Report on the long-term strategy to mobilise investment in the renovation of private and public residential and commercial buildings in the national building stock

(2nd Edition)

(Article 4, Directive 27/2012/EU)

Athens, April 2018

Contents

1 Introduction

This report is the second edition of the long-term strategy to mobilise investment in the renovation of public and private residential and commercial buildings in the national building stock, as provided for in Article 4 of Directive 2012/27/EU on energy efficiency.[1]

The European Commission has adopted two directives: Directive 2010/31/EU on the energy performance of buildings (recast of Directive 2002/91/EU) and Directive 2012/27/EU on energy efficiency. Both these directives underline the importance of work to improve the energy performance of buildings and the importance of taking a long-term view of investment in renovations of the building stock.

The building sector (residential and tertiary sector) accounts for a large proportion of total energy consumption. As the figure below illustrates, it accounted for 39 % of domestic consumption in 2016.

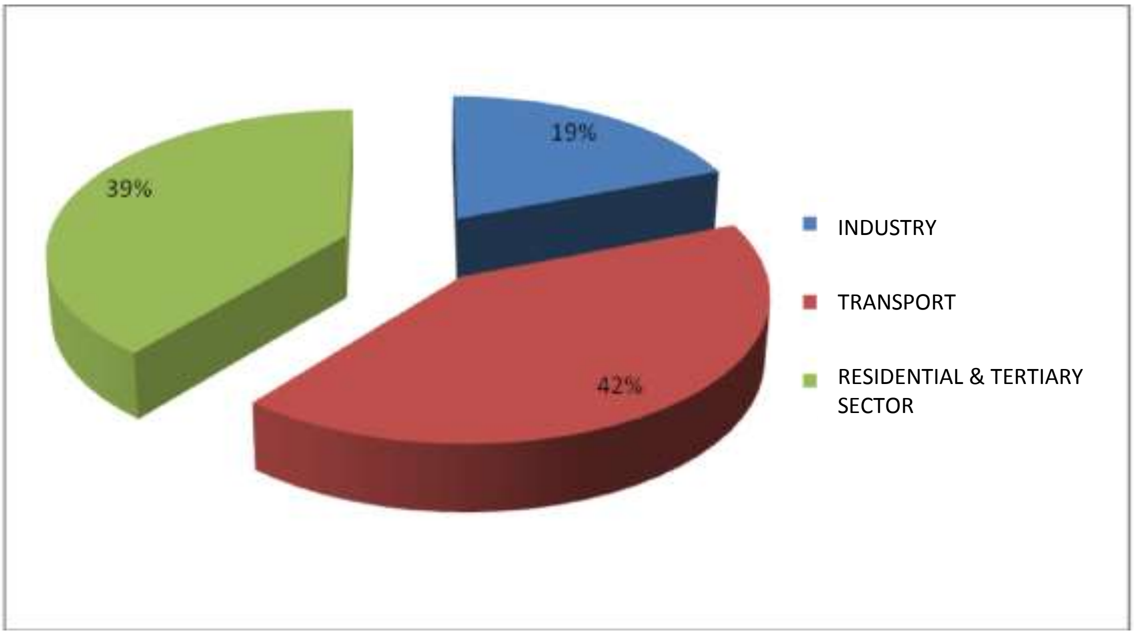


Figure 1: Distribution of final energy [consumption] by use, 2016 [1]

[1] The report was prepared in collaboration with senior servants of the Ministry of the Environment and Energy (YPEN) and of the Mild Forms of Energy and Environmental Protection Laboratory of the Department of Mechanical Engineering of the University of West Attica.

Table 1: Distribution of final energy consumption by use, 2016 [1]

Sector	Consumption (%)	Consumption (ktoe)
Industry	19.1	3.095
Transport	41.8	6.753
Residential and tertiary sector (offices, shops etc.)	39.1	6.322
	100	16.170

Buildings in Greece consume a very high proportion of electricity. As the figure below illustrates, 74.2 % of electricity consumed in Greece in 2016 was accounted for by the residential (37.6 %) and tertiary sectors (36.6 %) [1].

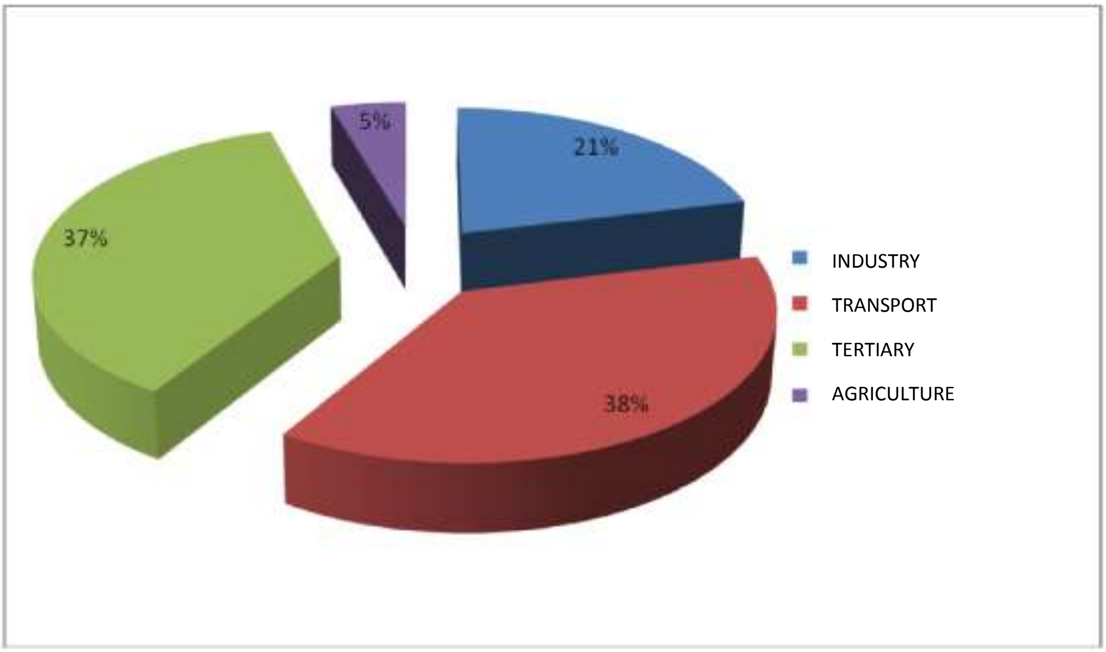


Figure 2: Distribution of electricity consumption by use, 2016 [1]

Table 2: Distribution of electricity consumption by use, 2016 [1]

Sector of use	Consumption of electricity (GWh)
Industry	11 281
Residential	19 992
Agricultural	2 407
Tertiary	19 445
TOTAL	53 126

The long-term strategy to improve the energy performance of the building stock is designed to provide a basic instrument for the purpose of defining policy both to improve the energy performance of buildings and to attract investors and mobilise private capital.

2 Methodology

This strategy includes:

a) an overview of the national building stock based on appropriate statistical sampling;

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

c) policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations;

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

e) an estimate of the expected energy savings and wider benefits based on specific evidence and a specific methodology.

The long-term strategy is based on an evaluation of the building stock made from the inventories and reports prepared by the Hellenic Statistical Authority (ELSTAT). Most buildings are for residential use. The rest, which are classed as non-residential, i.e. tertiary sector buildings, have been categorised by four (4) basic uses, namely buildings used for shops/commerce/offices, buildings for school and educational use, hotels and hospitals. The remainder, such as churches, car parks, sports buildings (housing stadia and buildings for general sports use) were excluded from the analysis.

Two (2) scenarios, depending on the type of energy-efficiency renovation, were then considered for the five (5) basic categories of building stock from the point of view of quantity and energy consumption. The type of energy-efficiency renovation is expressed based on the rate of energy savings achieved for the given number of buildings renovated. The above scenarios are examined in greater detail in terms of the investments needed for each particular renovation and in terms of their specific social impact.

3 Objectives/Timeline

Although the building sector has not set a specific energy-saving target, it should be noted that the objective of the European strategy set out in Directive 2010/31/EU on the energy performance of buildings is for all new buildings to be nearly zero-energy buildings (NZEB) after 2020.

Directive 2012/27/EU on energy efficiency sets an annual renovation target of 3 % of the total floor area of buildings owned and occupied by central government with a floor area of over 250 m^2. In order to meet that requirement, the Ministry of the Environment and Energy (YPEN) has issued an initial list of 82 buildings over 500 m^2 owned by central government (total floor area approx. 310 000 m^2) and is in the process of collecting data to update and supplement that list in collaboration with central government agencies.

Article 7 of Directive 2012/27/EU sets a cumulative target for new annual savings of 3 332.7 ktoe by 2020. That target is being achieved through a combination of policy measures (90 % of the target) and energy efficiency obligation schemes (10 % of the target), including measures to improve the energy performance of (residential and tertiary sector) buildings which will equate to 2 300 ktoe in cumulative energy savings. That saving includes both measures covering investments in the construction and fitting-out of buildings and measures to bring about a behavioural change among building stock users (households and workers).

The measures taken to improve the energy performance of buildings within the framework of a more general national energy policy and Directive 2012/27/EU should also:

- create new jobs;
- improve living conditions and the quality of the internal environment, in both the home and the workplace;
- reduce energy dependency and associated currency outflows to pay for imported energy;
- improve long-term use of natural resources; and

- educate and inform final consumers in matters of the efficient use of energy and energy savings.

4 Participation of Stakeholders

Identifying stakeholders and involving them in the adoption of the measures described in this report is vital to the successful application of a long-term strategy for energy-efficiency renovations of buildings. Stakeholders and operators are identified by analysing the overall model describing energy-efficiency renovations. The figure below illustrates the basic factors involved in the building renovation decision-making process.

Figure 3: Basic factors involved in building renovation decision-making process

Centre: Owner
Clockwise from top: Contractors/Builders; Consultants/Engineers/Technicians; Suppliers; Banks; State/Municipalities/Ministry of Energy & Climate Change (YPEKA); Associations of property owners (POMIDA); Energy Service Companies (ESCOs); Industry; Auditors/Inspectors

A number of Ministries and other public agencies are connected with building stock-related policies and it is therefore vital to involve them in the formulation of energy-saving policies in general and policies to improve the energy performance of public buildings in particular. They include:

- Ministry of Finance
- Ministry of the Interior
- Ministry of the Economy and Development
- Ministry of Education, Research and Religious Affairs

- Ministry of the Environment and Energy
- Ministry of Health
- Ministry of Infrastructure and Transport
- Regions and Decentralised Administrations
- Local Authorities
- Public Properties Company S.A.
- Buildings Infrastructures S.A. (formed by merger between School Buildings Organisation S.A. (OSK S.A.), Public Health Infrastructure Development Company S.A. (DEPANOM S.A.) and THEMIS KATASKEVASTIKI)
- Hellenic Property Federation (POMIDA)
- Centre for Renewable Energy Sources and Saving (KAPE)
- Piraeus University of Applied Sciences (University of West Attica)
- Hellenic Association of Accredited Energy Inspectors (PSYPENEP)
- Hellenic Statistical Authority (ELSTAT)
- National Technical University of Athens (EMP)
- Aristotle University of Thessaloniki (APTH)
- Hellenic Confederation of Professionals, Craftsmen and Merchants (GSEBEE)
- Athens Planetarium (EAA)
- Association of Greek Municipalities (KEDE)
- Association of Greek Regions (ENPE)
- Institute of Zero Energy Buildings (INZEB)
- Hellenic Banking Association
- Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH [German Society for International Cooperation Ltd] (GIZ)

The following are important agencies and institutions traditionally involved directly or indirectly in energy-efficiency renovations of buildings, whose input is vital to the successful implementation of the building renovation strategy in Greece:

- Academic institutions
- Technical Chamber of Greece
- Centre for Renewable Energy Sources and Saving
- Research institutions (e.g. Athens Planetarium etc.)
- Associations of property owners (e.g. Hellenic Property Federation)
- Associations of builders (e.g. Federation of Builders and Building Firms)
- Environmental NGOs and institutions (e.g. Greenpeace, WWF, INZEB, Institute of Passive Buildings etc.)
- Hellenic Banking Association

5 Overview of Building Stock

5.1 Number of buildings

The building stock in Greece mainly comprises residential buildings and a number of buildings for other uses by the tertiary sector. A national building stock census is carried out every ten years. This report uses the results of the most recent (2011) building census.

Table 3: Number of buildings (2011 Census) [17]

Single-use buildings									
Total single-use buildings	Single use of building								
	Residential	Church/ Monastery	Hotel	Factory/ Workshop	School building	Shop/ Office	Car park	Hospital, clinic etc.	Other use
3 775 848	**2 990 324**	**47 872**	**34 736**	**30 731**	**19 474**	**153 510**	**16 952**	**1 749**	**480 500**
Mixed-use buildings									
Total mixed-use buildings	Main use of mixed-use building								
	Residential	Church/ Monastery	Hotel	Factory/ Workshop	School building	Shop/ Office	Car park	Hospital, clinic etc.	Other use
329 789	**255 684**	**515**	**8 780**	**3 031**	**2 379**	**52 744**	**515**	**224**	**5 917**
NUMBER OF BUILDINGS PER USE	**3 246 008**	**48 387**	**43 516**	**33 762**	**21 853**	**206 254**	**17 467**	**1 973**	**486 417**
TOTAL NUMBER OF BUILDINGS 4 105 637									

Based on the above data, the building stock for renovation is categorised as follows for the purposes of this report:

a) Residential buildings (detached dwellings and apartment blocks): **3 246 008**

b) Buildings for other uses: **273 596**

- i) offices and shops: 206 254
- ii) schools and education: 21 853
- iii) hospitals and clinics: 1 973
- iv) hotels: 43 516

As the figure below illustrates, residential buildings (based on the above table) account for 79.1 % of the total number of buildings and are therefore extremely important in terms of energy savings under the national building renovation strategy. Non-residential buildings account for approximately 20 %, with offices and shops, buildings for educational use, hospitals and clinics and hotels accounting for approximately 6.6 % of the stock.

Table 4: Distribution of building stock by use

		Percentage
a) Residential buildings (detached dwellings and apartment blocks):	**3 246 008**	79.1%
b) Buildings for other uses:	**273 596**	
i) offices and shops:	206 254	5.0%
ii) schools and education:	21 853	0.5%
iii) hospitals and clinics:	1 973	0.0%
iv) hotels:	43 516	1.1%
Total		**85.7%**

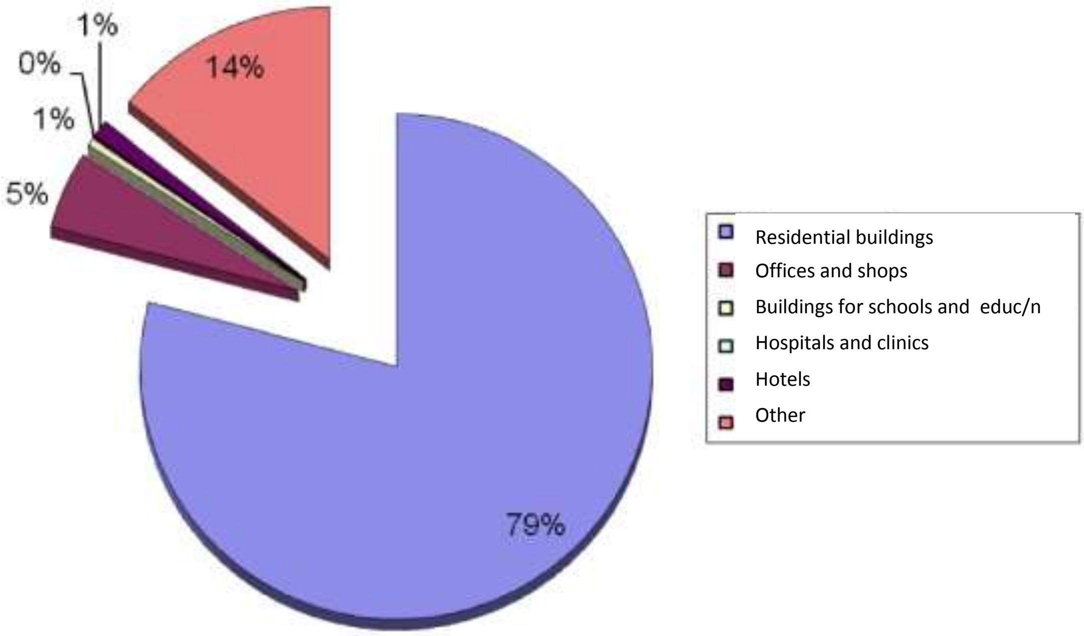


Figure 4: Distribution (%) of building stock by use

For the avoidance of doubt, residential buildings in the sense of self-contained spaces used for housing, include detached dwellings and the building units (apartments) in apartment blocks.

