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Παραδοτέο έργου GreeTHiS με τίτλο:

«Market research of innovative technologies for EE and climate protection in historic buildings and areas throughout the BSB countries»

Market research of innovative technologies for EE and climate protection in historic buildings and areas throughout the BSB countries.

Report by

Municipality of Orestiada
Greece

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1 Introduction

In EU, the existing building stock accounts for over 40% of final energy consumption and approximately 36% of the total greenhouse gas emissions. As far as the Hellenic building stock is concerned, the residential building sector represents about 75% of the total building stock, which is similar to the average European percentage. Additionally, the current Hellenic building stock accounts for approximately 36% of final energy consumption, which is below the European average. Nevertheless, the Hellenic building stock is considered as one of the most energy consuming in EU if scaled to EU average climate (Figure 1).

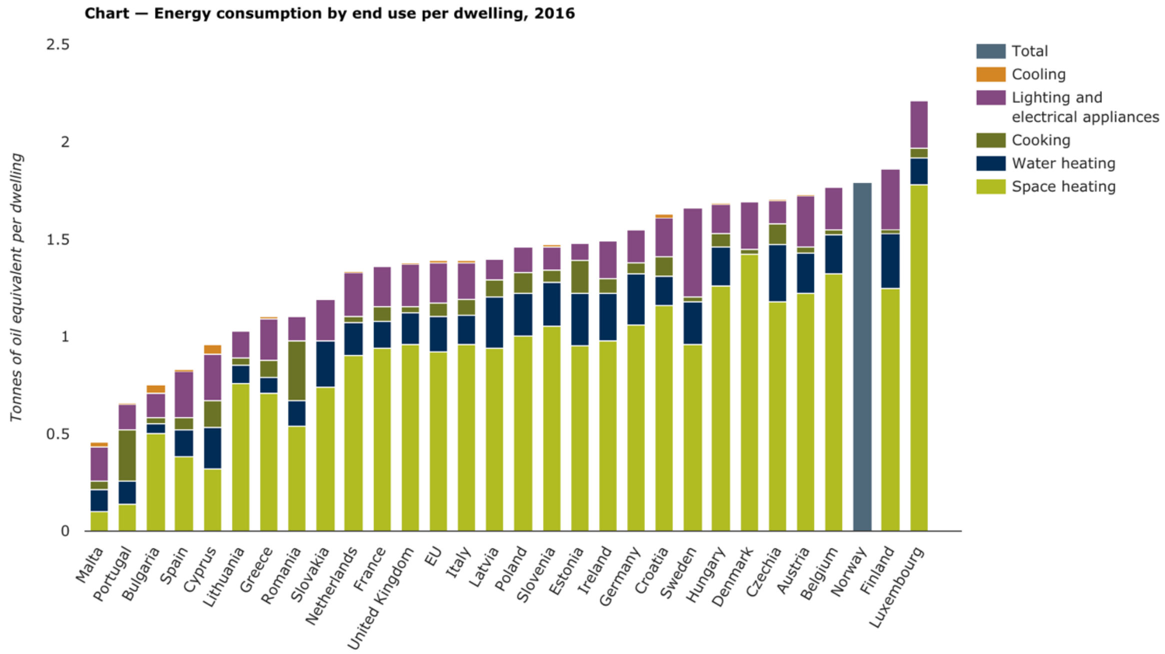

Figure 1. Energy Consumption by end use per dwelling, 2016 (source: European Environment Agency, 2019)

According to latest available data of the Hellenic Statistical Authority (El.Stat., 2013), the average annual thermal energy consumption per Greek household is 10,244kWh. The thermal energy consumption refers to 85.9% for heating, 4.4% for domestic hot water and 9.7% for cooking of Greek households. In addition, the average annual electrical energy consumption per Greek household is 3,750kWh, of which 38.4% is for cooking and only 6.6% is for lighting. It is important to highlight that 43.7% of Greek households investigated by the Hellenic Statistical Authority were built between 1961 and 1980 (Figure 2).

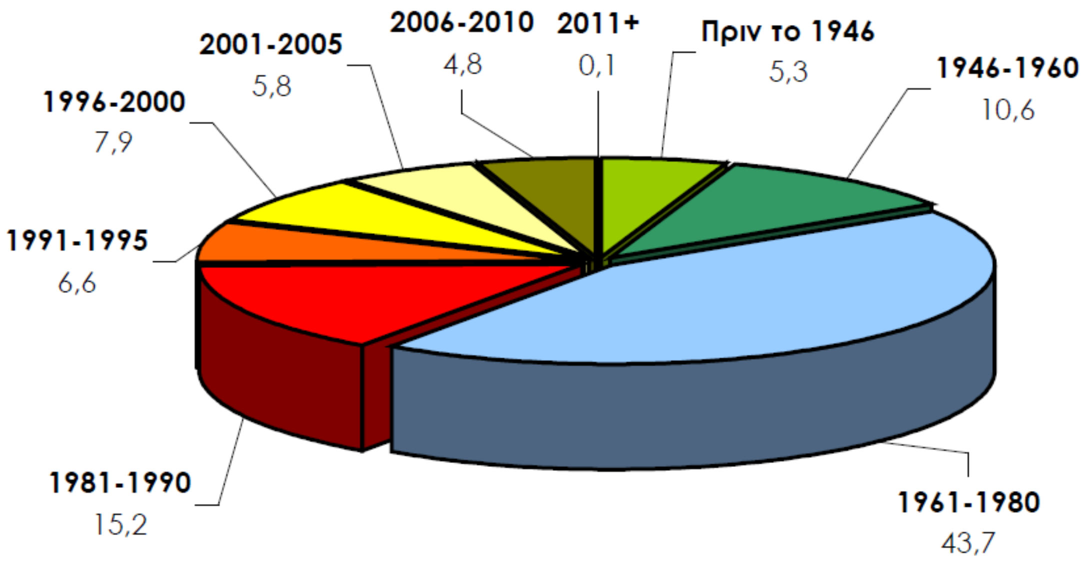

Figure 2. Percentage distribution of construction period of households in Greece (source: El. Stat.,2013)

