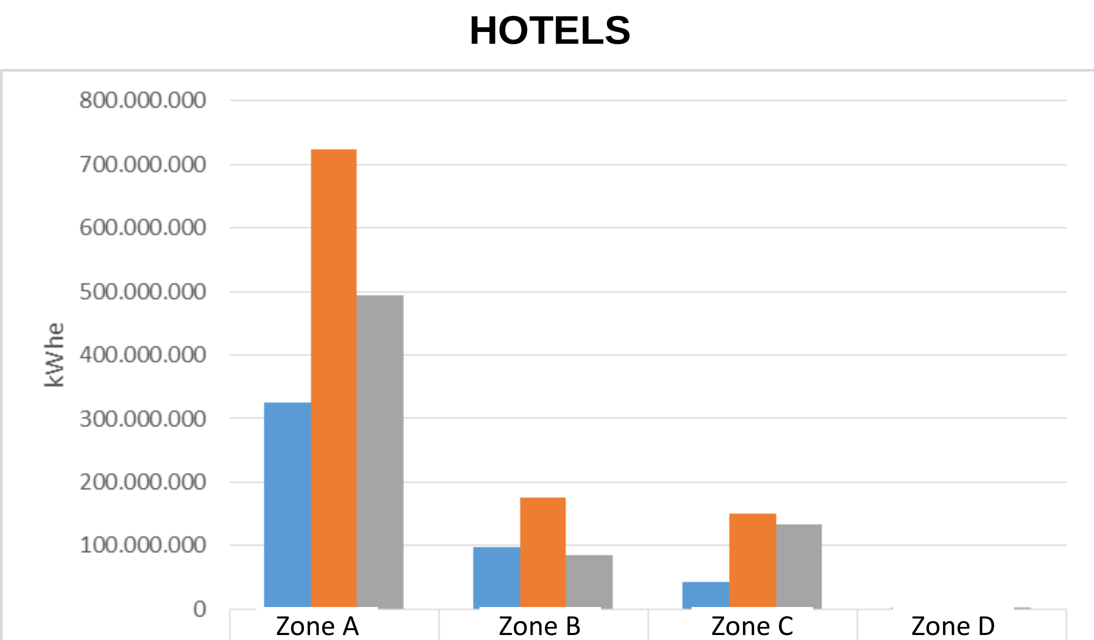
	1980	2001	2010
Zone A	137 885 866	144 199 432	126 768 720
Zone B	1 692 235 505	1 263 604 935	910 269 555
Zone C	1 262 630 495	966 057 175	706 611 536
Zone D	54 902 614	46 269 630	39 714 843

Figure BF2-6: Thermal energy consumption of offices/shops per age category and per climatic zone



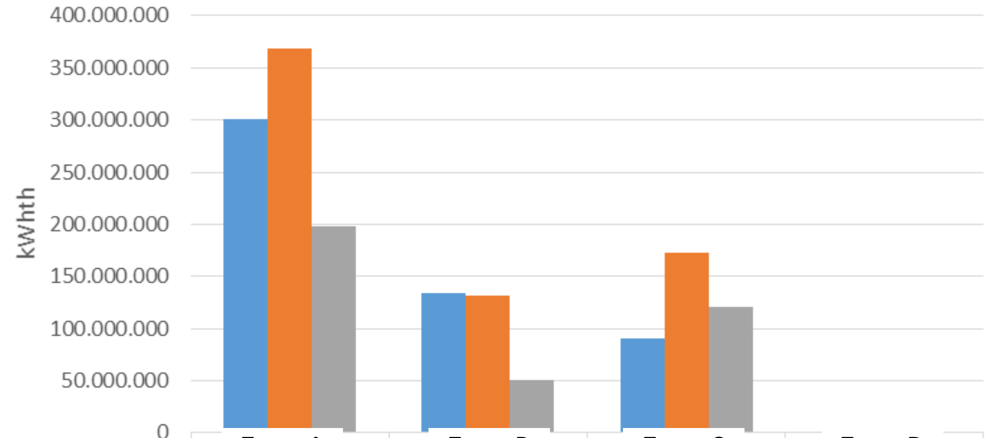
	up until 1980	1981-2001	2002-2010
Zone A	438 147 774	697 426 099	813 432 620
Zone B	4 344 068 085	4 417 123 338	3 925 362 404
Zone C	2 723 505 778	2 668 054 535	2 357 358 245
Zone D	103 167 748	109 448 707	114 131 976

Figure BF2-7: Total primary energy consumption of offices/shops per age category and per climatic zone



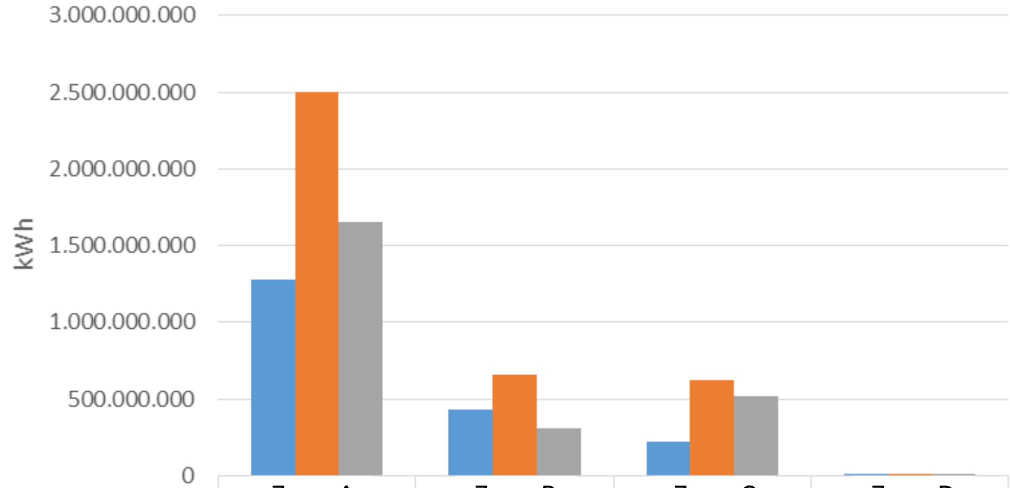
	Zone A	Zone B	Zone C	Zone D
up until 1980	325.975.881	97.813.848	43.198.542	403.190
1981-2001	724.192.732	175.642.480	149.984.688	818.622
2002-2010	495.055.665	85.861.995	133.705.476	656.937

Figure BF2-8: Electricity consumption of hotels per age category and per climatic zone