Table 5: Distribution of dwellings [2]

Distribution of dwellings (detached dwellings and building units)				
Inhabited (a)	Empty (b)	Regular (a + b)	Irregular (c)	TOTAL (a + b + c)
4 122 088	**2 249 813**	**6 371 901**	**12 452**	**6 384 353**

Inhabited dwellings (detached dwellings and building units)			
Detached dwellings	Building units (apartments) in apartment blocks	Other	TOTAL
1 394 440	2 717 418	110 230	4 122 088

Based on the above data, the dwellings considered for the purpose of the analysis in this report are regular dwellings (6 371 901): occupied (4 122 088) and empty (2 249 813). According to the definition provided by ELSTAT [3], 'regular dwelling' means a permanent and self-contained structure intended for use as a dwelling by one household for at least one year.

The number of regular dwellings is very large because it is the number from which the total number of dwellings is obtained which is used as a basis for calculating the available stock for energy-efficiency improvements/renovations.

As the figure below illustrates, regular occupied dwellings (detached dwellings and building units) account for 65 % of all regular dwellings; the remaining 35 % are empty.

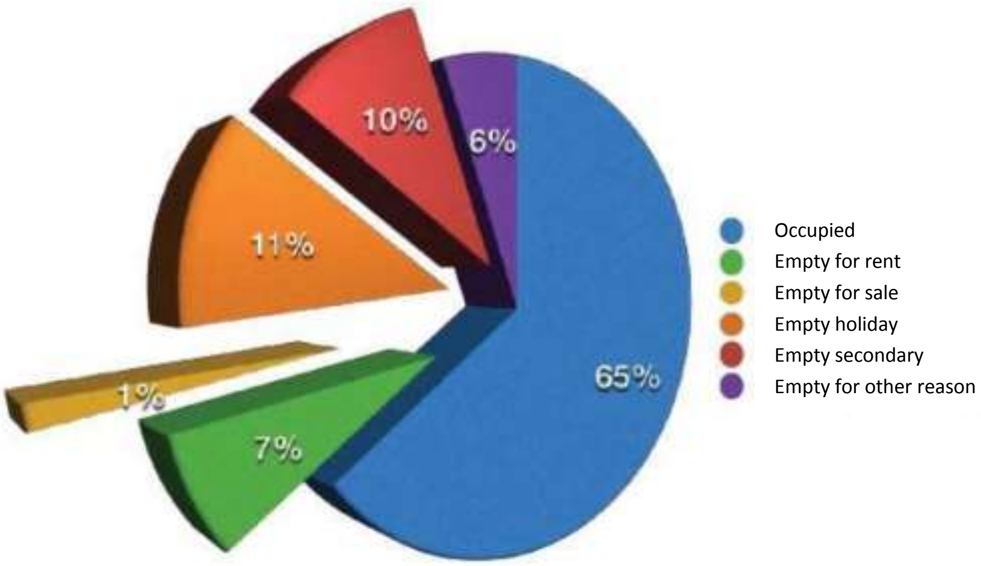


Figure 5: Distribution of dwellings (2011 census), ELSTAT [3]

Table 6: Status of dwellings (2011 census), ELSTAT [3]

STATUS OF DWELLING (Detached dwellings & building units)	NUMBER
Occupied	**4 122 088**
Empty for rent	453 901
Empty for sale	88 996
Empty holiday	729 964
Empty secondary	621 881
Empty for other reason	355 071
TOTAL	**6 371 901**

As the figure below illustrates, the distribution of regular dwellings in terms of size is as follows: 59 % are 50-99 m^2, 14 % are less than 49 m^2 and 27 % are over 100 m^2.

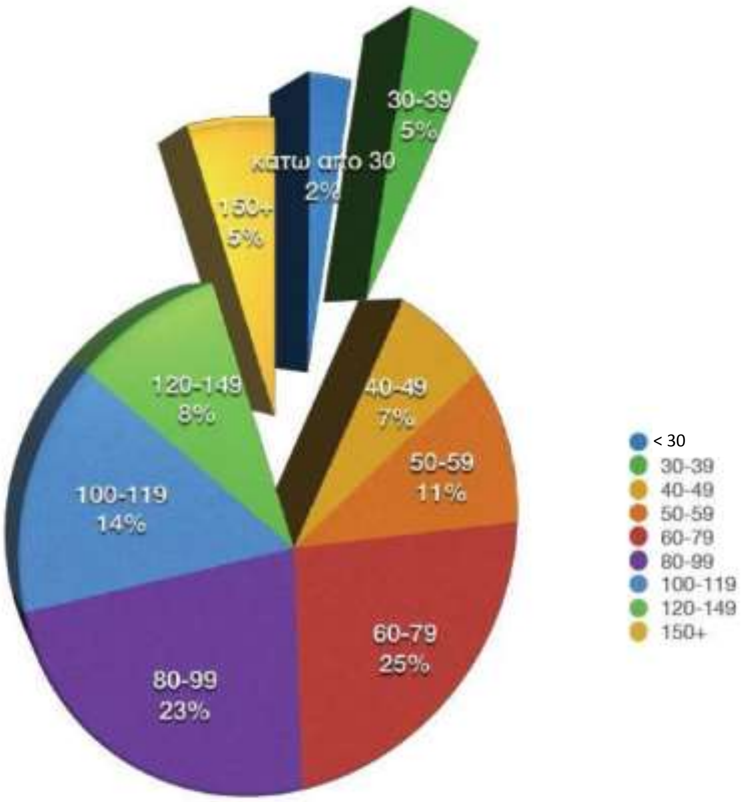


Figure 6: Size of dwellings (2011 census, ELSTAT [3])

As the figure below illustrates, the floor area per occupant is 34.6 m^2 per occupant.

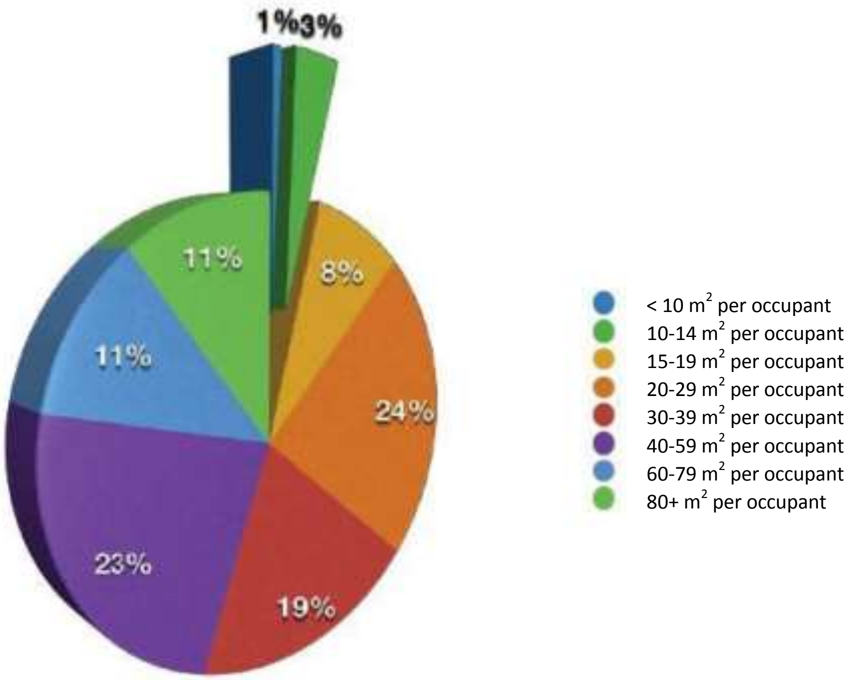


Figure 7: Occupancy density, floor area per occupant (2011 census, ELSTAT [3])

There is a lack of adequate data on the exact number and energy attributes of public buildings, which are considered particularly energy-intensive. There are 117 901 public buildings, most of which are buildings for schools and education owned by local authorities and buildings used for hospitals and health services. The remaining buildings owned by the State are managed, developed and operated by Public Properties Company S.A. (ETDA). According to a 2012 inventory [7], 1 552 buildings are used by central government, of which 348 are used for central government services. More than half the buildings are rented.

In terms of the building activity illustrated in the figure below, there was a sharp decline in the number of planning consents issued between 2006 and 2017 following the economic crisis. Building activity increased between 2000 and 2005 and then fell steadily between 2006 and 2017.

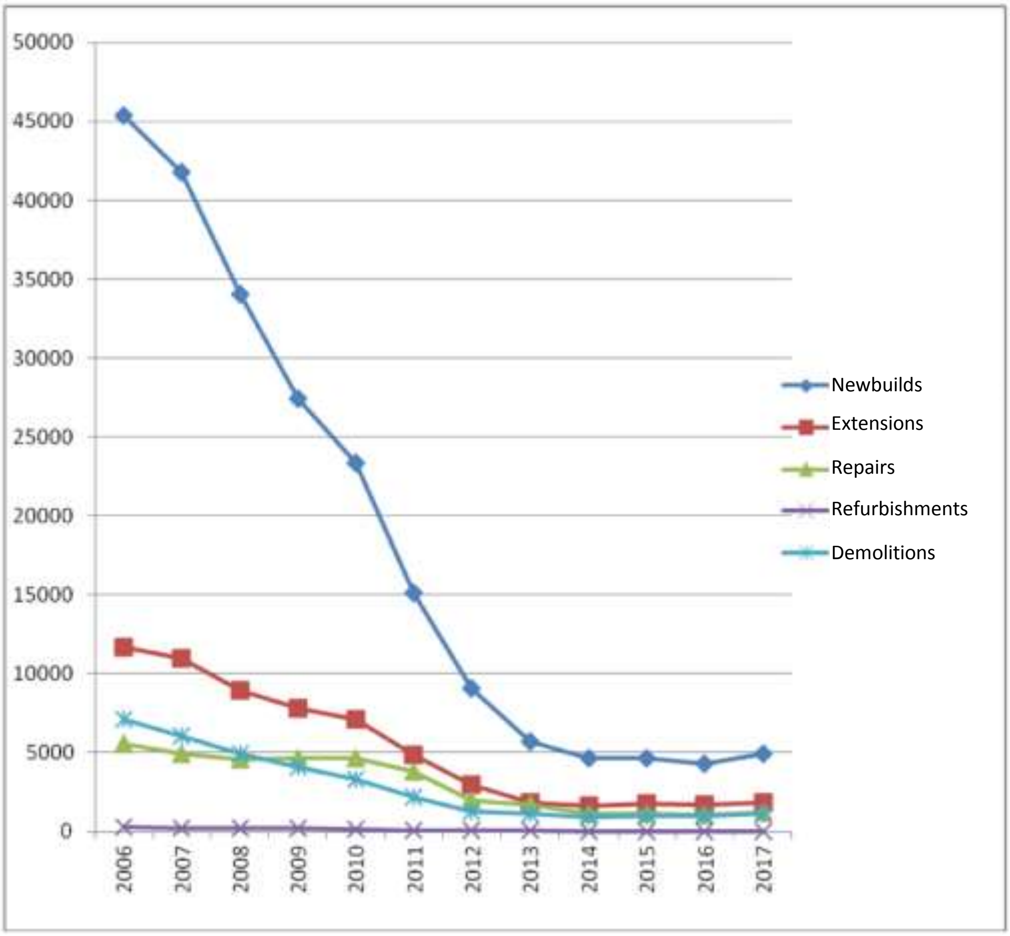


Figure 8: New planning consents 2006-2017 [based on ELSTAT data]

According to the planning consents granted between 2006 and 2017, 105 713 098 m^2 have been constructed (newbuilds and extensions). It should be noted that, although data are available on planning consents up to 2017, buildings constructed after 2001 have been disregarded for the purpose of this report on renovation of the building sector, as they are assumed to be highly energy efficient.

5.2 Age of buildings

In terms of age, buildings can be allocated to three basic different periods based on the legal framework (which was adopted initially in 1980 under the Building Insulation Regulations (KTHK) and subsequently, in 2010 and 2017, under the Regulations on the Energy Performance of Buildings (KENAK)) and the condition of and technologies applied to the building envelope and electrical and mechanical installations.

The tables below illustrate the age distribution of the national building stock by the periods defined by ELSTAT.

Table 7: Age distribution of buildings in Greece [based on ELSTAT data]

AGE DISTRIBUTION OF BUILDINGS IN GREECE							
Ownership	Pre-1919	1919-1960	1961-1980	1981-2000	2001-2011	In progress 2011	TOTAL
Public	17891	33025	28308	27669	10063	945	117901
Private	135498	863761	1313331	1203360	413448	51202	3980600
Mixed	617	1165	2176	2329	810	30	7136
Total	154006	897951	1343815	1233358	424321	52186	**4105637**

Table 8: Age distribution of buildings in Greece [based on ELSTAT data]

Construction period	Regular dwellings							
	Total	Occupied	Empty					
			Total	For rent	For sale	Holiday	Second	Other reason
TOTAL	6 371 901	4 122 088	2 249 813	453 901	88 996	729 964	621 881	355 071
Pre-1919	163 759	74 905	88 854	4 623	2 562	35 203	27 294	19 172
1919-1945	318 372	159 675	158 697	11 267	4 821	57 509	52 522	32 578
1946-1960	605 693	372 963	232 730	30 543	6 765	71 292	79 150	44 980
1961-1970	1 002 902	676 960	325 942	77 140	9 954	78 810	105 764	54 274
1971-1980	1 437 424	981 653	455 771	114 484	11 530	135 116	127 969	66 672
1981-1990	1 049 931	700 819	349 112	78 888	6 576	138 913	83 827	40 908
1991-2000	806 977	544 076	262 901	53 782	5 529	106 354	64 247	32 989
2000 onwards	986 843	611 037	375 806	83 174	41 259	106 767	81 108	63 498

As the preceding table illustrates, pre-1960 dwellings total 1 087 824 and post-2000 dwellings total 986 843.

Table 9: Distribution of tertiary sector buildings based on construction period and use (number of buildings) [based on ELSTAT data]

	Single- and mixed-used buildings				
Year of construction	Total	Hotels	School buildings	Shops/ Offices	Hospitals, clinics etc.
	273 596	**43 516**	**21 853**	**206 254**	**1 973**
Pre-1919	8 788	663	825	7 244	56
1919-1945	16 288	488	2 309	13 325	166
1946-1960	29 055	1 149	3 535	24 139	232
1961-1970	35 234	2 310	2 673	29 986	265
1971-1980	43 108	5 776	3 090	33 926	316
1981-1985	28 690	5 614	1 933	20 956	187
1986-1990	26 392	6 663	1 589	17 987	153
1991-1995	23 711	5 794	1 567	16 194	156
1996-2000	22 368	5 086	1 652	15 510	120
2001-2005	20 295	4 883	1 366	13 906	140
2000	16 666	4 284	1 162	11 069	151
onwards	3 001	806	152	2 012	31
In progress					

According to the 2011 census (ELSTAT 2014), 55 % of residential buildings in Greece were constructed before 1980, i.e. they have no thermal insulation and, due to the recession, buildings constructed after 2010 to the minimum standard required under the 1st KENAK (2010) account for just 1.5 % of the total stock of regular dwellings used by households.

The correlation between the construction period of a building and its energy performance as a result of changes to the legislative framework and technological advances is corroborated by the statistics on Energy Performance Certificates[2] (EPC) issued to date (approx. 1 180 000).