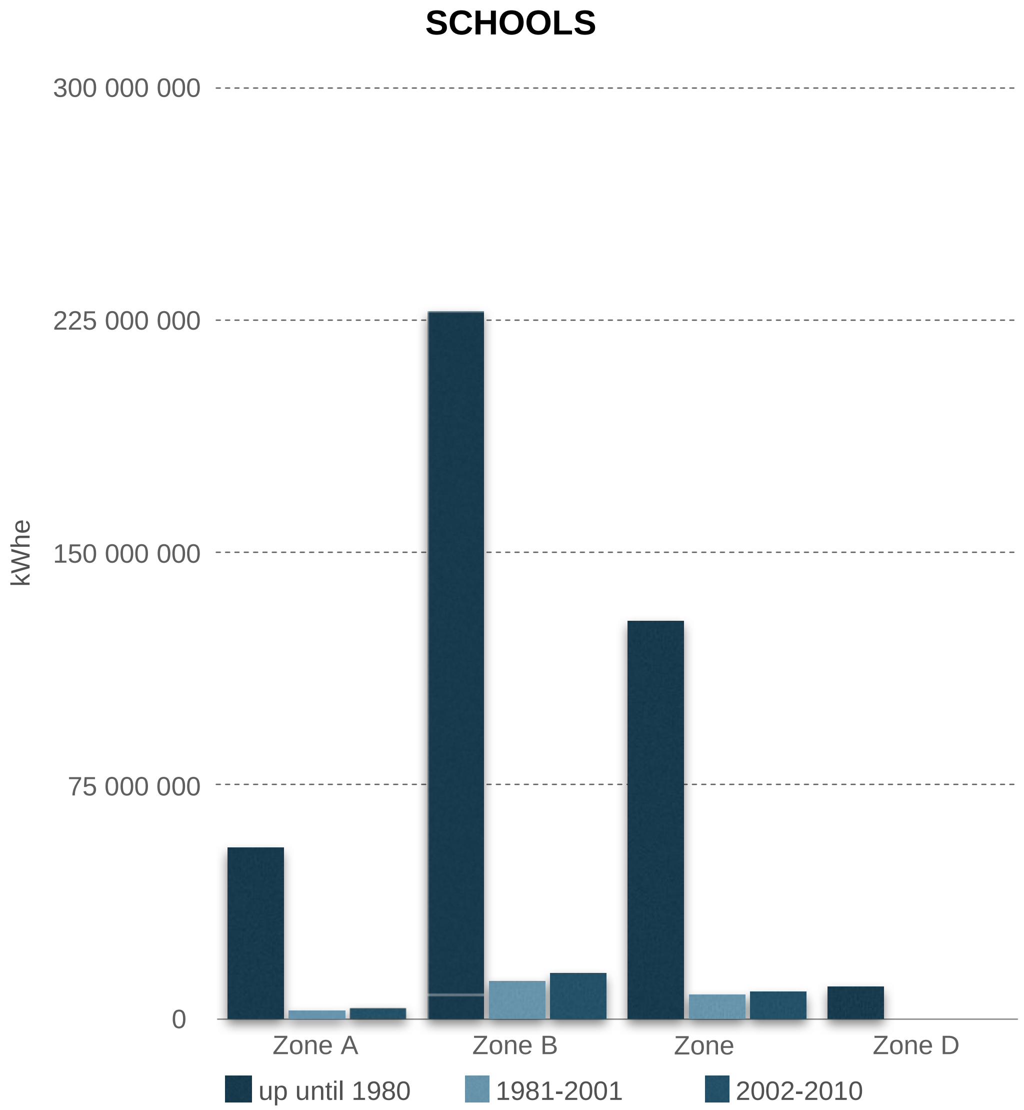
	Zone A	Zone B	Zone C	Zone D
up until 1980	300.575.163	133.382.520	90.396.949	1.244.630
1981-2001	368.032.372	131.731.860	172.656.792	1.390.536
2002-2010	198.022.266	50.958.745	120.597.096	868.365

Figure BF2-9: Thermal energy consumption of hotels per age category and per climatic zone



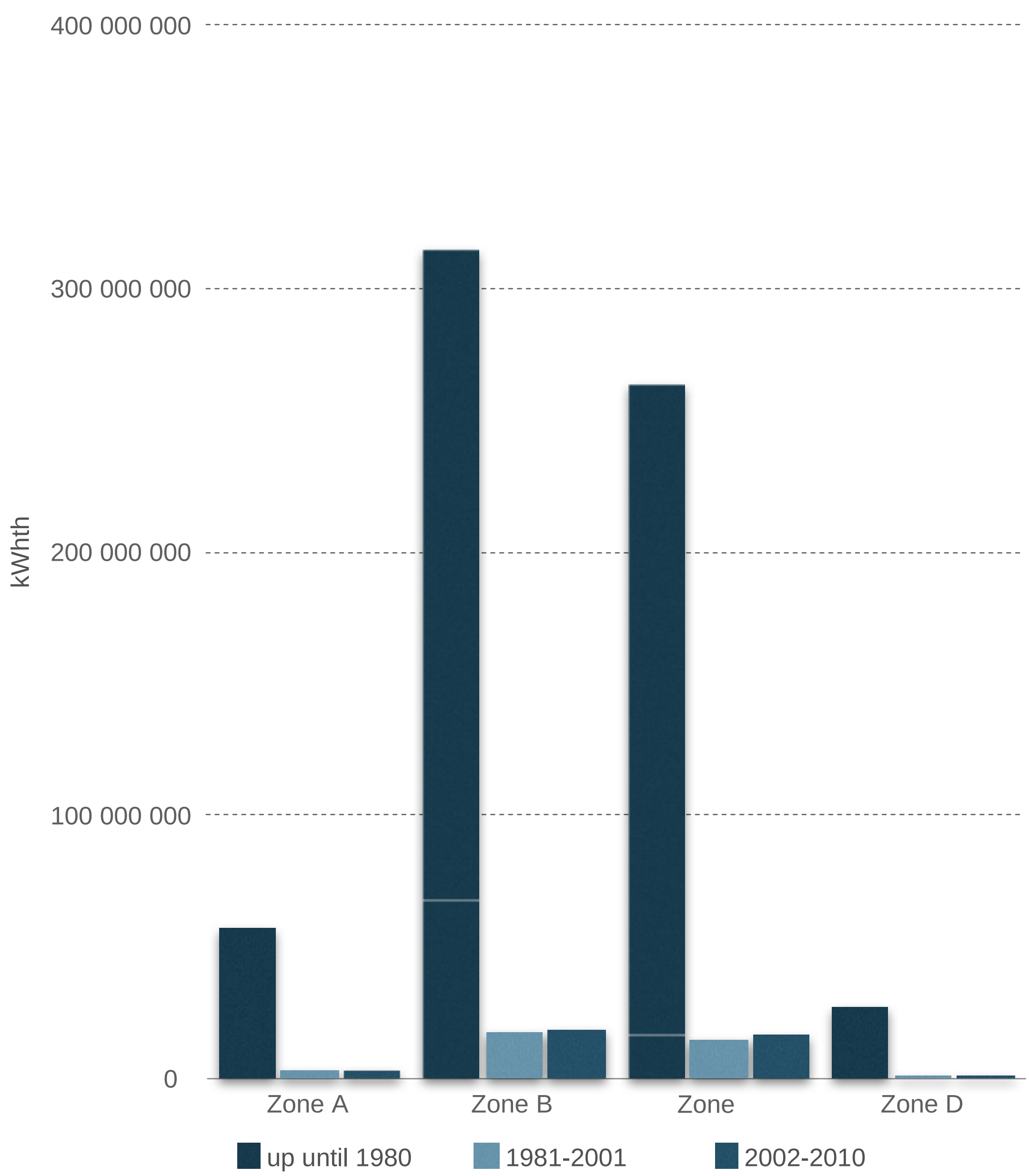
	Zone A	Zone B	Zone C	Zone D
up until 1980	1.275.962.734	430.380.931	224.712.416	2.538.344
1981-2001	2.504.994.532	654.268.238	624.878.066	3.903.593
2002-2010	1.653.485.921	305.054.405	520.402.686	2.860.319

Figure BF2-10: Total primary energy consumption of hotels per age category and per climatic zone



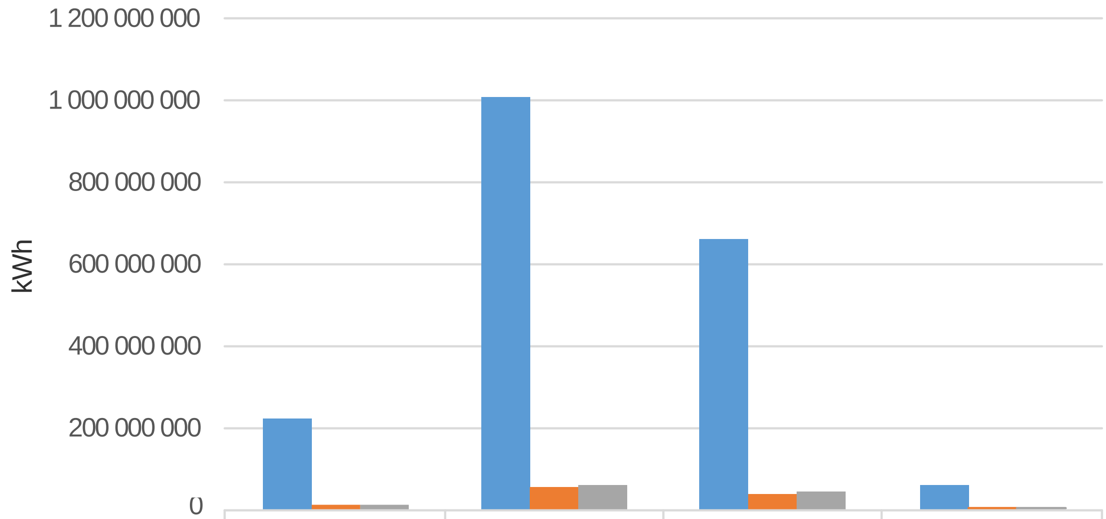
	up until 1980	1981-2001	2002-2010
Zone A	55 091 969	3 003 041	3 662 640
Zone B	227 794 749	12 616 170	14 906 320
Zone C	128 214 450	7 600 722	9 076 480
Zone D	10 220 536	557 107	689 472