	<1960	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010	>2010
H	7617	132448	128748	34695	8768	4999	224
Z	3311	58602	76965	24840	10173	7057	249
E	2160	40037	56128	42178	30766	29201	851
Δ	1727	31989	41473	45153	56303	83581	3167
Γ	674	13380	17207	25151	36866	80918	6662
B	55	1183	1663	2453	3736	13110	7987
B+	5	167	242	299	334	1226	1909
A		17	15	30	35	157	165
A+		3	3	1	4	20	81

NUMBER OF EPC BY DECADE OF CONSTRUCTION AND ENERGY CATEGORY
NUMBER OF EPC

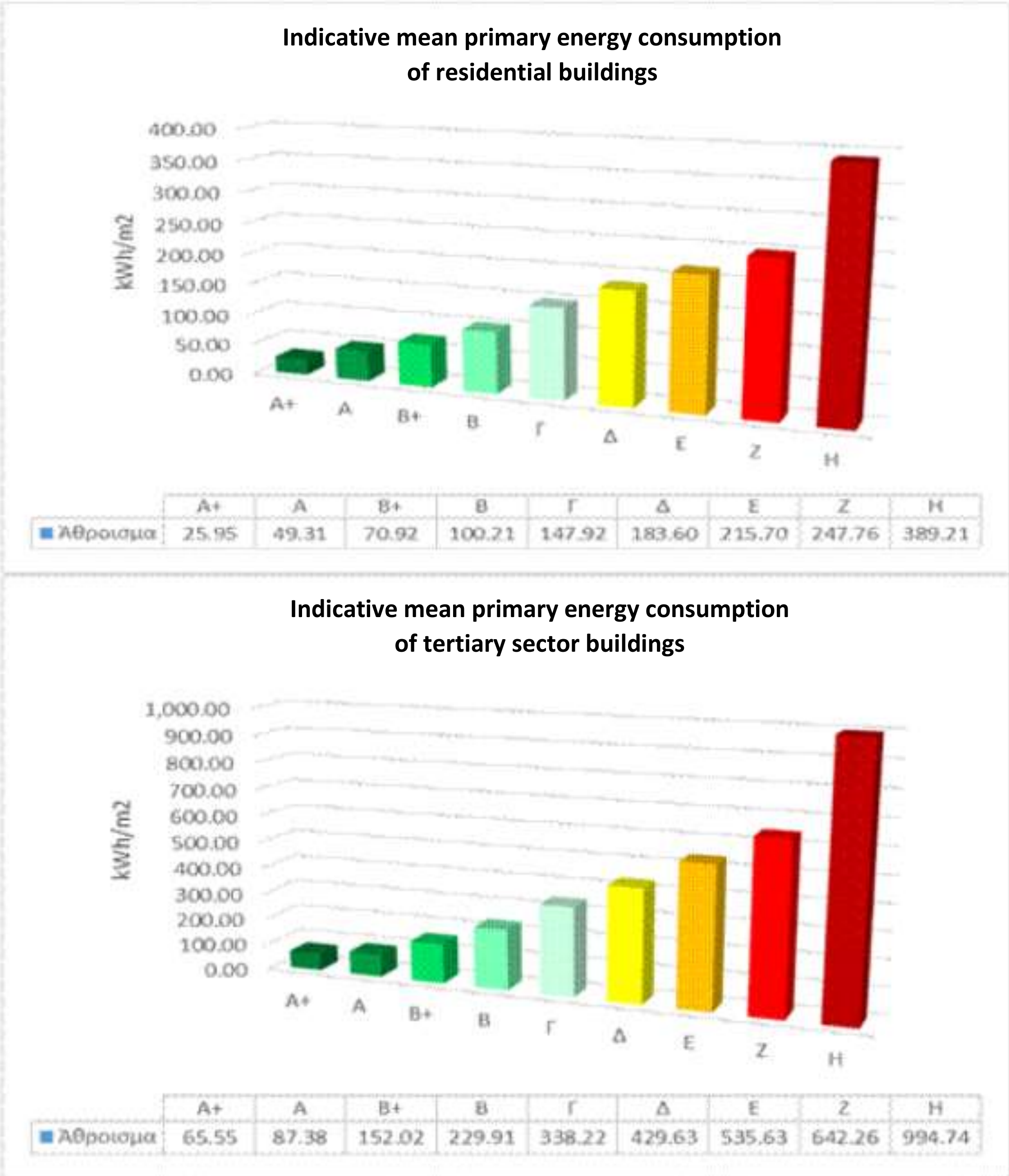
Figure 9: Number of EPC by decade of construction and energy category (2018, YPEN [5])

According to the above graph, most buildings that predate the KTHK (1980) are in energy category H. Buildings gradually improved under the KTHK (1981-2009) to categories D and C and, after 2010, most buildings have now been upgraded to categories C and B.

[2] According to the KENAK, buildings are classed in nine energy categories (from A+ to H), depending on their energy efficiency. The minimum requirement for new buildings and buildings subject to deep renovation is category B.

Table 10: Mean energy consumption by climatic zone (up to 2018)

Energy Category	Mean Energy Consumption by Climatic Zone			
	A	B	C	D
Residential buildings				
A+	18.58	23.34	42.66	26.60
A	37.74	53.98	52.44	76.53
B+	57.88	65.49	87.21	94.74
B	83.51	93.49	121.90	123.16
C	118.64	133.50	175.51	181.11
D	148.59	164.24	217.11	227.22
E	178.69	197.42	259.21	281.67
G	216.80	229.51	311.82	327.40
H	328.61	338.03	506.46	560.10
Tertiary sector buildings				
A+	79.66	46.21	76.73	29.70
A	110.91	81.29	97.03	81.60
B+	161.24	144.80	155.09	198.35
B	230.65	231.21	226.44	237.88
C	341.42	337.01	334.42	386.15
D	430.77	427.77	431.36	441.67
E	528.95	535.55	538.26	546.22
G	635.32	639.95	645.72	662.59
H	1,070.83	995.35	956.31	920.73



A+ A B+ B C D E G H
Cumulative

Figure 10: Indicative mean primary energy consumption of residential buildings and tertiary sector buildings (up to 2018)

5.3 Climatic zones

The Hellenic Republic is divided into four climatic zones (A, B, C and D, from hottest to coldest, based on heating degree-days) for the purpose of calculating the energy performance of buildings. The figure below shows the four climatic zones adopted under the KENAK.

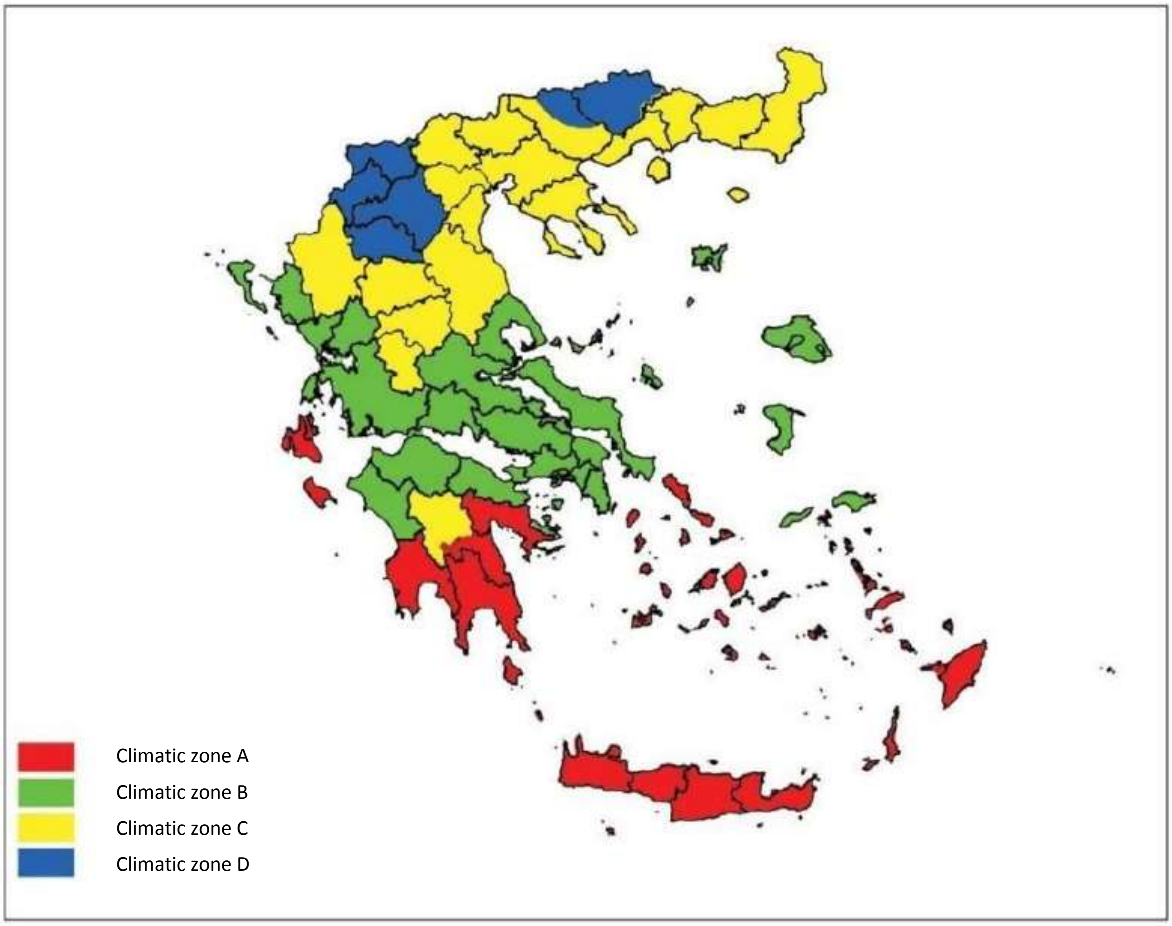


Figure 10: The four climatic zones of the Hellenic Republic based on the KENAK [6]

5.4 Energy consumption of buildings

According, moreover, to the 2016 Energy Balance Sheet, buildings (residential, commercial etc.) in Greece consume 6 322 ktoe or 39 % of total energy consumption, with the residential sector accounting for 27 %. These data illustrate the huge impact of the building sector on the overall energy balance sheet and the massive potential (margin) to reduce the energy consumption of buildings and improve their energy performance.

According to a specific survey of the energy consumption of residential buildings carried out by the Hellenic Statistical Authority (2011-2012), every household in the country consumes

10 244 kWh of thermal energy and 3 750 kWh of electricity a year on average to meet their energy requirements (see figure below).

THERMAL ENERGY **ELECTRICITY** **TOTAL ENERGY**

Figure 12: Mean annual consumption of energy per household 2011-2012 (ELSTAT, 2013) [4]

The EPC statistics published to date also illustrate the variations in consumption for each type of building in each climatic zone. The table below gives the mean energy consumption[3] of buildings by use in each climatic zone, the mean energy consumption of the corresponding reference building[4] in each climate zone and the potential for energy savings in the existing building stock.

[3] N.B. The consumption of buildings is theoretical consumption calculated based on the characteristics of the building (asset method), not real consumption based on the use of buildings by their occupants.

[4] Theoretical building with the same geometrical characteristics, location, orientation, use and operating characteristics as the building considered, which meets minimum KENAK requirements governing the design, building envelope and electrical and mechanical installations of an energy category B building.

Table 11: Mean consumption by building use and climatic zone

CLIMATIC ZONE	CATEGORY OF USE	TOTAL FLOOR AREA (m^2)	COMPUTED MEAN ANNUAL PRIMARY ENERGY CONSUMPTION OF EXISTING BUILDING (kWh/m^2)	COMPUTED MEAN ANNUAL PRIMARY ENERGY CONSUMPTION OF EXISTING BUILDING (GWh)	COMPUTED MEAN ANNUAL PRIMARY ENERGY CONSUMPTION OF KENAK-COMPLIANT BUILDING (kWh/m^2)	COMPUTED MEAN ANNUAL PRIMARY ENERGY CONSUMPTION OF KENAK-COMPLIANT BUILDING (GWh)	ENERGY SAVING (%)
A	**Commerce**	2 669 693.143	433.08	1 156.20	243.19	649.24	**43.85**
	Health & welfare	392 339.0534	410.75	161.15	274.71	107.78	**33.12**
	Lodging	2 370 314.035	440.13	1 043.25	256.23	607.34	**41.78**
	Education	368 403.238	167.41	61.67	109.23	40.24	**34.75**
	Public assembly	743 573.0246	729.37	542.34	454.16	337.70	**37.73**
	Correctional facility	3005.03	640.56	1.92	369.88	1.11	**42.26**
	Office	563 206.302	353.51	199.10	207.33	116.77	**41.35**
	Detached dwelling	3 911 994.649	254.05	993.82	95.33	372.94	**62.47**
	Apartment block	7 765 713.226	191.63	1 488.14	87.97	683.13	**54.10**
B	**Commerce**	9 906 443.659	451.86	4 476.32	256.41	2 540.14	**43.25**
	Health & welfare	991 942.214	441.31	437.76	288.00	285.68	**34.74**
	Lodging	1 404 196.855	510.14	716.34	288.01	404.42	**43.54**
	Education	1 520 058.749	190.46	289.51	121.18	184.21	**36.37**
	Public assembly	2 335 469.799	760.92	1 777.12	467.72	1 097.02	**38.27**
	Correctional facility	110 608.35	675.86	74.76	433.00	47.89	**35.93**
	Office	7 138 260.822	353.45	2 523.00	218.92	1 562.72	**38.06**
	Detached dwelling	7 914 336.098	332.92	2 634.87	113.12	895.25	**66.02**
	Apartment block	39 305 720.98	222.16	8 732.24	95.50	3 753.66	**57.01**
C	**Commerce**	5 021 449.769	459.11	2 305.38	250.62	1 258.49	**45.41**
	Health & welfare	961 530.1345	441.45	424.47	285.08	274.12	**35.42**
	Lodging	1 100 617.708	442.57	487.10	268.37	295.37	**39.36**
	Education	877 471.398	223.63	196.23	125.34	109.98	**43.95**
	Public assembly	1 276 550.596	780.69	996.59	455.88	581.95	**41.61**
	Correctional facility	35 482.53	528.31	18.75	418.02	14.83	**20.88**
	Office	1 618 577.923	358.08	579.58	217.20	351.56	**39.34**
	Detached dwelling	5 237 154.188	444.80	2 329.49	146.40	766.74	**67.09**
	Apartment block	18 864 187.55	285.75	5 490.37	129.24	2 438.01	**54.77**
D	**Commerce**	437 519.7525	493.15	215.76	249.77	109.28	**49.35**
	Health & welfare	78 938.814	420.92	33.23	286.05	22.58	**32.04**
	Lodging	49 328.13	752.37	37.11	366.63	18.09	**51.27**
	Education	84 370.74	243.65	20.56	119.90	10.12	**50.79**
	Public assembly	144 077.595	822.84	118.55	474.51	68.37	**42.33**
	Correctional facility	926.4	1 586.60	1.47	493.70	0.46	**68.88**
	Office	114 632.108	375.33	43.02	208.94	23.95	**44.33**
	Detached dwelling	876 510.3971	496.77	435.42	156.52	137.19	**68.49**
	Apartment block	1 873 273.308	314.10	588.40	133.43	249.95	**57.52**

The above table illustrates that, had the buildings in the aforementioned categories been constructed to KENAK standards, the energy savings would be 61 % for residential buildings and 41 % for tertiary sector buildings.

5.5 Building ownership

One important factor that must be considered when deciding on the renovation of a building is the ownership of the building. As the table below illustrates, most buildings (96.9 %) are privately owned and just 2.9 % are owned by the broader public sector.

Table 12: Distribution of buildings by ownership [based on ELSTAT data]

Distribution of buildings by ownership		
Public	Private	Joint
117 901	**3 980 600**	**7 136**
TOTAL NUMBER OF BUILDINGS		**4 105 637**

Another important factor is the use of the building by the owner or tenant.

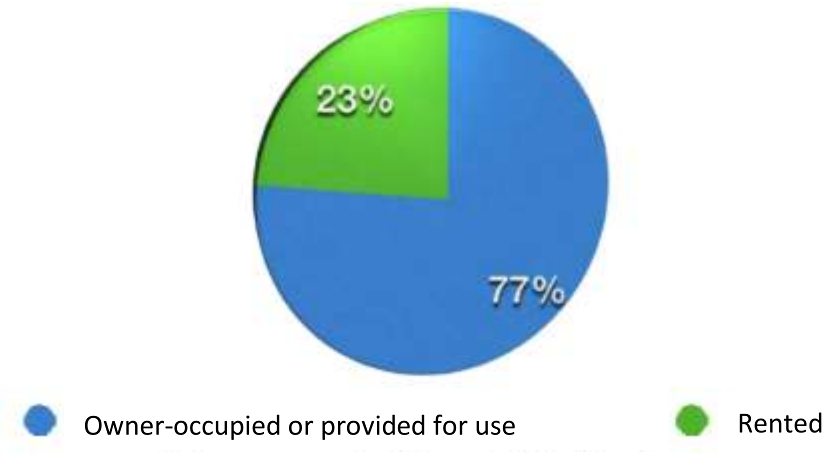


Figure 13: Ownership of buildings in Greece based on user (owner/tenant) [8]

The figure above confirms that most buildings are owner-occupied and that just 23 % of buildings are rented [8]. This particular factor is extremely important as it slows down interventions. That is why Directive 2012/27/EU on energy efficiency requires the Member States to adopt appropriate, mainly institutional, initiatives to remove such barriers.

5.6 Energy profile of buildings

The results of the 2011-2012 energy consumption survey by the Hellenic Statistical Authority [4] illustrate the distribution of mean annual total energy consumption by fuel and by type of use (see tables below).

Table 13: Distribution (%) of total energy consumption of households by type of fuel used [4]

Heating oil	44.1
Natural gas	5.4
District heating	0.5
Kerosene	0.3
Nuclear	0.3
Liquefied gas	1.8
Firewood	17.4
Wood pellets	0.5
Thermal energy (from thermal solar systems)	2.9
Electricity	26.8
Total	100.0

Table 14: Distribution (%) of total energy consumption of households by final use [4]

Heating	63.7
Domestic hot water	5.7
Cooking	17.3
Cooling	1.3
Lighting	1.7
Appliances (electrical/electronic)	10.2
Total	100.0

In terms of thermal energy, 85.9 % is used to heat dwellings, 9.7 % is used for cooking and 4.4 % is used for domestic hot water. The figure below illustrates the mean annual consumption of thermal energy by type of fuel:

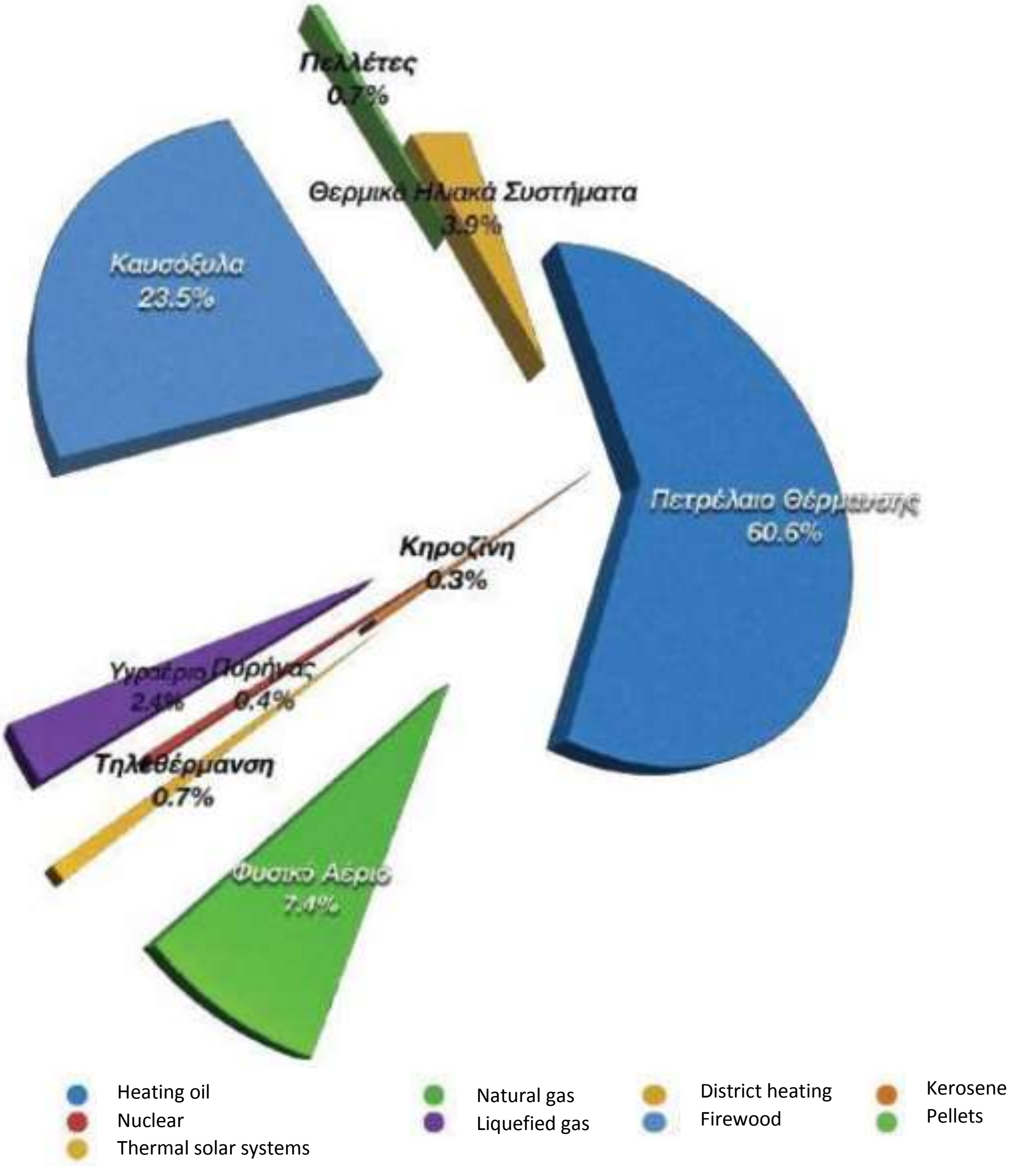


Figure 14: Distribution (%) of thermal energy consumption of households by type of fuel [4]

According to the survey, the most widely used fuel for thermal energy is oil (60.3 %), followed by firewood (12.4 %). Use of natural gas is still at relatively low levels (7.4 %). The table below lists the heating methods used by households.

Table 15: Household heating methods [4]

	2004	2008	2009	2010	2012	
Central heating	68.8	68.2	66.9	65.9	60.3	63.8
Oil-fired stove	8.3	5.3	5.2	5.0	3.5	
Natural gas-fired heating	0.7	5.0	6.6	7.2	7.4	8.7
Liquefied gas-fired stove	1.4	0.6	0.8	1.4	1.3	
Storage heaters	2.8	2.8	2.7	2.6	12.4	
Electric appliances	4.4	4.4	4.7	4.7		
Air-conditioning system	3.2	4.0	4.3	4.8		
Firewood-/biomass-fired stove	6.9	6.1	5.9	5.4	12	
Other	3.06	2.6	3.2	2.3	2.5	
No heating	0.5	0.4	0.4	0.5	0.6	

The figure below illustrates the average annual consumption of electricity by households, which is 38.4 % for cooking, 14.7 % for refrigerators, 10.6 % for washing machines and just 6.6 % for lighting and 4.9 % for space cooling.

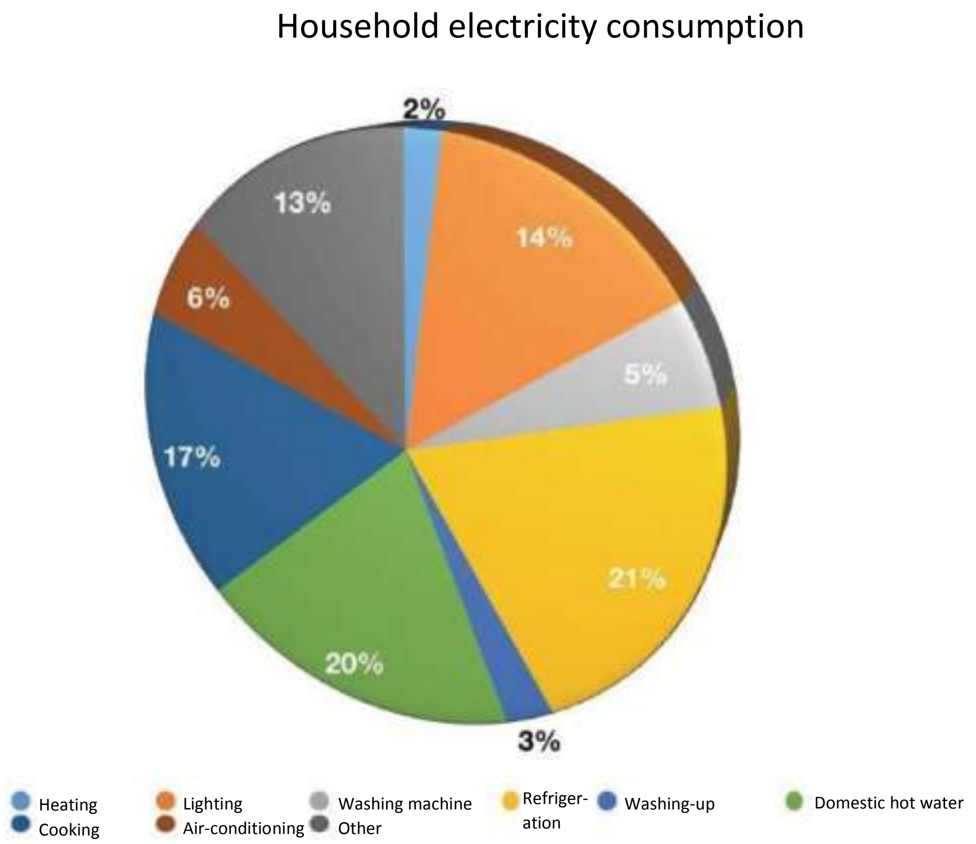


Figure 15: Distribution (%) of electricity consumption by final use [4]

A number of very important conclusions concerning the energy profile of Greek households can be drawn from the above survey and from statistics obtained from other surveys and studies:

- 59 % of dwellings have thermal insulation
- 98.9 % of dwellings have some form of heating system/equipment
- 50.8 % of households use central heating, 48.6 % use independent (free-standing) heaters and 0.6 % use district heating
- the fuel used for the dwelling's main heating system is:
    - heating oil (63.8 %)
    - electricity 12.4 %)
    - biomass (firewood, pellets, briquettes, agricultural and forestry residues) (12.0 %) and
    - natural gas (8.7 %)
- 33 % of households use some form of system in addition to the main heating system:
    - open fire (32.3 %)
    - independent air-conditioning units (28.2 %)
    - portable electrical devices (electric stove, fan heater etc.) (26.5 %)
- 98.6 % of households have a system/equipment that provides domestic hot water as follows:
    - 74.5 % of households used an immersion heater
    - 37.6 % have a solar-powered hot-water tank
    - 25.2 % have a system connected to the central heating (boiler)
- 60 % of households use a cooling system in the summer months as follows:
    - 99.7 % are split units
    - 0.3 % are central cooling systems

6 Cost-effective approaches to renovations

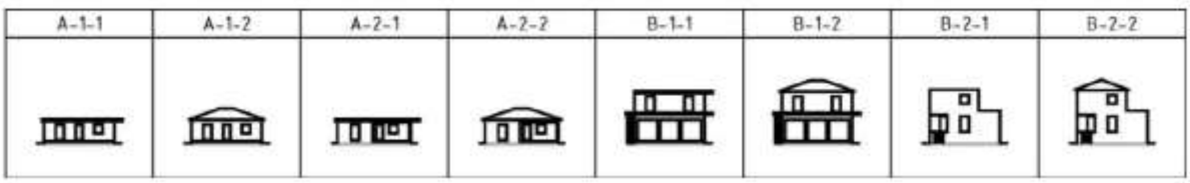
6.1 Typical cost-optimal buildings

The report to determine the cost-optimal levels of minimum energy performance requirements of buildings and structural components was prepared as required under Article 5 of Directive 2010/31/EU for buildings used as 'detached dwellings', 'apartment blocks' and 'offices'. Offices were examined in the report as being representative of the tertiary sector.

For building used as 'detached dwellings', four (4) basic types of building were considered with the variations shown below:

Table 16: Description of variations on typical 'detached dwelling' building

Basic type	Variation code	Description of types:					
		Number of storeys	Pitched roof	Flat roof	Semi-open-air	Pilotis or shop	Basement
A-1	A-1-1	Ground floor	Yes	-	-	-	-
	A-1-1.u	Ground floor	Yes	-	-	-	Yes
	A-1-2	Ground floor	-	Yes	-	-	-
	A-1-2.u	Ground floor	-	Yes	-	-	Yes
A-2	A-2-1	Ground floor	Yes	-	Yes	-	-
	A-2-1.u	Ground floor	Yes	-	Yes	-	Yes
	A-2-2	Ground floor	-	Yes	Yes	-	-
	A-2-2.u	Ground floor	-	Yes	Yes	-	Yes
B-1	B-1-1	1	Yes	-	-	Yes	-
	B-1-2	1	-	Yes	-	Yes	-
B-2	B-2-1	1	Yes	-	Yes	-	Yes
	B-2-2	1	-	Yes	Yes	-	Yes



The four basic types of buildings taken as representative of detached dwellings throughout the country (A1, A2, B1 and B2) were considered parametrically, i.e. based on the various conditions that characterise the alternative types. The parametric approach was used to examine the buildings in the four climatic zones and four time periods considered based on two parameters: a) type of roof and b) type of foundation. The above permutations gave a population of 256 different types of buildings.

Sixteen of the 256 permutations were ultimately selected for examination based on the study identifying the main types of zones in Greece, as illustrated in the table below:

Table 17: Types of typical 'detached dwelling' buildings selected by time period and climate zone

Two basic types of 'apartment blocks' were examined:

- A three-storey apartment block (P3) with 3 apartments per floor (two large and one small)
- A five-storey apartment block (P5) with 4 apartments per floor (two large and two small)

Both have a ground storey. Therefore, the three-storey apartment block is in fact a 4-level building and the five-storey apartment block is in fact a 6-level building. The three-storey apartment block can be considered a medium-height building with few storeys (from two to four) and the five-storey apartment block can be considered a medium height multi-storey building (more than four storeys).