Figure BF2-11: Electricity consumption of schools per age category and per climatic zone



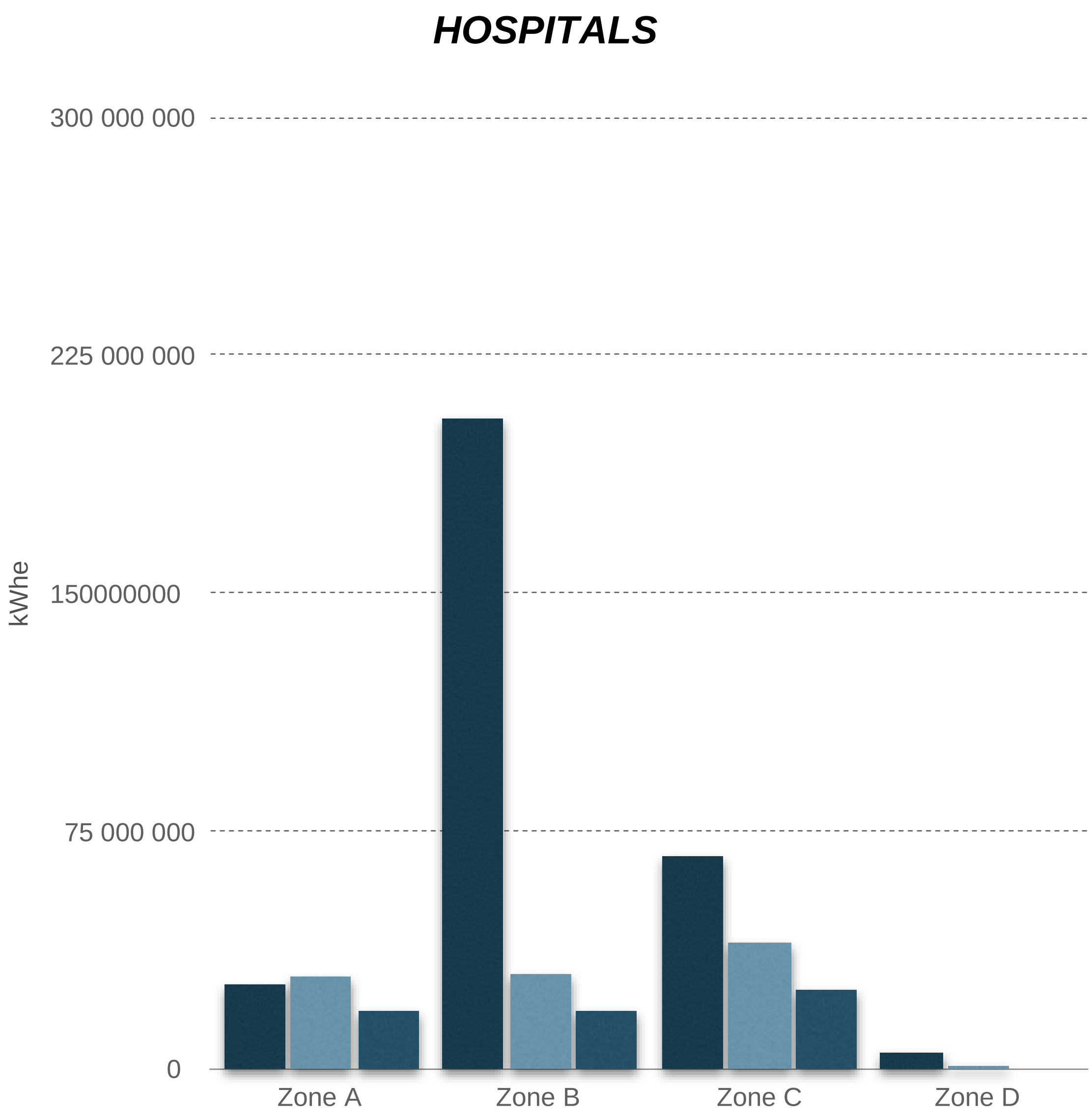
	up until 1980	1981-2001	2002-2010
Zone A	57 487 272	3 003 041	3 510 030
Zone B	314 573 701	17 422 330	18 971 680
Zone C	263 551 925	14 401 368	16 337 664
Zone D	27 655 568	1 507 466	1 723 680

Figure BF2-12: Thermal energy consumption of schools per age category and per climatic zone



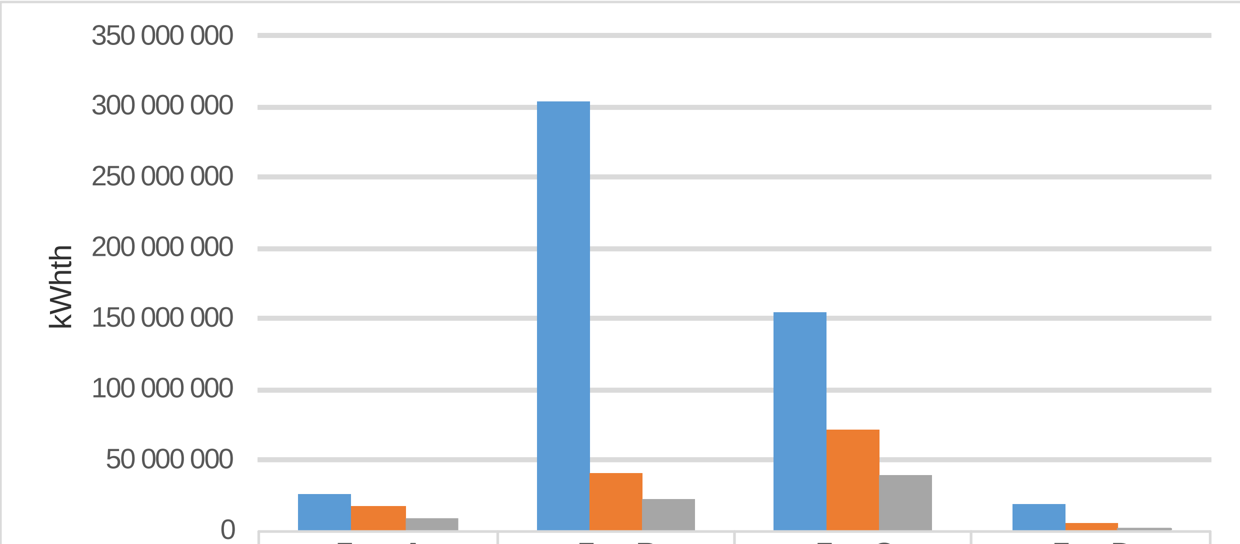
	Zone A	Zone B	Zone C	Zone D
up until 1980	223 002 709	1 006 635 843	661 729 023	60 060 679
1981-2001	12 012 164	55 751 456	37 883 599	3 273 823
2002-2010	14 482 689	64 097 176	44 293 222	3 895 517

Figure BF2-13: Total primary energy consumption of schools per age category and per climatic zone