The three-storey building was examined twice: once with the ground floor enclosed but unheated (P3-A) and once with a pilotis-type (open) ground floor (P3-B). The P5-type building was examined for climate zones B and C only. The geographical distribution of the different types is given below:

Table 18: Geographical distribution of typical 'apartment block' buildings

Climatic zone	Construction time period 55-80	81-00	01-10	11-16
A	P3	P3	P3	P3
	-	-	-	-
B	P3	P3	P3	P3
	P5	P5	P5	P5
C	P3	P3	P3	P3
	P5	P5	P5	P5
D	P3	P3	P3	P3
	-	-	-	-

Two basic types of buildings used as 'offices' (representative of the tertiary sector) were examined: a 'single-storey' building (C1) (ground floor + 1 storey), which is representative of the whole country, and a 'multi-storey' building (C5) (ground floor + 5 storeys), which is representative of the towns and cities with high, dense blocks. The geographical distribution of these types of building is given below:

Table 19: Geographical distribution of typical 'office' buildings

Climatic zone	Construction time period 55-80	81-00	01-10	11-16
A	C1	C1	C1	C1
	C5	C5	C5	C5
B	C1	C1	C1	C1
	C5	C5	C5	C5
C	C1	C1	C1	C1

	C5	**C5**	**C5**	**C5**
D	**C1**	**C1**	**C1**	**C1**
	C5	**C5**	**C5**	**C5**

6.2 Cost-effective renovation scenarios

According to the report to determine the cost-optimal levels of minimum energy performance requirements, optimal energy-efficiency interventions in a building, combined with a cost-benefit analysis, help to achieve the energy savings summarised in the tables below:

Table 20: Mean primary energy consumption and savings for typical 'detached dwelling' building

		DETACHED DWELLINGS				
		(1)	(2)	(3)	(4)	(5)
Time period	Climatic zone	Mean primary energy consumption (kWh/m^{2}p.a.)	Cost-optimal primary energy consumption (kWh/m^{2}p.a.)	Difference (%) (1) - (2)	Mean primary energy consumption with 40 % saving (kWh/m^{2}p.a.) (1) x 60 %	Mean primary energy consumption with 60 % saving (kWh/m^{2}p.a.) (1) x 40 %
1955-1980	A	546.7	184.7	66.2 %	328.0	218.7
	B	623.6	190.3	69.5 %	374.2	249.4
	C	971.6	187.5	80.7 %	583.0	388.6
	D	1108.8	203.8	81.6 %	665.3	443.5
1980-2000	A	321.4	128.0	60.2 %	192.8	128.6
	B	363.0	177.3	51.2 %	217.8	145.2
	C	545.8	246.2	54.9 %	327.5	218.3
	D	619.7	229.6	62.9 %	371.8	247.9
2000-2010	A	251.8	128.0	49.2 %	151.1	100.7
	B	282.4	120.9	57.2 %	169.4	113.0
	C	422.2	122.9	70.9 %	253.3	168.9
	D	476.0	257.0	46.0 %	285.6	190.4
2010-2016	A	139.7	73.4	47.5 %	83.8	55.9
	B	153.5	81.6	46.8 %	92.1	61.4
	C	250.0	129.1	48.4 %	150.0	100.0
	D	281.7	151.0	46.4 %	169.0	112.7

Table 21: Mean primary energy consumption and savings for typical '3-story apartment block' building

		3-STOREY APARTMENT BLOCK ADJACENT TO UNHEATED SPACE				
		(1)	(2)	(3)	(4)	(5)
Time period	Climatic zone	Mean primary energy consumption (kWh/m^2p.a.)	Cost-optimal primary energy consumption (kWh/m^2p.a.)	Difference (%) (1) - (2)	Mean primary energy consumption with 40 % saving (kWh/m^2p.a.) (1) x 60 %	Mean primary energy consumption with 60 % saving (kWh/m^2p.a.) (1) x 40 %
1955-1980	A	295.1	82.4	72.1 %	177.1	118.0
	B	342.0	100.0	70.8 %	205.2	136.8
	C	542.5	122.3	77.5 %	325.5	217.0
	D	608.6	137.2	77.5 %	365.2	243.4
1980-2000	A	182.9	86.9	52.5 %	109.7	73.2
	B	203.6	100.8	50.5 %	122.2	81.4
	C	295.8	124.9	57.8 %	177.5	118.3
	D	310.1	140.2	54.8 %	186.1	124.0
2000-2010	A	149.9	94.2	37.2 %	89.9	60.0
	B	165.9	93.4	43.7 %	99.5	66.4
	C	241.7	142.3	41.1 %	145.0	96.7
	D	274.0	162.2	40.8 %	164.4	109.6
2010-2016	A	89.9	77.1	14.2 %	53.9	36.0
	B	101.9	88.0	13.6 %	61.1	40.8
	C	167.8	121.0	27.9 %	100.7	67.1
	D	181.6	159.3	12.3 %	109.0	72.6

Table 22: Mean primary energy consumption and savings for typical '3-story apartment block' building

		3-STOREY APARTMENT BLOCK ADJACENT TO PILOTIS				
		(1)	(2)	(3)	(4)	(5)
Time period	Climatic zone	Mean primary energy consumption (kWh/m²p.a.)	Cost-optimal primary energy consumption (kWh/m²p.a.)	Difference (%) (1) - (2)	Mean primary energy consumption with 40 % saving (kWh/m²p.a.) (1) x 60 %	Mean primary energy consumption with 60 % saving (kWh/m²p.a.) (1) x 40 %
1955-1980	A	304.5	79.1	74.0 %	182.7	121.8
	B	353.0	96.0	72.8 %	211.8	141.2
	C	559.1	126.0	77.5 %	335.5	223.6
	D	626.4	141.5	77.4 %	375.8	250.6
1980-2000	A	177.0	83.7	52.7 %	106.2	70.8
	B	202.0	99.9	50.5 %	121.2	80.8
	C	299.2	126.7	57.7 %	179.5	119.7
	D	313.7	142.4	54.6 %	188.2	125.5
2000-2010	A	145.4	78.0	46.4 %	87.2	58.2
	B	164.1	92.0	43.9 %	98.5	65.6
	C	244.3	144.5	40.9 %	146.6	97.7
	D	277.1	164.5	40.6 %	166.3	110.8
2010-2016	A	88.9	76.1	14.4 %	53.3	35.6
	B	101.8	88.0	13.6 %	61.1	40.7
	C	167.7	120.9	27.9 %	100.6	67.1
	D	180.6	158.4	12.3 %	108.4	72.2

Table 23: Mean primary energy consumption and savings for typical '5-storey apartment block' building

		5-STOREY APARTMENT BLOCK ADJACENT TO PILOTIS				
		(1)	(2)	(3)	(4)	(5)
Time period	Climatic zone	Mean primary energy consumption (kWh/m^2p.a.)	Cost-optimal primary energy consumption (kWh/m^2p.a.)	Difference (%) (1) - (2)	Mean primary energy consumption with 40 % saving (kWh/m^2p.a.) (1) x 60 %	Mean primary energy consumption with 60 % saving (kWh/m^2p.a.) (1) x 40 %
1955-1980	A					
	B	268.1	65.9	75.4 %	160.9	107.2
	C	424.5	98.2	76.9 %	254.7	169.8
	D					
1980-2000	A					
	B	158.6	44.9	71.7 %	95.2	63.4
	C	231.6	61.8	73.3 %	139.0	92.6
	D					
2000-2010	A					
	B	128.1	67.7	47.2 %	76.9	51.2
	C	188.0	104.6	44.4 %	112.8	75.2
	D					
2010-2016	A					
	B	78.9	67.5	14.4 %	47.3	31.6
	C	131.3	113.7	13.4 %	78.8	52.5
	D					

Table 24: Mean primary energy consumption and savings for a typical 'single-storey office' building

		SINGLE-STOREY OFFICE BUILDING				
		(1)	(2)	(3)	(4)	(5)
Time period	Climatic zone	Mean primary energy consumption (kWh/m^{2}p.a.)	Cost-optimal primary energy consumption (kWh/m^{2}p.a.)	Difference (%) (1) - (2)	Mean primary energy consumption with 40 % saving (kWh/m^{2}p.a.) (1) x 60 %	Mean primary energy consumption with 60 % saving (kWh/m^{2}p.a.) (1) x 40 %
1955-1980	A	630	120	81.0 %	378.2	252.2
	B	678	131	80.7 %	406.6	271.1
	C	705	136	80.7 %	423.1	282.0
	D	755	141	81.3 %	452.8	301.8
1980-2000	A	486	115	76.4 %	291.4	194.3
	B	505	122	75.8 %	302.8	201.8
	C	521	134	74.3 %	312.5	208.4
	D	547	141	74.3 %	328.1	218.8
2000-2010	A	475	161	66.1 %	285.0	190.0
	B	492	172	65.1 %	295.2	196.8
	C	511	192	62.4 %	306.3	204.2
	D	535	202	62.2 %	321.2	214.2
2010-2016	A	376	155	58.8 %	225.4	150.2
	B	383	165	57.1 %	230.0	153.3
	C	378	180	52.4 %	226.8	151.2
	D	383	187	51.2 %	229.9	153.2

Table 25: Mean primary energy consumption and savings for a typical 'multi-storey office' building

		MULTI-STOREY OFFICE BUILDING				
		(1)	(2)	(3)	(4)	(5)
Time period	Climatic zone	Mean primary energy consumption (kWh/m^{2}p.a.)	Cost-optimal primary energy consumption (kWh/m^{2}p.a.)	Difference (%) (1) - (2)	Mean primary energy consumption with 40 % saving (kWh/m^{2}p.a.) (1) x 60 %	Mean primary energy consumption with 60 % saving (kWh/m^{2}p.a.) (1) x 40 %
1955-1980	A	446.6	101.8	77.2 %	268.0	178.6
	B	484.7	111.8	76.9 %	290.8	193.9
	C	530.5	120.4	77.3 %	318.3	212.2
	D	575.0	127.5	77.8 %	345.0	230.0
1980-2000	A	363.8	96.5	73.5 %	218.3	145.5
	B	393.3	104.6	73.4 %	236.0	157.3
	C	423.8	115.1	72.8 %	254.3	169.5
	D	452.8	121.4	73.2 %	271.7	181.1
2000-2010	A	361.3	137.6	61.9 %	216.8	144.5
	B	381.2	149.5	60.8 %	228.7	152.5
	C	414.8	167.6	59.6 %	248.9	165.9
	D	442.9	178.1	59.8 %	265.7	177.2
2010-2016	A	277.4	131.0	52.8 %	166.4	111.0
	B	285.7	140.7	50.8 %	171.4	114.3
	C	285.3	152.5	46.5 %	171.2	114.1
	D	290.9	159.2	45.3 %	174.5	116.4

Another important point is the potential energy savings from passive systems and bioclimatic design methods. New buildings designed to KENAK standards must incorporate at least one passive solar system, such as direct solar collection (south-facing openings), solid walls, Trombe walls, solar spaces (greenhouse) etc.

6.3 Use of RES

The share of renewable energy sources in the buildings sector up to 2000, as estimated in the Action Plan for Renewable Energy Sources, is illustrated in the table below.

Table 26: Estimated share of renewable energy sources in the buildings Sector (RES Action Plan [16])

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

In fact, schemes to provide financial support for RES systems for heating and cooling have either already been completed under the Partnership Agreement for the Development Framework (PADF) 2007-2013 Operational Programmes or are being implemented under the PADF 2014-2020 Operational Programmes. For example, the ‘Savings at Home II’ scheme (PADF 2014-2020) states that eligible interventions include upgrading with RES systems for heating/cooling, such as fitting a solar system to supply domestic hot water and/or boost the main heating system (collector, water tank, mounting base, pipes, etc.) and systems to satisfy heating/cooling requirements that use RES (e.g. biomass burner, heat pumps, solar thermal systems, etc.) or high-efficiency combined heat and power systems (HECHP). The ‘Savings at Home’ scheme (PADF 2007-2013) made an important contribution here. Also, the various PADF 2014-2020 Operational Programmes include schemes designed to increase thermal and/or cooling energy from RES in public buildings (‘Upgrading the Energy Performance of Public Buildings’ and ‘Support for RES-fired heating and cooling systems and combined heat and power systems’).

Solar systems supplying hot water

In terms of solar systems used to supply domestic hot water in buildings, part of the domestic hot water demand in new buildings and buildings subject to deep renovation must be satisfied using solar thermal systems (KENAK and Article 6(4) of Law 4122/2013 entitled

‘Energy performance of buildings/harmonisation with Directive 2010/31/EU of the European Parliament and of the Council and other provisions’, GG I/42). The minimum demand that must be satisfied from solar energy has been set at 60 % per annum.

This requirement does not apply to uses exempt from the KENAK or where domestic hot water is supplied by other decentralised RES-fired energy systems, CHP, district heating systems supplying the area or a particular block or heat pumps that satisfy the minimum eco-labelling criteria adopted in Commission Decision 2007/742/EC of 9 November 2007, as amended.

Photovoltaic solar energy

A special scheme to promote photovoltaic solar systems installed on buildings and use of the energy they generate was introduced in 2009. The scheme applies to systems up to 10 kWp and to buildings used for residential or micro-business purposes.

The scheme covers photovoltaic systems installed on a (flat or pitched) roof, including balcony roofs, façades, overhangs and auxiliary spaces or the car park of a building, as defined in building regulations, which are used to generate energy delivered to the Network. The scheme, which is available throughout the country, will run until 31 December 2019.

The facility for net metering of systems installed within the same electrical installation was introduced in 2014. Ministerial Decision APEHL/A/F1/oik.175067 of 19 April 2017 introduced the facility for virtual net metering, but only for certain categories of consumers. This scheme only applies to photovoltaics (although it is planned to include other technologies). The basic provisions of the current framework include:

- Station power: up to 20 kW or 50 % of the agreed power (100 % for public- or private-law legal entities pursuing public-benefit or other public-interest objectives on a general or local scale) for > 20 kW. For non-interconnected islands: up to 10 kW (Crete: 20 kW) or 50 % of the agreed power (100 % for public- or private-law legal entities pursuing public-benefit or other public-interest objectives on a general or local scale) for > 10 kW (Crete: > 20 kW).

- Maximum power limit: 500 kW for the Interconnected Network, 300 kW for Crete, 100 kW for other non-interconnected islands.
- Contract: 25-year net metering contract or virtual net metering contract.
- For virtual net metering, netting of the production of one station against consumption at different times by the same natural person or legal entity (1 to n).

Virtual net metering is only allowed for certain categories of consumers, as account has to be taken of the fact that 100 % of the energy produced is delivered to the network (0 % simultaneity; the energy produced and the energy consumed are netted for accounting purposes only). As such and given the short time this scheme has been available, virtual net metering is still relatively limited.

Finally, Law 4513/2018 enables Energy Communities to establish RES stations and hybrid stations of up to 1 MW to use virtual net metering to satisfy the energy demand of their members and vulnerable consumers or citizens living below the poverty line.

Table 27: Installation of photovoltaics by category (HELAPCO 2013 [9])

INTERCONNECTED SYSTEMS BY CATEGORY (Feb. 2018)	P/V	ROOF P/V ≤10 KWp	P/V net metering
Total installed power (MWp)	2 230.0	375.0	14.9

SYSTEMS OTHER THAN HOME SYSTEMS	CUMULATIVE	NEW INSTALLATIONS
SYSTEMS OTHER THAN HOME SYSTEMS IN THE INTERCONNECTED SYSTEM	1 126.1	687
SYSTEMS OTHER THAN HOME SYSTEMS ON NON-INTERCONNECTED ISLANDS	112.4	29.7
HOME SYSTEMS	297.8	195.3

6.4 Connection to district heating system

District heating using heat from power plants started to develop in Greece in the early 1990s. The thermal energy used to feed district heating systems is generated by combined heat and power plants and high-efficiency combined heat and power plants.

The district heating networks already commissioned or in progress are networks and installations provided by the following corporations:

- Ptolemaida Municipal District Heating Corporation (D.E.TH.P.)
- Kozani Municipal Water and Sewage Corporation (DEYAK)
- Greater Amyntaio Municipal District Heating Corporation (DETEPA)
- Megalopoli District Heating
- Florina Municipal Water Board (D.E.Y.A.F.) (under construction) and
- THERMI SERRON - Serres District Heating (private network)

District heating has been used in Serres since 2007. More than 10 000 apartments and other buildings (800 000 m^2) are connected to the network. District heating has been used in Amyntaio since 2004 (1 330 connections up to early 2013 and a further 600 pending). District heating has been used in Megalopoli since 2000 (500 homes connected).

Directive 2012/27/EU sets particular store by high-efficiency cogeneration and efficient district heating and cooling and requires the Member States to assess its potential and carry out a cost-benefit analysis to identify the most efficient solutions in terms of resources and costs to meet the demand for heating and cooling.

Furthermore, efforts are being made to recover waste heat from power plants or industrial installations by ensuring that a waste heat recovery cost-benefit analysis is carried out for new units or networks or existing units or networks that are extensively refurbished.

The YPEN has complied with Article 14 of Directive 2012/27/EU (which sets out the above obligations) by notifying the European Commission of the criteria for exempting installations for which waste heat recovery would not be cost-effective from the aforementioned obligation to carry out the cost-benefit analysis required under that article.