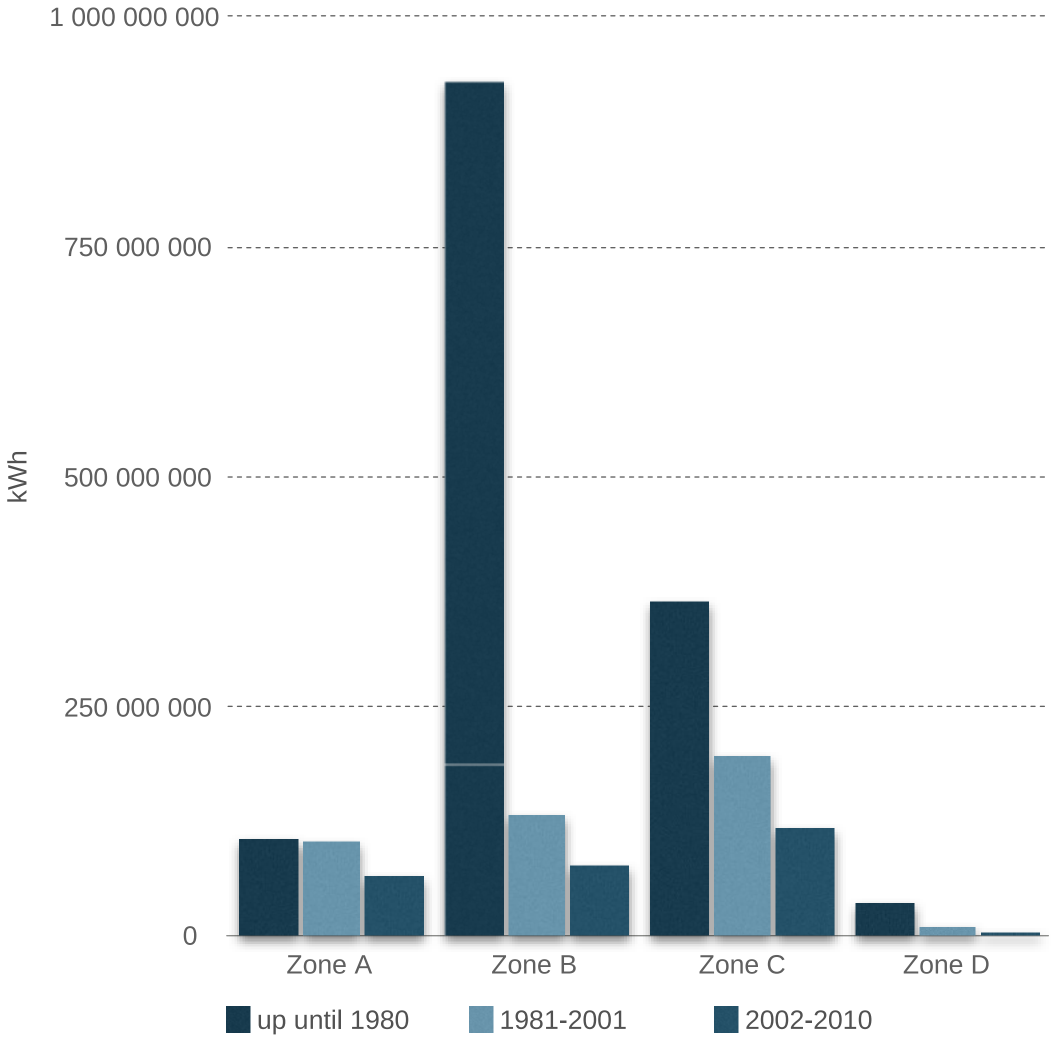
	up until 1980	1981-2001	2002-2010
Zone A	26 881 794	29 594 708	19 158 370
Zone B	205 606 476	30 664 901	18 621 834
Zone C	67 229 094	40 257 098	25 721 696
Zone D	5 862 241	1 791 972	1 121 120

Figure BF2-14: Electricity consumption of hospitals per age category and per climatic zone



	Zone **A**	Zone **B**	Zone **C**	Zone **D**
up until 1980	25 300 512	303 940 008	154 134 996	19 185 516
1981-2001	17 900 025	40 781 157	71 948 856	5 055 921
2002-2010	9 510 270	23 003 442	39 571 840	2 845 920

Figure BF2-15: Thermal energy consumption of hospitals per age category and per climatic zone



	up until 1980	1981-2001	2002-2010
Zone A	105 787 766	105 514 681	66 020 570
Zone B	930 592 789	133 787 486	79 307 105
Zone C	364 512 868	195 889 326	118 121 942
Zone D	38 104 567	10 758 232	6 381 760

Figure BF2-16: Total primary energy consumption of hospitals per age category and per climatic zone

ANNEX III- CALCULATION MODEL

The following is a description of the calculation model for renovation and energy saving interventions used to develop the scenarios for renovating the building stock, with indicative examples of parameter values:

Parameters of the problem:

EXPLANATION	VALUES
building stock (Btot)	Btot=4 000 000 typical domestic residences Btot= 16 000 school buildings Btot= 9 000 hotels Btot= 161 000 offices/shops Btot= 1 700 hospitals
Average surface area of a typical building Sav	Sav=90 m^2 typical domestic residences Sav=1 440 m^2 school buildings Sav=2 330 m^2 hotels Sav=580 m^2 offices/shops Sav=2.940 m^2 hospitals
Annual intervention percentage (ξ) in buildings, compared to the entire building stock	ξ= ξm =0.625% (Scenario 1 typical residences) ξ= 0.625% to 4.39% (Scenario 2 typical residences) ξ= 0.625% to 2.92% (Scenario 3 typical residences) ξ= 0.625% to 2.48% (Scenario 4 typical residences) ξ= 0.7% to 4.0% (Scenario 5 typical residences) ξ= 0.625% to 2.92% (targets scenario for tertiary sector buildings – school buildings, hotels, offices/shops, hospitals)
Adjusted annual primary energy consumption (ε)	Typical residences: ε=360 kWh/m^2 School buildings ε=146 kWh/m^2 Hotels ε=277 kWh/m^2 Offices ε=400 kWh/m^2 Hospitals ε=550 kWh/m^2
Adjusted annual (final) electricity (final) consumption ($ε_1$)	Typical residences: e_1=56 kWh/m^2 School buildings: e_1=20 kWh/m^2 Hotels: e_1=50 kWh/m^2 Offices: e_1=95 kWh/m^2 Hospitals: e_1=80 kWh/m^2

EXPLANATION	VALUES
Adjusted annual (final) heat consumption (ε_2)	Typical residences: e_2=170kWh/m^2 School buildings: e_2=80kWh/m^2 Hotels: e_2=120kWh/m^2 Offices: e_2=113kWh/m^2 Hotels: e_2=290kWh/m^2
Energy Intervention Level (λ)	λ=20% (minor savings) λ=40% (medium savings) λ=60% (major savings) λ=80% (nearly zero-energy consumption savings)
Cost of money - discount rate (i):	i=8% for typical residences i= 1% to 8% for tertiary sector buildings
Investment cost per energy savings unit (IC_o)	IC_o=1 €/kWh for typical residences IC_o=1.2 €/kWh for school buildings IC_o=1.5 €/kWh for hotels, offices, hospitals
Annual maintenance of energy upgrade equipment:	m=1%
Annual inflation rate of electricity:	ε=0.5%
Annual inflation rate of heat:	θ=0.55%
Annual inflation rate of the economy:	The calculations made are net of inflation.
Learning rate for energy efficiency interventions:	LR=1%
Total annual cost of energy efficiency interventions C_o	Calculated based on the model
Cost of electricity:	p=0.10€/kWh
Coast of heat:	h=0.14€/kWh
Weighted average lifecycle of energy interventions based on Joint Ministerial Decision No Δ6/7094/2011)	Tmax = 20 years

ALGORITHM

The algorithm uses a stepped approach to calculate the relevant levels for each year. Based on the above, the following will apply to year ‘j’:

Buildings undergoing energy upgrade $Bj=\xi j.Btot$ (1)

Total surface area of buildings $Sj=Bj.Sav=\xi j.Btot.Sav$ (2)

Annual national energy savings $Ej=\lambda.\varepsilon.Sj$ (3)

Energy Savings per typical building: $\Delta\varepsilon=\lambda.\varepsilon.Sav$ (4)

Annual energy cost savings (present values): $R_j=(\lambda.\varepsilon_1.p_j+\lambda.\varepsilon_2.h_j).Sav$ (5)

Annual savings (present values) due to the interventions less the maintenance costs of the energy interventions:

$R_j-m_j.ICo.\lambda.\varepsilon.S_{av}=\lambda.S_{av}(\varepsilon_1.p_j+\varepsilon_2.h_j-m_j.IC_o.\varepsilon)$ (6)

Annual national financing: $C\gamma=\gamma.Co=ICo.(\lambda.\varepsilon.S_{av}).\xi.B_{tot}$ (7)

Total investment cost of private investors: $(1-\gamma).ICo.\lambda.\varepsilon.S_{av}$ (8)

The coefficient (γ) can be used to quantify the participation of non-public bodies wishing to invest in renovation actions. Its value for the present analysis is 1.

Certain necessary values are determined based on the following formulas:

Electricity purchasing price in year j: $p_j=p.(1+e)^j$

Heat purchasing price in year j: $h_j=h.(1+\theta)^j$

Factor for adjustment to current prices in year j: $1/(1+i)^j$

ANNEX IV- RESULTS OF SCENARIOS

TYPICAL DOMESTIC RESIDENCES – SCENARIO S1

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Cost of renovation interventions in present values Discounting interest rate i=8%	Aggregate cost of renovation interventions in present values Discounting interest rate i=8%	Annual benefit from energy savings	Annual aggregate benefit from energy savings in present values Discounting interest rate i=8%
	TWh	TWh	Mtoe	M€	M€	M€	M€	M€
2015	0.2026	0.203	0.017	202.6	187.600	187.60	16.6	15.4
2016	0.2026	0.405	0.035	200.6	171.967	359.57	33.5	44.1
2017	0.2026	0.608	0.052	198.6	157.620	517.19	50.4	84.1
2018	0.2026	0.810	0.070	196.5	144.455	661.64	67.6	133.8
2019	0.2026	1.013	0.087	194.5	132.376	794.02	85.0	191.7
2020	0.2026	1.216	0.105	192.5	121.294	915.31	102.5	256.3
2021	0.2026	1.418	0.122	190.5	111.127	1 026.44	120.3	326.5
2022	0.2026	1.621	0.139	188.4	98.407	1 124.85	138.2	401.1
2023	0.2026	1.823	0.157	186.4	87.030	1 211.87	156.3	479.3
2024	0.2026	2.026	0.174	184.4	76.860	1 288.74	174.6	560.2
2025	0.2026	2.229	0.192	182.3	67.778	1 356.51	193.1	643.1
2026	0.2026	2.431	0.209	180.3	59.673	1 416.19	211.8	727.2
2027	0.2026	2.634	0.227	178.3	52.447	1 468.63	230.7	812.0
2028	0.2026	2.837	0.244	176.3	46.010	1 514.64	249.8	897.1
2029	0.2026	3.039	0.261	174.2	40.281	1 554.92	269.1	981.9
2030	0.2026	3.242	0.279	172.2	35.188	1 590.11	288.6	1 066.1
2031	0.2026	3.444	0.296	170.2	30.665	1 620.78	308.3	1 149.5
2032	0.2026	3.647	0.314	168.2	26.653	1 647.43	328.2	1 231.6
2033	0.2026	3.850	0.331	166.1	23.098	1 670.53	348.3	1 312.3
2034	0.2026	4.052	0.349	164.1	19.952	1 690.48	368.6	1 391.4
2035	0.2026	4.255	0.366	162.1	17.173	1 707.65	370.6	1 465.0
2036	0.2026	4.457	0.384	160.1	14.721	1 722.37	372.6	1 533.5

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Cost of renovation interventions in present values Discounting interest rate i=8%	Aggregate cost of renovation interventions in present values Discounting interest rate i=8%	Annual benefit from energy savings	Annual aggregate benefit from energy savings in present values Discounting interest rate i=8%
	TWh	TWh	Mtoe	M€	M€	M€	M€	M€
2037	0.2026	4.660	0.401	158.0	12.561	1 734.93	374.6	1 597.3
2038	0.2026	4.863	0.418	156.0	10.661	1 745.60	376.6	1 656.7
2039	0.2026	5.065	0.436	154.0	8.994	1 754.59	378.7	1 712.0
2040	0.2026	5.268	0.453	152.0	7.533	1 762.12	380.7	1 763.5
2041	0.2026	5.470	0.471	149.9	6.256	1 768.38	382.8	1 811.4
2042	0.2026	5.673	0.488	147.9	5.143	1 773.52	384.8	1 856.0
2043	0.2026	5.876	0.506	145.9	4.175	1 777.70	386.9	1 897.5
2044	0.2026	6.078	0.523	143.9	3.336	1 781.03	389.0	1 936.2
2045	0.2026	6.281	0.540	141.8	2.610	1 783.64	391.1	1 972.2
2046	0.2026	6.483	0.558	139.8	1.985	1 785.63	393.2	2 005.7
2047	0.2026	6.686	0.575	137.8	1.449	1 787.08	395.4	2 036.9
2048	0.2026	6.889	0.593	135.7	0.992	1 788.07	397.5	2 065.9
2049	0.2026	7.091	0.610	133.7	0.603	1 788.67	399.6	2 092.9
2050	0.2026	7.294	0.628	131.7	0.275	1 788.95	401.8	2 118.1

TYPICAL DOMESTIC HOUSEHOLDS – SENARIO S2

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Cost of renovation interventions in present values Discounting interest rate i=8%	Aggregate cost of renovation interventions in present values Discounting interest rate i=8%	Annual benefit from energy savings	Aggregate annual benefit from energy savings in present values Discounting interest rate i=8%
	TWh	TWh	Mtoe	M€	M€	M€	M€	M€
2015	**0.203**	0.203	0.017	202.69	187.68	187.68	16.6	15.4
2016	**0.214**	0.417	0.036	211.70	181.50	369.18	34.4	44.9
2017	**0.249**	0.665	0.057	243.86	193.58	562.76	55.2	88.7
2018	**0.283**	0.948	0.082	274.05	201.44	764.20	79.1	146.9

2019	**0.319**	1.267	0.109	306.06	208.30	972.50	106.3	219.2
2020	**0.342**	1.609	0.138	325.04	204.83	1 177.33	135.7	304.7
2021	**0.386**	1.995	0.172	363.04	211.83	1389.15	169.2	403.4
2022	**0.430**	2.425	0.209	400.15	208.98	1598.14	206.8	515.2
2023	**0.508**	2.933	0.252	467.39	218.22	1 816.36	251.5	641.0
2024	**0.529**	3.462	0.298	481.18	200.59	2016.95	298.4	779.2
2025	**0.558**	4.020	0.346	502.14	186.64	2 203.60	348.4	928.6
2026	**0.619**	4.640	0.399	551.34	182.46	2 386.05	404.2	1 089.1
2027	**0.682**	5.321	0.458	599.89	176.46	2562.51	466.1	1 260.5
2028	**0.796**	6.117	0.526	692.30	180.70	2 743.22	538.7	1 443.9
2029	**0.868**	6.985	0.601	746.76	172.63	2 915.85	618.5	1 638.9
2030	**0.931**	7.916	0.681	790.95	161.61	3 077.46	704.7	1 844.6
2031	**0.993**	8.909	0.766	833.90	150.25	3 227.71	797.4	2 060.1
2032	**1.063**	9.971	0.858	882.06	139.80	3367.51	897.3	2 284.6
2033	**1.185**	11.156	0.960	971.33	135.04	3 502.55	1 009.3	2 518.5
2034	**1.218**	12.374	1.065	986.77	119.97	3 622.52	1 125.6	2 760.0
2035	**1.252**	13.626	1.172	1 001.55	106.11	3 728.63	1 227.6	3 003.9
2036	**1.288**	14.914	1.283	1 017.70	93.60	3822.23	1 333.1	3 249.1
2037	**1.322**	16.236	1.397	1 031.10	81.95	3 904.18	1 439.5	3 494.2
2038	**1.389**	17.625	1.516	1 069.77	73.10	3 977.29	1 550.1	3 738.7
2039	**1.431**	19.056	1.640	1 087.40	63.51	4 040.80	1 662.4	3 981.4
2040	**1.475**	20.531	1.766	1 106.14	54.84	4 095.64	1 777.8	4 221.8
2041	**1.519**	22.050	1.897	1 123.99	46.90	4 142.54	1 894.4	4 458.9
2042	**1.594**	23.644	2.034	1 163.68	40.47	4 183.00	2 015.2	4 692.5
2043	**1.687**	25.331	2.180	1 214.92	34.77	4 217.78	2 138.7	4 922.1
2044	**1.755**	27.086	2.331	1 245.90	28.89	4 246.67	2 268.0	5 147.5
2045	**1.822**	28.908	2.487	1 275.52	23.47	4 270.14	2 402.3	5 368.5
2046	**1.928**	30.837	2.653	1 330.63	18.89	4 289.03	2 542.3	5 585.1
2047	**1.996**	32.833	2.825	1 357.17	14.28	4 303.31	2 684.2	5 796.9
2048	**2.066**	34.899	3.003	1 384.10	10.11	4 313.42	2 823.3	6 003.1
2049	**2.118**	37.016	3.185	1 397.66	6.30	4 319.72	2 961.8	6 203.4
2050	**2.159**	39.175	3.371	1 403.44	2.93	4 322.65	3 099.6	6 397.5