6.5 Renovation of building stock

Based on the review of the Greek building stock, buildings in Greece can be categorised by combinations of their use, construction period and climatic zone for the purpose of analysing the scenarios used in the long-term energy-saving strategy. The parameters that potentially affect the energy performance of buildings are:

- its type (residential/non-residential);
- its age (different building regulations/technologies)
- its location (climatic zone).

However, residential-type buildings are the only category used for the purposes of this specific long-term strategy.

Of the total number of regular residential buildings (6 371 901), dwellings built before 1960 (1 087 824) are considered unsuitable for energy-efficiency renovation for numerous reasons (e.g. declared to be a monument or listed building), as are more recent (post-2001) buildings, which are considered too new for renovation. That leaves a residential building stock for renovation of approximately 4.3 buildings.

6.5.1 Building renovation rate

One basic parameter when investigating options for and configuring a long-term strategy is the renovation rate of the building stock. According to international experience to date, that rate varies from 0.36 % to 2.6 % for permanent renovations other than simply individual, one-off renovations [10].

According to statistics for previous years from funding schemes and estimates, an average of 25 000 dwellings a year could be renovated to improve their energy performance over the next twelve years. Assuming that approximately one million dwellings will not be renovated, and one million dwellings will be classed as new (as stated above), a total of 300 000 dwellings will have been renovated and an estimated 200 000 new buildings will have been built by 2030. Thus, by 2030, the building stock for renovation will have declined from 4.3 million (today) to approximately 3.8 million.

6.5.2 Type of building renovation

This analysis considers two different types of renovation for dwellings, depending on the depth of renovation, i.e. the anticipated reduction in energy consumption, which affects the cost of the investment. The two types of renovation are described in the table below:

Table 28: Type of building renovation

TYPE OF RENOVATION	SAVINGS
Moderate	40 %
Deep	60 %

Moderate renovation applies experience gained from the 'Savings at Home' scheme, which achieved mean energy savings of approximately 40 %. Similarly, based on the Energy Performance Certificates issued, it follows that deep renovation (i.e. upgrading of building to Category B) would enable savings to be achieved of in the order of 60 % for dwellings.

Table 29: Energy saving measures and indicative cost (YPEN – SAVINGS AT HOME II SCHEME)

No	Intervention/renovation for energy savings	Cost
1	External thermal insulation	EUR 50/m^2
2	Glazing – frames and glass	EUR 200-250/m^2
3	Solar hot-water tank	EUR 1 000 -1 300 for a typical dwelling
4	More efficient heating	EUR 8 000-10 000
5	High-efficient lighting systems	EUR 2/m^2
	Green/planted roofs	EUR 90-120/m^2

As the analysis carried out in this study illustrates, typical renovations of dwellings cost an estimated EUR 1/kWh.

According to the various renovation scenarios for typical buildings, cheap one-off measures (e.g. installation of a solar hot-water tank) give commensurately small energy savings. Renovation should therefore be deeper, combining measures for savings by the building as a whole (both the envelope and operational systems such as heating, air-conditioning, lighting).

6.5.3 Building renovation scenarios

Based on the above two parameters, two scenarios combining the type of renovation and renovation rate were established for dwellings, as explained below:

- **Scenario (K1)** is based on a stable distribution of the renovation rate of dwellings of 25 000 buildings/year and 40 % renovation (moderate renovation).
- **Scenario (K2)** is based on a stable distribution of the renovation rate of dwellings of 25 000 buildings/year and 60 % renovation (deep renovation).

The number of buildings renovated, based on the assumptions made at the beginning of section 6.5, is illustrated in the table and figure below:

Table 30: Progress in residential renovations.

Number of dwellings (in millions)	2018	2020	2025	2030
Total stock	6.4	6.4	6.4	6.4
'Old' stock cannot be renovated	1.1	1.1	1.1	1.,1
'Recent' stock cannot be renovated	1.0	1.0	1.0	1.0
Dwellings that can be renovated	0.0	0.1	0.2	0.3
Newbuild dwellings	0.0	0.0	0.1	0.2
Total stock for renovation	4.3	4.2	4.0	3.8

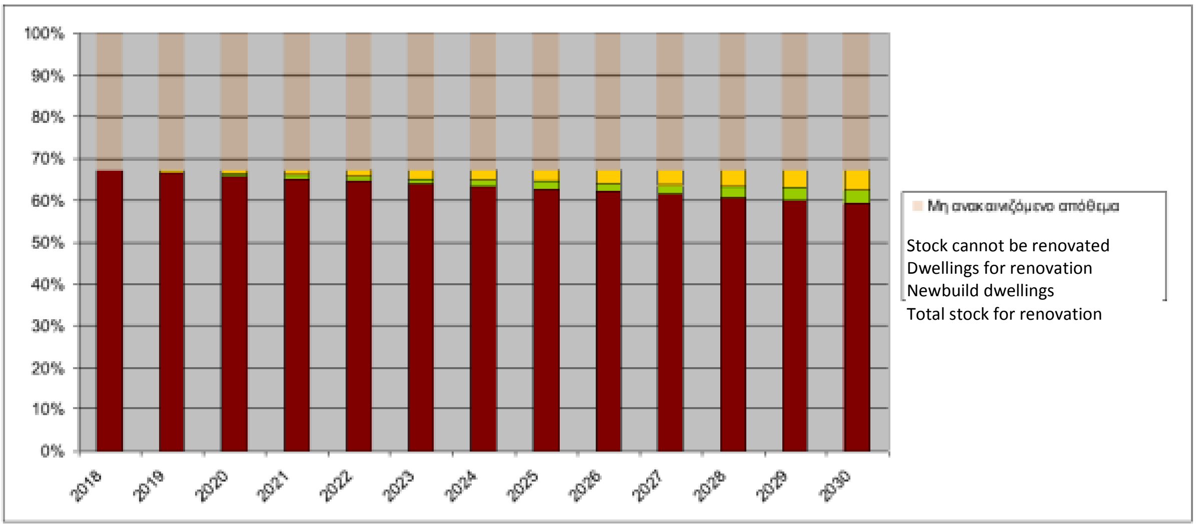


Figure 16: Renovation timeline (dwellings)

6.6 Economic model – Assumptions

The long-term strategy to encourage investment in renovations to improve the energy performance of the building stock is based on a cost-benefit economic model. The cost analysis and the optimum solutions are based on the theory that the building stock is as stated in Table 6 in section 5.1, whereby the energy profiles of the building stock are taken as constant in the computed cost-benefit model.

Annex I lists the assumptions made in the calculations and in the analysis of the energy savings scenarios. The typical floor area of the buildings was estimated from the database of the Building Inspection Archive (which contains information from Energy Performance Certificates issued), in combination with the relevant census reports. The Building Inspection Archive also contains data on typical mean annual total primary energy consumption and the corresponding consumption of electricity and thermal energy. This particular data collection and processing method (asset method) was preferred over actual consumption data (operational method), as the objective is to estimate the potential energy savings of the stock as property. A calculation based on actual consumption, especially in the present climate of significantly lower prices, would reflect operating conditions which do not satisfy the estimated minimum level of heating and energy required for a comfortable internal environment and might give incorrect results in terms of the potential to improve the energy performance of a building.

7 Policies and Measures to Stimulate Renovations

7.1 Existing methods and policies

Heavy subsidies notwithstanding, the national strategic policy for building renovations primarily targets individual dwellings and individual consumers and individual pilot schemes in the public sector. This section describes the basic existing measures taken in recent years to stimulate investment in renovations of the residential and tertiary-sector building stock. The main measures of note are as follows:

1. **Regulations on the Energy Performance of Buildings (KENAK)**

The KENAK introduced integrated energy design for buildings in the aim of increasing the energy performance of buildings, energy savings and environmental protection by:

- requiring an energy performance study for new buildings and for existing buildings subject to deep renovation;
- setting minimum standards for the energy performance of buildings;
- classifying buildings in Energy Performance Certificates;
- requiring inspection of heating and air-conditioning systems by energy inspectors.

The KENAK are a set of regulations that combine all the parameters affecting the energy performance of a building, namely its design, envelope and electrical and mechanical installations, and enact a specific method for calculating the energy performance of buildings and classifying them in energy categories.

Energy inspections are an important tool for diagnosing the energy performance of existing buildings and potential improvements. The energy inspections and energy performance certificates introduced form the mainstay of national energy policy, providing the property market with new standards that directly affect property values and citizens (as property owners/purchasers or tenants) with quantified information on the annual costs of heating and cooling, hot water, lighting, etc. Energy inspections and energy performance certificates have proven to provide considerable added value for the property market itself, as every building acquires an 'energy identity' that reflects its energy profile, and useful advice on how to improve its energy performance [11].

2. 'Savings at Home' scheme

The 'Savings at Home' scheme (initial budget EUR 548 million) was initiated in 2011 in the aim of encouraging intervention to improve the energy performance of the envelope and heating and domestic hot water systems of residential buildings. Since it was introduced nearly seven years ago, approximately 100 000 households have participated in the scheme (total eligible budget in the order of EUR 400 million, average energy savings of 41 %). Most interventions have been in old, energy-intensive buildings. The scheme is expected to generate total annual primary energy savings of approximately 40 ktoe.

The scheme counts as one of the most advanced schemes available, providing direct benefits both to citizens and in terms of employment by directly generating turnover for companies (especially SMEs) and professionals in well-placed sectors of the Greek economy with good prospects. In the construction industry in particular, which has been in protracted recession due to the economic crisis, the scheme has provided a real boost by guaranteeing employment and promoting the use of construction and other materials that help to save energy and have enhanced added value, much of which are produced in Greece.

The scheme has created over 3 000 new jobs a year and a total of EUR 700 million has been invested in the real economy to date.

3. 'Savings at Home II' scheme

The 'Savings at Home II' scheme introduced in 2018 follows on from the 'Savings at Home' scheme. The objectives of the scheme are to encourage intervention to improve the energy performance of the envelope and heating and hot water systems in residential buildings with a poor energy rating. Public funds invested in the scheme total EUR 292.43 million (EUR 248.06 million from the Competitiveness, Entrepreneurship, Innovation Operational Programme (EPANEK) and EUR 44.37 million from Regional Operational Programmes (PEP)). Approximately 45 000 applications have been submitted. Interventions to improve energy performance are scheduled for completion in 2020 at a total eligible budget in the order of EUR670 million, average energy savings of 58 %, as the majority of interventions are in old, energy-intensive buildings (50 % of applications are for buildings built before 1980).

The scheme is expected to general total annual primary energy savings of approximately 93 ktoe.

4. Compulsory solar thermal systems (STS) in new buildings

The KENAK require part of the domestic hot water demand to be satisfied using solar thermal systems (the minimum demand that must be satisfied from solar energy is 60 % per annum).

5. Renovation of public buildings

In the public sector, a scheme to improve the energy performance of public buildings is to be introduced (total budget in the order of EUR 500 million), in the aim of encouraging energy savings and highlighting the strategic and exemplary role of the public sector.

The 'LOCAL AUTHORITY SAVINGS I and II' schemes support energy saving interventions in existing public buildings and local authority (including open building) infrastructure. The schemes were introduced in 2009 with a total budget of EUR 150 million. The Ministry of Energy & Climate Change has issued numerous invitations to tender for public building renovation contracts under the Environment and Sustainable Development Operational Programme, which includes the Bioclimatic Improvements to Urban Public Open Spaces programme, the Green Roofs programme, the Green Neighbourhoods pilot programmes, the Green Island programme, etc. These are designed to improve energy performance, encourage viable local development, improve citizens' quality of life and create new jobs, thereby maximising the added value of the programmes and supporting local economies.

6. National Energy Efficiency Action Plan

The measures needed to renovate residential buildings, public buildings and commercial buildings that are being or will be implemented (timeframe: 2011-2020) were identified under the 4th National Energy Efficiency Action Plan. The table below lists the measures for buildings:

Table 31: Energy savings from policy measures implemented 2014-2016 (ktoe)

No	Policy measure	Number of interventions	New			Cumulative
			2014	2015	2016	2014-2020
M1	'Savings at Home' scheme	26 164 buildings	21.98	8.17	1.55	210.64
M2	'Local Authority Savings' scheme	59 municipalities	-	-	2.25	11.25
M3	'Local Authority Savings II' scheme	14 municipalities	-	0.05	0.17	1.12
M11	Replacement of old light commercial vehicles (public and private sector)	10 952 vehicles	4.17	5.12	3.14	75.61
M12	Replacement of old passenger vehicles (private sector)	165 778 vehicles	28.27	29.86	17.13	462.71
M14	EPPERAA[5] measures	-	0.24	1.24	11.66	67.44
M16	Athens metro extension	-	29.30	-	-	205.10
M17	Offset fines for buildings without planning permission	522 buildings	0.00	0.13	0.50	3.25
M18	Energy officers	204 buildings	-	-	1.19	5.95
M19	EPC issued for other reason	5 724 EPC	2.09	3.51	2.26	15.73
Total energy savings			**86.06**	**48.08**	**39.84**	**1 058.81**

Table 32: Energy savings from planned policy measures 2017-2020 (ktoe)

No	Policy measure	New				Cumulative
		2017	2018	2019	2020	2017-2020
M1	'Savings at Home' scheme	7.19	-	-	-	28.74
M4	Improved energy performance of buildings	-	25.04	18.78	18.78	131.47
M5	Improved energy performance of buildings	-	7.14	7.14	7.14	42.82
M6	Energy efficiency and demonstration projects in SMEs & support measures	-	3.01	3.01	3.01	18.08
M7	ISO 50001-based energy management system in public- and broader public-sector agencies	-	1.19	1.19	-	5.97
M8	Use of energy service providers for energy-efficiency renovations of commercial buildings	-	-	0.85	0.85	2.54
M10	Smart energy measurement systems	1.39	-	6.30	6.30	24.45
M14	EPPERAA measures	6.31	-	-	-	25.26
M18	Energy officers and action plans for public buildings	8.39	76.13	84.53	-	437.00
M19	EPC issued for other reason	2.62	2.62	2.62	2.62	20.97

[5] Environment & Sustainable Development Operational Programme.

No	Policy measure	New				Cumulative
		2017	2018	2019	2020	2017-2020
M20	**Improved energy efficiency of street lighting**	-	10.00	-	-	30.00
M21	**Improved energy efficiency of pumping stations**	-	-	4.00	2.00	6.00
M22	**Levy schemes**	25.00	44.33	33.50	33.00	333.00
Total energy savings		**50.90**	**169.47**	**159.92**	**73.70**	**1 097.70**

7. Tax incentives

The tax incentives introduced in 1994 allowed 20 % of the cost of measures to improve energy performance and install RES, capped at EUR 700, to be deducted from the taxpayer's total income. From 2010, 10 % of the cost of measures to improve the energy performance of property and install RES, capped at EUR 6 000 (i.e. EUR 600 maximum) could be deducted from income tax and, in 2011, that cap was reduced to EUR 3 000 (i.e. EUR 300 maximum). Although most tax breaks, including for energy-efficiency measures, were abolished in 2013, a new law was passed allowing income tax to be reduced by a specific percentage of the cost of measures carried out to improve the energy performance of a building following an energy inspection.

8. Planning incentives

Article 25 of Law 4067/2012 (GG I/79) entitled 'New Planning Regulations' enacts incentives for minimum energy buildings. There is an incentive in the form of a 5 % increase in the building-to-land ratio for A+ rated buildings and a 10 % increase in the building-to-land ratio for very high-efficiency buildings (with primary energy consumption of less than 10kWh/m^2/year).

9. Offsetting of fines for buildings without planning permission against energy improvement measures

This particular measure follows from Article 20 of Law 4178/2013 (GG I/174) and Article 102 of Law 4495/2017 (GG I/167), which allow up to 50 % of the special fine to be offset against the cost of fees for services, work and materials to improve the energy performance of the building. The fine is offset provided that the measures improve the building by at least one energy category or generate annual primary energy savings of over 30 % of the consumption of the reference building.