TYPICAL DOMESTIC RESIDENCES – SCENARIO S3

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Cost of renovation interventions in Present values Discounting interest rate i=8%	Aggregate cost of renovation interventions in present values Discounting interest rate i=8%	Annual benefit from energy savings	Annual aggregate benefit from energy savings in present values Discounting interest rate i=8%
	TWh	TWh	Mtoe	M€	M€	M€	M€	M€
2015	0.203	0.203	0.017	202.694	187.68	187.68	16.6	15.4
2016	0.270	0.472	0.041	266.872	228.80	416.48	39.0	48.8
2017	0.513	0.985	0.085	502.952	399.26	815.74	95.7	124.8
2018	0.674	1.659	0.143	653.702	480.49	1 296.23	152.4	236.8
2019	0.876	2.535	0.218	841.052	572.41	1 868.64	226.7	391.1
2020	1.045	3.580	0.308	992.347	625.35	2 493.98	316.1	590.3
2021	1.309	4.889	0.421	1 230.422	717.94	3 211.92	428.8	840.5
2022	1.503	6.392	0.550	1 398.125	730.18	3 942.11	559.3	1 142.6
2023	1.664	8.056	0.693	1 530.939	714.79	4 656.90	705.0	1 495.3
2024	1.791	9.848	0.847	1 629.876	679.45	5 336.35	863.2	1 895.1
2025	1.928	11.776	1.013	1735.603	645.12	5 981.48	1 034.9	2 339.0
2026	1.928	13.704	1.179	1 716.319	567.98	6 549.45	1 208.5	2 818.9
2027	1.928	15.633	1.345	1 697.034	499.20	7 048.65	1 384.0	3 327.8
2028	1.928	17.561	1.511	1 677.750	437.93	7 486.58	1 561.3	3 859.4
2029	1.928	19.490	1.677	1 658.465	383.40	7 869.98	1 740.5	4 408.0
2030	1.928	21.418	1.843	1 639.181	334.92	8 204.90	1 921.6	4 968.9
2031	1.928	23.347	2.009	1 619.896	291.87	8 496.77	2 104.6	5 537.7
2032	1.928	25.275	2.175	1 600.612	253.68	8 750.45	2 289.5	6 110.7
2033	1.928	27.204	2.341	1 581.327	219.85	8 970.30	2 476.3	6 684.5
2034	1.928	29.132	2.507	1 562.043	189.91	9 160.21	2 665.1	7 256.3
2035	1.928	31.060	2.672	1 542.758	163.45	9 323.66	2 837.4	7 819.9
2036	1.928	32.989	2.838	1 523.474	140.11	9 463.78	3 005.2	8 372.7
2037	1.928	34.917	3.004	1 504.189	119.55	9 583.33	3 136.9	8 907.0
2038	1.928	36.846	3.170	1 484.905	101.47	9 684.81	3 270.4	9 422.7
2039	1.928	38.774	3.336	1 465.620	85.60	9 770.41	3 386.5	9 917.2
2040	1.928	40.703	3.502	1 446.336	71.70	9 842.11	3 487.8	10 388.8
2041	1.928	42.631	3.668	1 427.052	59.55	9 901.66	3 565.2	10 835.1

2042	1.928	44.560	3.834	1 407.767	48.95	9 950.61	3 624.8	11 255.2
2043	1.928	46.488	4.000	1 388.483	39.74	9 990.35	3 669.7	11 649.1
2044	1.928	48.416	4.166	1 369.198	31.75	10 022.10	3 702.7	12 017.1
2045	1.928	50.345	4.332	1 349.914	24.84	10 046.94	3 722.7	12 359.6
2046	1.928	52.273	4.498	1 330.629	18.89	10 065.84	3 742.8	12 678.5
2047	1.928	54.202	4.664	1 311.345	13.79	10 079.63	3 763.1	12 975.4
2048	1.928	56.130	4.829	1 292.060	9.44	10 089.07	3 783.4	13 251.7
2049	1.928	58.059	4.995	1 272.776	5.74	10 094.81	3 803.9	13 509.0
2050	1.928	59.987	5.161	1 253.491	2.62	10 097.43	3 824.4	13 748.5

TYPICAL DOMESTIC RESIDENCES – SCENARIO S4

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Cost of renovation interventions in Present values Discounting interest rate i=8%	Aggregate cost of renovation interventions in present values Discounting interest rate i=8%	Annual benefit from energy savings	Annual aggregate benefit from energy savings in present values Discounting interest rate i=8%
	TWh	TWh	Mtoe	M€	M€	M€	M€	M€
2015	0.203	0.203	0.017	202.69	187.68	187.68	17.3	16.0
2016	0.270	0.472	0.041	266.87	228.80	416.48	44.8	54.4
2017	0.513	0.985	0.085	502.95	399.26	815.74	100.5	134.2
2018	0.674	1.659	0.143	653.70	480.49	1 296.23	174.5	262.5
2019	0.876	2.535	0.218	841.05	572.41	1 868.64	271.5	447.3
2020	1.045	3.580	0.308	992.35	625.35	2 493.98	387.8	691.6
2021	1.309	4.889	0.421	1 230.42	717.94	3 211.92	531.5	1 001.8
2022	1.503	6.392	0.550	1 398.12	730.18	3 942.11	696.3	1 378.0
2023	1.664	8.056	0.693	1 530.94	714.79	4 656.90	878.0	1 817.2
2024	1.791	9.848	0.847	1 629.88	679.45	5 336.35	1 074.0	2 314.7
2025	1.890	11.737	1.010	1 700.61	632.11	5 968.47	1 282.7	2 864.8
2026	1.923	13.660	1.175	1 711.70	566.45	6 534.92	1 497.1	3 459.3
2027	1.928	15.589	1.341	1 697.03	499.20	7 034.12	1 714.4	4 089.7
2028	1.918	17.507	1.506	1 668.73	435.57	7 469.69	1 933.4	4 748.0
2029	1.913	19.420	1.671	1 645.09	380.31	7 850.00	2 154.6	5 427.2
2030	1.928	21.348	1.837	1 639.18	334.92	8 184.92	2 380.0	6 121.9
2031	1.928	23.277	2.003	1 619.90	291.87	8 476.79	2 608.0	6 826.8
2032	1.960	25.236	2.171	1 626.43	257.77	8 734.57	2 842.3	7 538.0
2033	1.970	27.206	2.341	1 615.33	224.58	8 959.14	3 080.5	8 251.8
2034	1.975	29.181	2.511	1 599.83	194.50	9 153.64	3 322.1	8 964.6
2035	1.998	31.180	2.683	1 598.75	169.39	9 323.03	3 550.1	9 669.8
2036	2.037	33.217	2.858	1 609.48	148.02	9 471.05	3 774.0	10 364.0
2037	2.050	35.267	3.034	1 599.21	127.11	9 598.16	3 970.9	11 040.3
2038	2.071	37.338	3.213	1 594.68	108.97	9 707.14	4 151.7	11 695.0
2039	2.087	39.425	3.392	1 585.79	92.62	9 799.76	4 314.7	12 325.1
2040	2.092	41.517	3.572	1 568.81	77.77	9 877.53	4 460.3	12 928.1
2041	2.100	43.616	3.753	1 553.64	64.83	9 942.36	4 578.8	13 501.3

2042	2.107	45.723	3.934	1 538.33	53.49	9 995.85	4 677.5	14 043.5
2043	2.105	47.828	4.115	1 515.39	43.37	10 039.23	4 755.3	14 553.9
2044	2.105	49.933	4.296	1 494.34	34.65	10 073.88	4 823.0	15 033.2
2045	2.133	52.066	4.480	1 493.25	27.48	10 101.36	4 882.2	15 482.4
2046	2.141	54.207	4.664	1 477.28	20.98	10 122.33	4 939.3	15 903.3
2047	2.149	56.356	4.849	1 461.16	15.37	10 137.70	4 998.5	16 297.6
2048	2.157	58.512	5.034	1 444.88	10.55	10 148.26	5 061.3	16 667.3
2049	2.180	60.692	5.222	1 438.72	6.49	10 154.75	5 128.3	17 014.1
2050	2.232	62.924	5.161	1 450.61	3.03	10 157.77	5 200.1	17 339.8

TYPICAL DOMESTIC RESIDENCES – SCENARIO S5

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Cost of renovation interventions in present values Discounting interest rate i=8%	Aggregate cost of renovation interventions in present values Discounting interest rate i=8%	Annual benefit from energy savings	Aggregate annual benefit from energy savings in present values Discounting interest rate i=8%
	TWh	TWh	Mtoe	M€	M€	M€	M€	M€
2015	0.376	0.376	0.032	375.84	348.00	348.00	30.9	28.6
2016	0.570	0.946	0.081	564.54	484.00	832.00	78.1	95.5
2017	0.687	1.633	0.140	673.14	534.36	1 366.36	135.5	203.1
2018	0.791	2.424	0.209	766.84	563.65	1 930.01	202.2	351.8
2019	0.855	3.279	0.282	821.15	558.86	2 488.87	275.1	539.0
2020	0.879	4.158	0.358	834.75	526.04	3 014.91	350.7	760.0
2021	0.907	5.065	0.436	852.77	497.58	3 512.49	429.5	1 010.6
2022	0.920	5.985	0.515	855.75	446.92	3 959.41	510.3	1 286.3
2023	0.959	6.944	0.597	882.32	411.95	4 371.37	595.3	1 584.1
2024	0.985	7.929	0.682	896.31	373.65	4 745.02	683.4	1 900.6
2025	1.011	8.940	0.769	909.79	338.17	5 083.19	774.7	2 232.9
2026	1.037	9.977	0.858	922.75	305.36	5 388.55	869.2	2 578.1
2027	1.063	11.039	0.950	935.19	275.09	5 663.65	967.0	2 933.6
2028	1.089	12.128	1.043	947.12	247.22	5 910.86	1 068.1	3 297.3
2029	1.115	13.243	1.139	958.52	221.59	6 132.45	1 172.6	3 666.9
2030	1.140	14.383	1.238	969.41	198.07	6 330.52	1 280.4	4 040.6
2031	1.166	15.549	1.338	979.78	176.54	6 507.06	1 391.7	4 416.8
2032	1.192	16.742	1.440	989.63	156.85	6 663.90	1 506.6	4 793.8
2033	1.218	17.960	1.545	998.96	138.88	6 802.79	1 624.9	5 170.3

2034	1.244	19.204	1.652	1 007.77	122.52	6 925.31	1 746.9	5 545.1
2035	1.270	20.474	1.762	1 016.06	107.65	7 032.96	1 838.1	5 910.3
2036	1.296	21.770	1.873	1 023.84	94.16	7 127.12	1 914.8	6 262.5
2037	1.322	23.092	1.987	1 031.10	81.95	7 209.08	1 983.8	6 600.3
2038	1.348	24.440	2.103	1 037.84	70.92	7 280.00	2 046.3	6 923.0
2039	1.374	25.814	2.221	1 044.06	60.98	7 340.98	2 105.9	7 230.5
2040	1.400	27.213	2.341	1 049.76	52.04	7 393.02	2 166.2	7 523.4
2041	1.452	28.665	2.466	1 074.12	44.82	7 437.84	2 229.3	7 802.5
2042	1.503	30.168	2.596	1 097.45	38.16	7 476.00	2 296.8	8 068.7
2043	1.529	31.698	2.727	1 101.08	31.51	7 507.52	2 363.6	8 322.4
2044	1.607	33.305	2.866	1 141.00	26.46	7 533.98	2 436.1	8 564.5
2045	1.724	35.028	3.014	1 206.58	22.20	7 556.18	2 518.1	8 796.2
2046	1.848	36.876	3.173	1 275.19	18.11	7 574.29	2 610.4	9 018.6
2047	1.970	38.846	3.342	1 339.55	14.09	7 588.38	2 713.1	9 232.6
2048	2.048	40.894	3.519	1 371.95	10.02	7 598.40	2 821.8	9 438.8
2049	2.151	43.045	3.704	1 419.90	6.40	7 604.80	2 939.3	9 637.5
2050	2.229	45.274	3.895	1 448.93	3.02	7 607.83	3 063.1	9 829.4

OFFICES/SHOPS – TARGETS SCENARIO

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Aggregate cost of interventions	Annual benefit from energy savings	Annual aggregate benefit from energy savings
	TWh	TWh	Mtoe	M€	M€	M€	M€
2015	0.093	0.093	0.008	140.07	140.07	5.9	5.9
2016	0.119	0.213	0.018	177.22	317.29	13.6	19.6
2017	0.195	0.408	0.035	286.47	603.76	26.2	45.8
2018	0.195	0.602	0.052	283.55	887.31	38.9	84.7
2019	0.195	0.797	0.069	280.63	1 167.94	51.8	136.5
2020	0.195	0.992	0.085	277.70	1 445.64	64.8	201.3
2021	0.240	1.232	0.106	338.38	1 784.03	80.9	282.3
2022	0.283	1.515	0.130	394.19	2 178.22	100.0	382.3
2023	0.390	1.905	0.164	538.14	2 716.36	127.3	509.6
2024	0.516	2.421	0.208	704.62	3 420.98	162.5	672.1
2025	0.556	2.977	0.256	750.33	4 171.30	200.6	872.7

2026	0.556	3.533	0.304	741.99	4 913.29	239.2	1 111.9
2027	0.556	4.088	0.352	733.65	5 646.95	278.1	1 390.0
2028	0.556	4.644	0.400	725.32	6 372.26	317.5	1 707.5
2029	0.556	5.200	0.447	716.98	7 089.24	357.3	2 064.8
2030	0.556	5.756	0.495	708.64	7 797.88	397.5	2 462.3
2031	0.556	6.312	0.543	700.31	8 498.19	438.1	2 900.4
2032	0.556	6.867	0.591	691.97	9 190.16	479.1	3 379.5
2033	0.556	7.423	0.639	683.63	9 873.79	520.6	3 900.1
2034	0.556	7.979	0.687	675.29	10 549.08	562.5	4 462.5
2035	0.556	8.535	0.734	666.96	11 216.04	598.2	5 060.7
2036	0.556	9.091	0.782	658.62	11 874.66	632.4	5 693.1
2037	0.556	9.646	0.830	650.28	12 524.94	661.6	6 354.6
2038	0.556	10.202	0.878	641.95	13 166.89	691.0	7 045.7
2039	0.556	10.758	0.926	633.61	13 800.50	720.8	7 766.5
2040	0.556	11.314	0.973	625.27	14 425.77	750.8	8 517.3
2041	0.556	11.870	1.021	616.94	15 042.71	777.9	9 295.2
2042	0.556	12.425	1.069	608.60	15 651.31	802.1	10 097.3
2043	0.556	12.981	1.117	600.26	16 251.57	817.6	10 914.9
2044	0.556	13.537	1.165	591.92	16 843.49	824.9	11 739.8
2045	0.556	14.093	1.213	583.59	17 427.08	829.3	12 569.0
2046	0.556	14.649	1.260	575.25	18 002.33	833.7	13 402.7
2047	0.556	15.204	1.308	566.91	18 569.24	838.1	14 240.8
2048	0.556	15.760	1.356	558.58	19 127.82	842.6	15 083.4
2049	0.556	16.316	1.404	550.24	19 678.06	847.0	15 930.4
2050	0.556	16.872	1.452	541.90	20 219.96	851.5	16 782.0

SCHOOLS – TARGETS SCENARIO

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Aggregate cost of renovation interventions	Annual benefit from energy savings	Annual aggregate benefit from energy savings
	TWh	TWh	Mtoe	M€	M€	M€	M€
2015	0.0053	0.0053	0.0005	6.313	6.31	0.48	0.48
2016	0.0070	0.0123	0.0011	8.312	14.63	1.12	1.60
2017	0.0133	0.0256	0.0022	15.665	30.29	2.75	4.35