10. Replacing oil-fired systems with natural gas-fired systems

The energy improvement and energy savings policy for the residential sector includes a scheme to replace oil-fired heating systems with natural gas-fired systems in dwellings (GG II/3071). The scheme subsidises the cost of a natural gas-fired system to replace the existing oil-fired heating system in the home, in order to reduce pollution and save energy. The budget for the scheme totals EUR 15 million in public funds (PADF 2007-2013), of which EUR 10 million for Attica, EUR 3 million for Thessaly and EUR 2 million for West Macedonia.

The subsidy covers 60 % of the total eligible cost of the internal natural gas-fired system. This particular scheme is expected to benefit approximately 50 000 households and is designed to reduce household energy bills, improve the energy efficiency of heating systems and reduce atmospheric pollution in urban areas in which it is applied by using a cleaner energy source.

7.2 Barriers

The long-term plan to renovate the building stock in Greece faces and must overcome the usual series of barriers and obstacles encountered whenever there is social/technical change. Similarly, action to attract investment based on cost-optimal renovations of buildings for residential and other uses (offices, shops, hospitals, education, etc.) faces a series of interconnected barriers that must be overcome.

Greece's building renovation policy must take account of a number of critical factors, such as:

- the fact that the building stock in Greece comprises a large number of old buildings constructed to outdated operating standards, often with no thermal insulation, as a result of which they require a great deal of energy to provide current accepted standards of comfort in the winter;
- the moderate condition of heating systems, resulting in reduced output and thus increased energy consumption and environmental pollution;
- the long period of time required to amortise energy-efficiency interventions;

- the need for interventions to comply with special regulations to protect the cultural and architectural heritage of many residential areas of Greece;
- the fact that external intervention in individual apartments in apartment blocks presents practical difficulties, resulting in long implementation periods;
- the often extremely low energy gain and capital re-accumulation rate from the recommended renovation;
- the difficulty in implementing energy interventions in properties with numerous owners due to obsolete decision-making procedures; and
- the economic and social pressure on low income brackets, which has increased energy poverty in Greece.

The energy consumption of buildings correlates directly with social and economic factors, as both the thermal standard of buildings and their energy consumption depend directly on household income. Just 8 % of low-income households live in buildings with double-glazing and insulation, compared to 64 % of high income households. As a result of differing building standards, there is high thermal consumption per square metre in very low- and very high-income households. The per capita cost of heating and air-conditioning per unit of floor area is 127 % higher in low-income households than in high-income households.

It should also be noted that there is as yet no solid energy awareness in Greece, at either a national or a personal level. The benefits from improving the energy performance of buildings that are passed on in large measure to society are not directly felt by investors and owners, resulting in a benefit gap. This is one factor that explains the low level of investment in energy-efficiency renovations of buildings by their owners.

Similarly, energy-efficiency renovations in the public sector have yet to achieve a holistic result that could set an example both to users of public buildings and to the public who visit them.

Various barriers are analysed below in order to identify the challenges and ways of encouraging investment in renovations of the building stock.

7.2.1 Immature market – Technical barriers

The new market of energy-efficiency renovations of buildings is in a relatively early start-up phase and faces the usual problems that beset the development of any new market. This particular market is the offspring of the slump in economic activity, which flourished in Greece between 2000 and 2007.

The market also faces technical barriers, such as:

- technical restrictions on interventions in the building envelope and in the provision of renovation services, such as architectural and infrastructure access issues and common heating systems;
- obsolete regulations that complicate decision-making in apartment blocks;
- an inadequate renovation service supply chain;
- a lack of energy labelling, energy standard and construction material certification schemes;
- the lack of technical support and the unreliability of energy services;
- the lack of meters/direct mechanisms (e.g. smart meters) that clearly and directly show the energy savings from the renovation.

Another problem is that often the person who decides on (and bears the cost of) the level of energy performance of a building and the person who bears the cost of the energy consumed in the building are not one and the same person. A typical example is rented buildings, where the cost of energy-efficiency renovation is borne by the owner and the benefit of the energy saving is felt by the tenant. This mismatch could be remedied by passing the cost of energy-efficiency improvements on to the tenant by increasing the rent to reflect the lower energy costs.

It should also be noted that often there is no broad certification scheme for the materials used in the Greek construction industry (insulation, light fittings, glazing, door/window frames, electrical equipment etc.). The same applies to the tradesmen who install and service building systems, who are usually not certified.

7.2.2 Institutional barriers

There is still no established national standard for adequate and verifiable measurement of the actual energy consumption of buildings. The calculation method adopted in the KENAK is based on the asset method, rather than the operational method, and is therefore useless as a standard for recording actual consumption. The international community developed an International Performance Measurement & Validation Protocol at the beginning of the century in a bid to establish a standard method for conducting and verifying measurements for both energy and water savings.

7.2.3 Economic barriers

The non-contributory benefits generated by energy-efficiency renovations of buildings are often valued over time and are therefore considered uncertain due to a lack of reliable market data compared to other investments. In Greece in particular, which currently presents an enhanced country risk due to the economic crisis, the uncertainty of and the risk of return on long-term investments are even more acute.

Bank loans, which have traditionally been the main source of funding of consumer and investment demand in Greece, have been cut back and this has had a knock-on effect on investments in building renovations.

The economic barriers include the reduction in income and change to consumption habits in Greece over recent years due to the recession. Under such circumstances, investment in energy-efficiency renovations is often not a priority.

7.2.4 Lack of information

These barriers are exacerbated by the shortage of skills and training of the persons responsible for applying new energy-efficiency renovation techniques and technologies. These shortages are seen in connection both with energy-saving technologies and with the renewable energy sources used as standard internationally for renovations.

The lack of suitable and reliable information on the energy efficiency of deep renovation is delaying the application of new techniques to improve the building stock. The primary information available is of a general nature and it is impossible or difficult to adapt it to the circumstances of each investor in and/or user of a building. Information is provided sporadically and investors and even individual users are unable to make an overall and complete assessment of the benefits of an investment in energy-efficiency renovations.

Universities and technological educational institutes in particular urgently need to modify their curricula in various scientific and technological sectors to include the concept of energy savings through renovation, both of the building envelope and of building systems and installations, and the behaviour of users of the building stock in all individual disciplines. At the same time, they should be involved in both the technical and financial side of building renovation research programmes.

8 Forward-looking perspective

8.1 New policy landscape design/transitional stages

It is a fact that it will not be easy to implement the transition to a sustainable building stock in a short space of time. Obviously measures are needed at all levels to eliminate the barriers and obstacles outlined in the previous section. First of all, the necessary political will is needed, in the form of powerful initiatives. Institutional action and incentives are also needed, combined with measures to mobilise the private sector and obtain appropriate capital commitments.

A stronger energy awareness among the public is vital to the successful outcome of the new policy. This awareness is developing gradually and depends on continual information and publicity campaigns and important financial, planning and tax incentives.

As stated previously, this study is based on gradual, coordinated action to improve the energy performance of at least 7 % of the current building stock by 2030. Therefore, energy-efficiency policies and energy-efficiency measures both need to be analysed up to 2030, even though most national targets set to date are for the period up to 2020.

The policy framework for the energy performance of buildings up to 2020 is shaped by institutional action, primarily in the form of European directives, but it is also being implemented through measures already planned for the new programming period (2014-2020). The new programming period 2020-2030 includes priorities for the building stock designed to help make the transition to a low-carbon dioxide economy, address the challenges and achieve the targets for Greece. For the building stock, special attention will be paid to measures to:

- improve the energy performance of buildings and application of the KENAK;
- save energy and improve energy efficiency and the use of RES in residential and tertiary-sector buildings;
- develop energy management systems in public-sector and tertiary-sector buildings;
- raise awareness and provide information on the rational use of energy;
- promote the provision of energy services (ESCOs);
- support research and technological development in RES-related, energy-saving and other technologies;
- develop environmentally-friendly energy production and apply energy-saving interventions through more efficient use of energy in farming, forestry and food processing, through investment in more energy-efficient buildings and systems and/or by encouraging the collective use of more cost-effective renewable energy sources such as biomass.

8.2 Action required

The table below lists the recommended action needed to eliminate barriers to the techno-social transition and action to compile the data needed for the transition to the sustainable operation of buildings by 2030.

Table 33: Recommended action

No	ACTION
1	Secure funding for energy-efficiency renovations
2	Implement subsidy schemes for energy-efficiency renovations in households, public buildings and tertiary-sector buildings
3	Improve legislative framework by introducing cost-effective minimum energy efficiency standards
4	Define specifications for nearly zero-energy buildings and adopt policies and measures to accelerate and facilitate the penetration of energy-efficient practices and nearly-zero energy buildings
5	Encourage/grant tax relief to consumers/household users who adopt energy-efficient methods and/or implement renovations
6	Identify energy-poor households (Energy Poverty Observatory)
7	Implement public building renovation schemes via ESCOs
8	Amend legislation to apply ESCOs to the public sector
9	Introduce incentives for energy officers in public buildings to save energy and resources
10	Set up databases listing and mapping the energy consumption of public buildings
11	Introduce incentives to renovate building complexes
12	Upgrade public buildings and tertiary-sector buildings via ESCOs and public private partnerships
13	Apply energy management systems in public buildings and organisations

8.3 Funding for energy-efficiency renovations

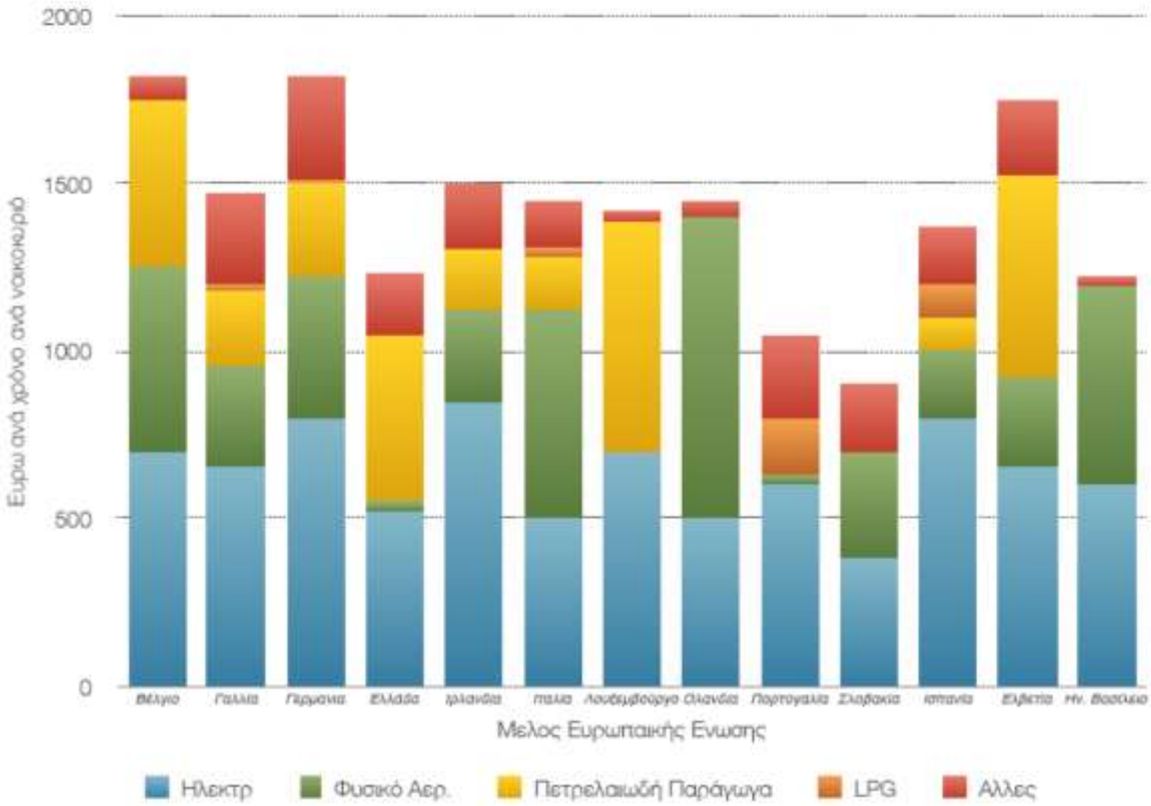
8.3.1 Private funding

Many energy-efficiency renovations of the building stock are implemented on a one-off basis by the property owner, either as part of more general renovations to the property or as separate renovations to improve its energy performance. However, as the economic benefit is not felt immediately and the benefits other than the reduced running costs the building have not been publicised, the number of front runners is relatively small. Usually, energy-efficiency works are amortised (disregarding the additional benefits) over a relatively long period of time (in the order of 10 years), while various studies illustrate that owners want to amortise investments to improve the energy performance of their buildings in five years.

Also, where energy-efficiency improvements are funded entirely by the owner, it is not always easy to raise the initial capital required. The difficulty in raising the initial capital is exacerbated by the difficulty in obtaining loans from financial institutions, especially in the current economic climate and especially in Greece, where the need for renovations to improve the energy performance of buildings is still not appreciated.

Greek households spend a relatively large amount of money to satisfy their energy demands (EUR 1 230), as Figure 17 and Table 34 illustrate. It is equal to about one month's salary for the average household. Energy savings as a result of renovations would cut that bill significantly and free up other resources. Also, it is possible to establish from that sum the amount that owners would be prepared to spend to improve the energy performance of their home. However, it should be noted that that sum reflects actual consumption by households, which does not always ensure comfortable heating conditions, especially in recent years, which have been marked by high energy prices and reduced household income. As stated previously, the asset method used for the calculations (based on the property and its energy profile calculated using the method stipulated in the Regulations on the Energy Performance of Buildings) results in higher computed consumption (at least twice the actual consumption).

COST OF ENERGY CONSUMPTION IN EUR PER ANNUM PER HOUSEHOLD



<table>
<tr><td colspan="2">EUR per annum per household</td><td>BE</td><td>FR</td><td>DE</td><td>EL</td><td>IRL</td><td>IT</td><td>LX</td><td>NL</td><td>PT</td><td>SK</td><td>ES</td><td>CH</td><td>UK</td></tr>
<tr><td colspan="15">EU Member State</td></tr>
<tr><td colspan="3">Electricity</td><td colspan="3">Natural Gas</td><td colspan="3">Petroleum Products</td><td colspan="3">LPG</td><td colspan="3">Other</td></tr>
</table>

Table 34: Cost of energy consumption in EUR per annum per household [15]

	Electricity	Natural Gas	Petroleum 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
Luxembourg	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

Private funding also includes investment via Energy Service Companies (ESCOs), which are a new vehicle to promote, manage, fund and monitor energy-efficiency projects and, more importantly, to eliminate the economic barriers to energy-saving interventions. This particular method for implementing and funding energy projects is expected to play an important role, especially in renovations of public buildings and infrastructure and of hospitals, hotels and other energy-intensive buildings.

8.3.2 Potential funding sources and vehicles

Experience over recent years has taught us, first, that EU Member States are making increased use of cohesion policy financing to fund energy efficiency, especially the energy performance of buildings, and, second, that the take-up of funding sources is increasing. However, the data on the impact of that funding on energy savings in buildings is patchy.

The European Investment Bank (EIB) has a special provision to support investments in energy savings in buildings. The EIB has laid down a number of selection criteria for the projects which it supports, which include:

- cost-effective renovation;
- small projects under national regional development programmes;
- projects to achieve nearly-zero energy buildings;
- innovative energy-saving technologies.

The EIB is already involved in efforts to renovate the building stock through a number of banking products designed to provide technical and financial support to public sector-type organisations (ELENA projects, Infrastructure Fund) and ESCO-type companies.

The table below lists funding mechanisms that could potentially help to provide the necessary (public and private) capital for energy-efficiency improvements to buildings.

Table 35: Funding schemes to support renovations to improve the energy performance of buildings in Europe [50] [51] [52]

Funding source	Means/Mechanisms	Total available funding
Cohesion policy funding	Operational programmes, including funding resources	EUR 9.4 billion for sustainable energy (RES& renovation)
Funding for research	HORIZON 2020 programme	EUR 6.5 billion for 'Secure, clean and efficient energy' 2014-2020
Enlargement policy funding	Facilities provided by international funding organisations (SMEFF, MFF, EEFF)	EUR 552.3 million (381.5 + 117.8 + 53 respectively)
European Energy Programme for Recovery (EERP)	European Energy Efficiency Fund (EEEF)	EUR 265 million

Funding by local agencies (local authorities, etc.) for technical assistance for competitiveness and innovation (CIP)	Horizon programme (ELENA initiative) with support from the European Investment Bank (EIB)	Funding based on project leverage factor. Funding for assistance in the order of EUR 2 million, of which EUR 90 million available
Funding under the new LIFE Environment and Climate Actions	Private Financing for Energy Efficiency instrument (PF4EE)	EUR 80 million available in cooperation with the European Investment Bank
Funding from the European Fund for Strategic Investments	European Fund for Strategic Investments (EFSI)	Funding based on project leverage factor. EUR 500 billion available in total in cooperation with the European Investment Bank

The Partnership Agreement for the Development Framework 2014-2020 (PADF 2014-2020) is divided into sectoral operational programmes and corresponding regional operational programmes classed by actions and funding sectors which include energy saving actions. Energy issues are integrated into the Competitiveness, Entrepreneurship, Innovation Operational Programme (CEIOP) under the Transport Infrastructure, Environment and Sustainable Development Operational Programme and the regional operational programmes (ROP) that cover the entire country. Funds for energy saving actions total over EUR 1 billion in terms of total public expenditure, including funding instruments (Savings II Fund, Infrastructure Fund).

In fact, investment priority 4c under the PADF 2014-2020 operational programmes is designed to support energy efficiency, smart energy management and the use of renewable energy resources in public infrastructure, including public buildings, and in the housing sector. Residential building energy upgrade actions will be funded under the CEIOP, with a smaller contribution from the ROP.

9 Estimate of expected energy savings and wider benefits

The model for calculating renovation interventions and energy savings presented in section 6.6 and analysed in Annex I determines the annual investment needed between now and 2030 based on the assumptions made for each energy saving scenario.

Annex II lists in detail the results for both residential scenarios (K1 and K2). The figures below illustrate the results from cumulative investments in each case.

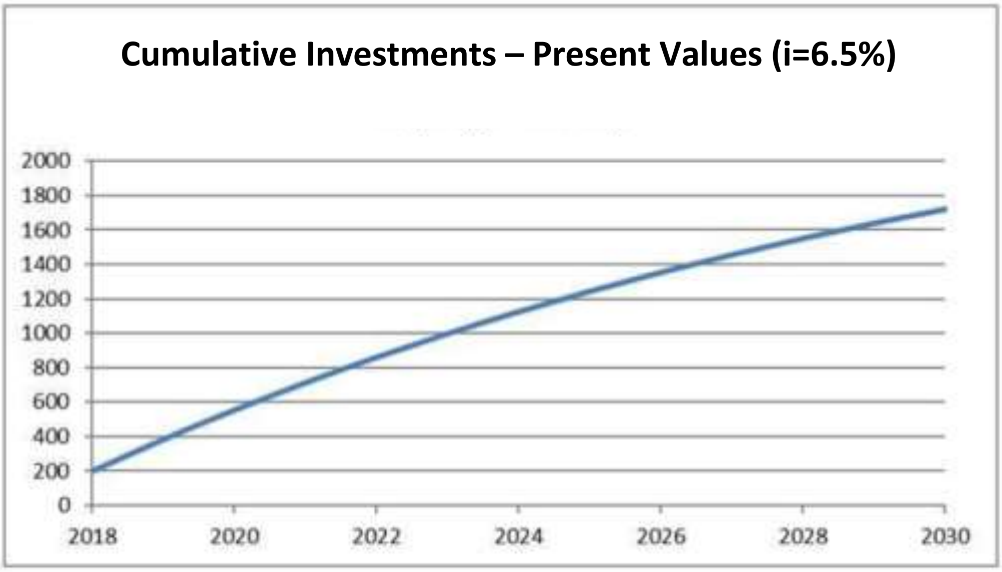


Figure 18: Total investment (in EUR millions) for residential dwelling renovation scenario with 40 % renovation

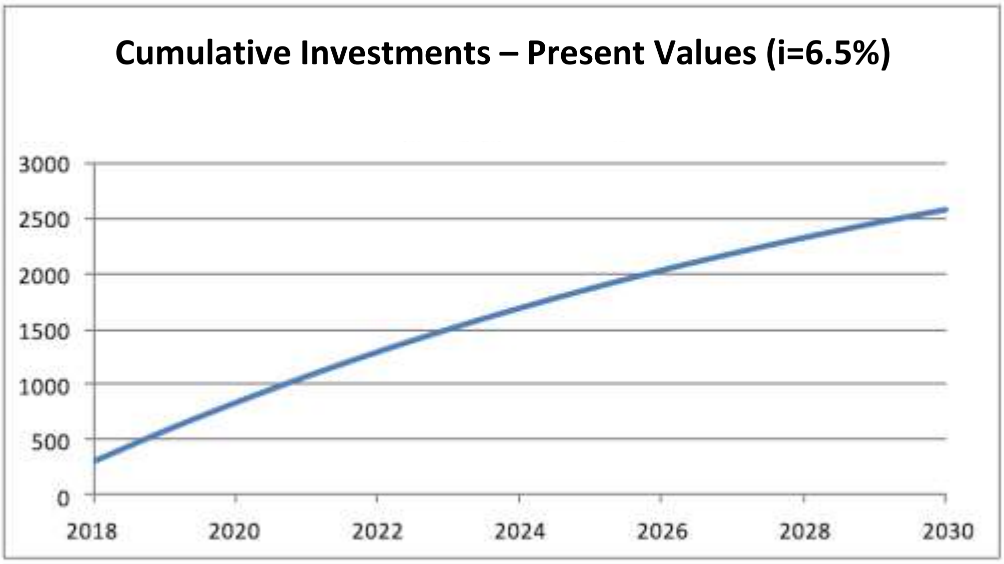


Figure: 19: Total investment (in EUR millions) for residential dwelling renovation scenario with 60 % renovation

10 Conclusions

Renovation of the building stock to achieve high energy performance is one of the most strategic investment sectors in any country as, aside from energy savings and reduced carbon dioxide emissions, it has additional benefits in other economic and social sectors, such as employment, health, energy security and the fight against energy poverty.

This long-term strategy report describes, first and foremost, the potential in Greece to modernise the existing building stock and thus save energy, by focusing primarily on the large number of regular residential buildings. Existing buildings in the tertiary sector, such as offices/shops, schools and buildings for educational use, hospitals, hotels and public buildings also offer opportunities for energy savings. The report also endeavours to analyse in greater detail the economic and additional social and environmental benefits of energy-efficiency renovations of buildings, in order to encourage interest on the part of investors in building stock renovations by acknowledging that a more holistic, complex social/technical transition is required that will contain the risks and thus ensure future success.

The long-term strategy report sets out a clear objective, namely the transition to a sustainable building stock by 2030, i.e. gradual and coordinated improvements to the building stock so that 7 % of existing residential buildings will have been renovated to improve their energy performance by 2030.

The strategy was prepared by considering two scenarios for residential buildings obtained by combining a constant renovation rate with various types of renovation (moderate and deep). The scenarios were analysed based on specific assumptions in terms of the size of the building stock, the method used to estimate the energy saved, the cost-effectiveness of the interventions and energy and economic data.

Based on those scenarios, 40 % renovation of residential buildings at a cost of EUR 1.7 billion would give cumulative primary energy savings of 236 ktoe and 60 % renovation at a cost of EUR 2.5 billion would give cumulative primary energy savings of 354 ktoe by 2030.

A recent study by the YPEN[6] demonstrated, based on a sensitivity and uncertainty analysis and multiple building optimisation parameters, that, of the policy measures proposed under the National Energy Efficiency Action Plan for a given available budget, building renovation is the portfolio of measures that provides maximum energy savings at minimum risk. Consequently, of the scenarios considered, the scenarios for residential buildings (K1 and K2) are the most robust strategy practices.

It must be said that actions to improve the energy performance of buildings generate additional benefits (health, employment, etc.) which should not be ignored, as they provide exponential benefits at individual, sectoral and national level. This report attempts a conservative quantification of the additional benefits of energy savings that illustrates the extent of the (social/economic/environmental) benefit to sustainable development, as the benefit from building renovations has an important impact on society as a whole and secures funds by reducing expenditure in other sectors.

Cumulatively, the benefits generated by energy savings in buildings and the corresponding multipliers may exceed double the cost of the energy savings.

There is also an important benefit to the economy from reactivation of the building industry, which shrank during the crisis to the point at which gross domestic product fell by 7 % in terms of its direct contribution and by 15 % in terms of its indirect contribution. Improving the energy performance of residential buildings, tertiary-sector buildings and public buildings may bring about a real and substantial recovery in the building sector and on the property market which will boost employment and promote sales of construction and other materials of increased added value, many of which are produced in Greece.

[6] National Technical University of Athens, School of Electrical and Computer Engineering, Decision Support Systems Laboratory, *'Evaluation of the optimum portfolio of energy efficiency measures'*, Athens October 2017.

The analysis illustrates that serious investment must be encouraged in order to increase energy savings from the building stock. The rate of investment will improve if the benefits are not purely economic and energy savings are not the only return on the capital invested. If private investment is to be encouraged, ambitions and aspirations must be reflected in a common awareness on the part of stakeholders and society as a whole of the economic and additional benefits to be had, for example in terms of employment, health, energy security and reduced energy dependency. Also, the return on investments to optimise the energy performance of buildings illustrates that there is an important energy savings dynamic. Taking advantage of this opportunity is now a clear priority and interventions involving the State need to be supported in order to make investments more attractive and ensure that they can be amortised in less than ten years.

Also, the success of the long-term strategy depends on the implementation of actions by the State, both in terms of institutional measures to improve the building stock and continual information on and publicity of the benefits to be had, and on the presentation and communication of successful good practices in order to establish the right level of energy awareness among all stakeholders. To conclude, the participation and cooperation of everyone involved will guarantee the success of the long-term plan to ensure that the energy efficiency renovation market flourishes, for the benefit of society as a whole.

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ANNEX I – Calculation Model

The renovation and energy-saving intervention calculation model used to establish the building stock renovation scenarios is described below using indicative parameters:

Parameters of the problem:

EXPLANATION	VALUE
Dwellings subject to energy-efficiency renovation	Bj = 25 000 dwellings/year
Average floor area of building Sav	Sav = 80 m^2 regular dwellings
Annualised primary energy consumption (ε)	Dwellings: ε = 264 kWh/m^2
Annualised (final) electricity consumption (ε_1)	Dwellings: ε_1 = 24 kWh/m^2

EXPLANATION	VALUE
Annualised (final) heat consumption (ε_2)	Dwellings: $\varepsilon_2 = 161 kWh/m^2$
Type of renovation (λ)	λ = 40 %(moderate renovation) λ = 60 % (deep renovation)
Cost of money - discounted interest rate (i):	i = 6.5 % for dwellings
Cost of investment per unit of energy saved (IC_o)	IC_o = 1 €/kWh for dwellings
Annual maintenance of energy upgrade equipment:	m = 1 %
Annual inflation rate of electricity:	e = 0.5 %
Annual inflation rate of heating:	θ = 0.55 %
Annual inflation rate of the economy:	Calculations are performed using deflated values.
Learning rate of energy-related interventions:	LR = 1 %
Total annual cost of energy-related interventions C_o	Calculated from the model
Cost of electricity:	p = 0.10€/kWh
Cost of heating:	h = 0.14€/kWh
Average lifetime of energy-related interventions (based on Joint Ministerial Decision D6/7094/2011)	Tmax = 20 years

ALGORITHM

The algorithm follows benchmark calculations of the parameters for each year. Based on the above, the following applies for year 'j':

Buildings subject to energy-related renovation $Bj = \xi j \times Btot$ (1)

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

Annual national energy saving $Ej = \lambda \times \varepsilon \times Sj$ (3)

Energy saving per typical building: $\Delta\varepsilon = \lambda \times \varepsilon \times Sav$ (4)

Annual energy costs saved (present values): $R_j = (\lambda \times \varepsilon_1 \times p_j + \lambda \times \varepsilon_2 \times h_j) \times Sav$ (5)

Annual saving (present values) due to interventions, less cost of maintaining energy-related interventions:

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

Annual national funding: $C\gamma = \gamma \times Co = ICo \times (\lambda \times \varepsilon \times Sav) \times \xi \times Btot$ (7)

Total investment cost of private investor: $(1 - \gamma) \times ICo \times \lambda \times \varepsilon \times Sav$ (8)

A factor (γ) can be used to quantify the contribution of agencies other than the public sector wishing to invest in renovations. It is equal to 1 in the present analysis.

Some necessary values are established from the following equations: Value of electricity purchased in year j: $p_j = p \times (1 + e)^j$

Value of heat purchased in year j: $h_j = h \times (1 + \theta)^j$

Coefficient to reduce to present values in year j: $1/(1 + i)^j$

Annex II – Results from scenarios

Dwellings subject to 40 % renovation

Year	Annual energy savings	Cumulative energy savings	Cumulative primary energy savings	Cost of renovations	Cost of renovations at present values (discount rate i = 6.5 %)	Cumulative cost of renovations at present values (discount rate i = 8 %)	Annual benefit from energy savings
	TWh	TWh	Mtoe	M€	M€	M€	M€
2018	0.2112	0.2112	0.0182	211.2	198.310	198.31	19.76
2019	0.2112	0.4224	0.0363	209.1	184.344	382.65	39.32
2020	0.2112	0.6336	0.0545	207.0	171.345	554.00	58.69
2021	0.2112	0.8448	0.0727	204.9	159.246	713.24	77.86
2022	0.2112	1.056	0.0909	202.8	147.985	861.23	96.85
2023	0.2112	1.2672	0.1090	200.6	137.505	998.73	115.66
2024	0.2112	1.4784	0.1272	198.5	127.754	1126.49	134.27
2025	0.2112	1.6896	0.1454	196.4	118.681	1245.17	152.71
2026	0.2112	1.9008	0.1635	194.3	110.239	1355.41	170.96
2027	0.2112	2.112	0.1817	192.2	102.386	1457.79	189.04
2028	0.2112	2.3232	0.1999	190.1	95.080	1552.87	206.94
2029	0.2112	2.5344	0.2181	188.0	88.285	1641.16	224.66
2030	0.2112	2.7456	0.2362	185.9	81.966	1723.13	242.20

Dwellings subject to 60 % renovation

Year	Annual energy savings	Cumulative energy savings	Cumulative primary energy savings	Cost of renovations	Cost of renovations at present values (discount rate i = 6.5 %)	Cumulative cost of renovations at present values (discount rate i = 8 %)	Annual benefit from energy savings
	TWh	TWh	Mtoe	M€	M€	M€	M€
2018	0.3168	0.3168	0.027257	316.8	297.465	297.46	29.63
2019	0.3168	0.6336	0.054515	313.632	276.517	573.98	58.98
2020	0.3168	0.9504	0.081772	310.464	257.017	831.00	88.03
2021	0.3168	1.2672	0.10903	307.296	238.868	1069.87	116.80
2022	0.3168	1.584	0.136287	304.128	221.977	1291.84	145.28
2023	0.3168	1.9008	0.163545	300.96	206.258	1498.10	173.49
2024	0.3168	2.2176	0.190802	297.792	191.631	1689.73	201.41
2025	0.3168	2.5344	0.21806	294.624	178.021	1867.75	229.07
2026	0.3168	2.8512	0.245317	291.456	165.359	2033.11	256.45
2027	0.3168	3.168	0.272575	288.288	153.579	2186.69	283.56
2028	0.3168	3.4848	0.299832	285.12	142.621	2329.31	310.40
2029	0.3168	3.8016	0.32709	281.952	132.428	2461.74	336.99
2030	0.3168	4.1184	0.354347	278.784	122.948	2584.69	363.31