2018	0.0175	0.0431	0.0037	20.361	50.65	4.38	8.73
2019	0.0227	0.0658	0.0057	26.196	76.85	6.52	15.24
2020	0.0271	0.0929	0.0080	30.908	107.76	9.08	24.33
2021	0.0340	0.1269	0.0109	38.324	146.08	12.32	36.65
2022	0.0390	0.1659	0.0143	43.547	189.63	16.07	52.72
2023	0.0432	0.2091	0.0180	47.684	237.31	20.26	72.98
2024	0.0465	0.2556	0.0220	50.765	288.07	24.81	97.79
2025	0.0501	0.3057	0.0263	54.058	342.13	29.74	127.53
2026	0.0501	0.3557	0.0306	53.458	395.59	34.73	162.27
2027	0.0501	0.4058	0.0349	52.857	448.45	39.78	202.05
2028	0.0501	0.4558	0.0392	52.256	500.70	44.88	246.92
2029	0.0501	0.5059	0.0435	51.656	552.36	50.03	296.95
2030	0.0501	0.5559	0.0478	51.055	603.41	55.23	352.18
2031	0.0501	0.6060	0.0521	50.454	653.87	60.49	412.68
2032	0.0501	0.6560	0.0564	49.854	703.72	65.81	478.49
2033	0.0501	0.7061	0.0608	49.253	752.98	71.18	549.67
2034	0.0501	0.7561	0.0651	48.652	801.63	76.61	626.28
2035	0.0501	0.8062	0.0694	48.052	849.68	81.56	707.85
2036	0.0501	0.8562	0.0737	47.451	897.13	86.39	794.24
2037	0.0501	0.9063	0.0780	46.850	943.98	90.18	884.42
2038	0.0501	0.9564	0.0823	46.250	990.23	94.02	978.44
2039	0.0501	1.0064	0.0866	45.649	1 035.88	97.36	1 075.79
2040	0.0501	1.0565	0.0909	45.049	1 080.93	100.27	1 176.06
2041	0.0501	1.1065	0.0952	44.448	1 125.38	102.50	1 278.56
2042	0.0501	1.1566	0.0995	43.847	1 169.22	104.21	1 382.78
2043	0.0501	1.2066	0.1038	43.247	1 212.47	105.51	1 488.28
2044	0.0501	1.2567	0.1081	42.646	1 255.12	106.46	1 594.74
2045	0.0501	1.3067	0.1124	42.045	1 297.16	107.03	1 701.77
2046	0.0501	1.3568	0.1167	41.445	1 338.61	107.62	1 809.39
2047	0.0501	1.4068	0.1210	40.844	1 379.45	108.20	1 917.59
2048	0.0501	1.4569	0.1254	40.243	1 419.69	108.79	2 026.38
2049	0.0501	1.5069	0.1297	39.643	1 459.34	109.38	2 135.75
2050	0.0501	1.5570	0.1340	39.042	1 498.38	109.97	2 245.72

HOSPITALS – TARGETS SCENARIO

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Aggregate cost of renovation interventions	Annual benefit from energy savings	Annual aggregate benefit from energy savings
	TWh	TWh	Mtoe	M€	M€	M€	M€
2015	0.0043	0.0043	0.00037	6.449	6.45	0.38	0.38
2016	0.0057	0.0100	0.000862	8.491	14.94	0.89	1.28
2017	0.0109	0.0209	0.001798	16.002	30.94	2.20	3.47
2018	0.0143	0.0352	0.003028	20.798	51.74	3.50	6.97
2019	0.0186	0.0538	0.004627	26.759	78.50	5.20	12.17
2020	0.0222	0.0759	0.006534	31.572	110.07	7.25	19.43
2021	0.0278	0.1037	0.008922	39.147	149.22	9.84	29.27
2022	0.0319	0.1356	0.011666	44.483	193.70	12.84	42.11
2023	0.0353	0.1709	0.014703	48.708	242.41	16.18	58.29
2024	0.0380	0.2089	0.017971	51.856	294.27	19.81	78.10
2025	0.0409	0.2498	0.021491	55.220	349.49	23.75	101.85
2026	0.0409	0.2907	0.02501	54.606	404.09	27.74	129.59
2027	0.0409	0.3316	0.028529	53.993	458.08	31.77	161.36
2028	0.0409	0.3725	0.032049	53.379	511.46	35.84	197.20
2029	0.0409	0.4134	0.035568	52.766	564.23	39.95	237.15
2030	0.0409	0.4543	0.039087	52.152	616.38	44.11	281.26
2031	0.0409	0.4952	0.042607	51.539	667.92	48.31	329.57
2032	0.0409	0.5361	0.046126	50.925	718.85	52.56	382.13
2033	0.0409	0.5770	0.049646	50.311	769.16	56.85	438.97
2034	0.0409	0.6179	0.053165	49.698	818.85	61.18	500.16
2035	0.0409	0.6588	0.056684	49.084	867.94	65.14	565.29
2036	0.0409	0.6997	0.060204	48.471	916.41	68.99	634.28
2037	0.0409	0.7406	0.063723	47.857	964.27	72.01	706.29
2038	0.0409	0.7815	0.067242	47.244	1 011.51	75.08	781.37
2039	0.0409	0.8224	0.070762	46.630	1 058.14	77.74	859.12
2040	0.0409	0.8633	0.074281	46.017	1 104.16	80.07	939.19
2041	0.0409	0.9042	0.0778	45.403	1 149.56	81.85	1 021.04

2042	0.0409	0.9451	0.08132	44.789	1 194.35	83.22	1 104.26
2043	0.0409	0.9860	0.084839	44.176	1 238.53	84.25	1 188.51
2044	0.0409	1.0269	0.088358	43.562	1 282.09	85.01	1 273.52
2045	0.0409	1.0678	0.091878	42.949	1 325.04	85.47	1 358.99
2046	0.0409	1.1088	0.095397	42.335	1 367.37	85.93	1 444.92
2047	0.0409	1.1497	0.098916	41.722	1 409.09	86.40	1 531.32
2048	0.0409	1.1906	0.102436	41.108	1 450.20	86.87	1 618.19
2049	0.0409	1.2315	0.105955	40.495	1 490.70	87.34	1 705.53
2050	0.0409	1.2724	0.109474	39.881	1 530.58	87.81	1 793.34

HOTELS – TARGETS SCENARIO

Year	Annual energy savings	Aggregate energy savings	Aggregate primary energy savings	Cost of renovation interventions	Aggregate cost of renovation interventions	Annual benefit from energy savings	Annual aggregate benefit from energy savings
	TWh	TWh	Mtoe	M€	M€	M€	M€
2015	0.0091	0.009085	0.0008	13.627	13.63	0.72	0.72
2016	0.0121	0.021167	0.0018	17.942	31.57	1.68	2.40
2017	0.0230	0.044169	0.0038	33.814	65.38	4.13	6.53
2018	0.0302	0.074374	0.0064	43.949	109.33	6.58	13.12
2019	0.0393	0.113641	0.0098	56.544	165.88	9.79	22.91
2020	0.0468	0.160459	0.0138	66.716	232.59	13.65	36.56
2021	0.0587	0.219127	0.0189	82.722	315.31	18.52	55.08
2022	0.0674	0.286508	0.0247	93.996	409.31	24.15	79.23
2023	0.0746	0.361091	0.0311	102.925	512.23	30.44	109.67
2024	0.0803	0.441368	0.0380	109.577	621.81	37.27	146.95
2025	0.0864	0.527801	0.0454	116.685	738.50	44.69	191.64
2026	0.0864	0.614234	0.0528	115.388	853.88	52.19	243.83
2027	0.0864	0.700667	0.0603	114.092	967.98	59.76	303.59
2028	0.0864	0.787101	0.0677	112.795	1 080.77	67.42	371.01
2029	0.0864	0.873534	0.0752	111.499	1 192.27	75.15	446.16
2030	0.0864	0.959967	0.0826	110.202	1 302.47	82.97	529.13
2031	0.0864	1.046401	0.0900	108.906	1 411.38	90.87	620.00

2032	0.0864	1.132834	0.0975	107.609	1 518.99	98.85	718.86
2033	0.0864	1.219267	0.1049	106.313	1 625.30	106.92	825.78
2034	0.0864	1.305701	0.1123	105.016	1 730.32	115.07	940.85
2035	0.0864	1.392134	0.1198	103.720	1 834.04	122.50	1 063.35
2036	0.0864	1.478567	0.1272	102.423	1 936.46	129.75	1 193.10
2037	0.0864	1.565	0.1347	101.127	2 037.59	135.43	1 328.52
2038	0.0864	1.651434	0.1421	99.830	2 137.42	141.19	1 469.72
2039	0.0864	1.737867	0.1495	98.534	2 235.95	146.20	1 615.92
2040	0.0864	1.8243	0.1570	97.237	2 333.19	150.57	1 766.49
2041	0.0864	1.910734	0.1644	95.941	2 429.13	153.91	1 920.39
2042	0.0864	1.997167	0.1718	94.644	2 523.78	156.48	2 076.87
2043	0.0864	2.0836	0.1793	93.348	2 617.12	158.41	2 235.29
2044	0.0864	2.170034	0.1867	92.051	2 709.18	159.84	2 395.12
2045	0.0864	2.256467	0.1941	90.755	2 799.93	160.70	2 555.82
2046	0.0864	2.3429	0.2016	89.458	2 889.39	161.56	2 717.38
2047	0.0864	2.429334	0.2090	88.162	2 977.55	162.43	2 879.81
2048	0.0864	2.515767	0.2165	86.865	3 064.42	163.31	3 043.12
2049	0.0864	2.6022	0.2239	85.569	3 149.99	164.19	3 207.31
2050	0.0864	2.688633	0.2313	84.272	3 234.26	165.07	3 372.38