2 Greek legal framework on energy efficiency

The main pillar of all the efforts towards achieving the EU target regarding the energy efficiency is based on Directive 2006/32/EC, transposed into Greek legislation by means of Law 3855/2010. Under this Directive, the National Energy Efficiency Action Plans (NEEAPs) provide a framework for the development of a strategy at national level, to further improve energy end-use efficiency through the implementation of concrete measure and policies in the various energy end-use sectors. For the period from 2021-2030, Greece has developed according to EU guidance a 10 year integrated national energy & climate plan (NECP), outlining the measures and actions to meet different targets for 2030 entailing the targets on energy efficiency.

The national legal framework of Greece on buildings energy efficiency is mainly based on the implementation of European Performance Building Directive (EPBD). The responsibility of the implementation of the EPBD in Greece lies with the Ministry of Environment and Energy (YPEN). Law 3661/2008 firstly introduced the minimum energy performance requirements for buildings in addition to those of the pre-existing heat insulation regulations, by transposing into the Greek legislation Directive 2002/91/EC on the energy performance of buildings. The Directive 2010/31/EC was adopted by the Greek Parliament under Law 4122/2013 (February 2013). This Law introduced the Regulation on the Energy Performance of Buildings, known as "KENAK". The calculation methodology is laid down in detail in the technical guidelines issued by the Technical Chamber of Greece (TOTEEs). KENAK states that all new buildings must conform to the minimum energy performance requirements and to be classified at least under category B. Also, all buildings undergoing major renovation to the extent that this is technically, functionally and financially feasible, whereas any isolated interventions made in existing buildings must conform to the minimum energy performance requirements.

Law 4342/2015 introduces to the Greek legislation the Directive 2012/27/EC that amends the Directive 2010/31/EC and Directive 206/32/EC. This Law sets the obligation for renovation of 3% of the total floor area of public buildings per year.

Law 4067/2012 includes an incentive for new buildings classified under energy category A+ (KENAK) to be allowed to increase the building ration by 5%. This incentive is increased to 10% in case there is exceptional environment performance of the buildings. Under Laws 4178/2013 and 4495/2017, incentives were given for offsetting the fine for illegal buildings against energy upgrading works.

Since 2013, all buildings that are being leased or rented must have an Energy Performance Certificate (EPC) and since 2015 all public buildings with floor area of more than 250 m^2 must also have an EPC. Law 4409/2016 introduced new qualifications and training requirements of energy auditors, as well as new categorization of energy auditor's classification.

It has to be mentioned that Law 4122/2013 included the obligation that every new building of the public sector from 1 January 2019 should be a Nearly Zero Energy Building and all new buildings constructed after 1 January 2021 should fulfil the same obligation.

Cultural and heritage monuments are protected under the Greek Constitution, article 24. As in other European countries, the old Directive on energy efficiency excluded listed buildings and protected monuments from energy efficient retrofitting. Currently there are not any technical regulations regarding the implementation of energy efficiency measures at historical building, however any interventions applied must be approved by the Ministry of Culture. It has to be mentioned that usually the energy saving measures can be applied provided that there is no change on the building envelope. Regarding the protection class of the historic building, more restrictions may be applied.

Energy efficiency in transport is promoted through the Greek legislation through several measures applied during the recent years. The measure "Incentives to replace private cars and promote energy efficient vehicles" was implemented by the Ministry of Infrastructure, Transport and Networks from 2009 to 2012. The measure was implemented by giving tax and economic incentives through Legislative Act No 16.9.2009/2 setting out measures to address air pollution. The measure "Linking vehicle taxation with energy efficiency and CO_2 emissions" aims to encourage the use of vehicles with lower fuel consumption and pollutant emissions levels.

As far as the industrial sector is concerned, the Greek legal framework is based on the 1st national climate change programme through the laws on development, i.e. Law 2244/1993 and the different operational programmes. A number of horizontal policy measures have been implemented and contribute towards promoting energy efficiency in the industrial sector.

3 Greek market analysis on energy efficiency technologies

3.1 Energy efficiency on building sector

Approximately 70% of the buildings in Greece are constructed before 1980, that is to say before thermal insulation regulation has been in force. The classification of dwellings of Municipality of Orestiada according to construction period, building type and area presented in table 1 is a characteristic example.

Table 1. Total area of dwellings of Municipality of Orestiada in 2012 (source: SECAP Orestiada)

Area (m^2)	Single & Double Dwellings	Apartment building
Έως 1980	1.038.529	125.312
1981 - 2001	336.068	142.145
2002 - 2011	71.315	158.479

As mentioned in section 2, all new buildings in Greece must fulfil the Energy Performance Regulation (KENAK), which obligates to have a specific U value regarding the thermal insulation of the building. Therefore, all new buildings are constructed with adequate thermal insulation specifically calculated for each climatic zone of Greece. In order to achieve significant impact regarding the energy efficiency of the building sector, it is important to focus on retrofitting of existing buildings.

The technical guidelines (TOTEE) from Technical Chamber of Greece provide with the information required in order to achieve the minimum U value for each climatic zone. Table 2 presents the U values for newly constructed buildings for walls and windows for each climatic zone of Greece, as included in TOTEE 20701-1/2017. The values presented in table 2 are slightly higher in case of radical energy renovation of a building. Figure 3 shows the climatic zones of Greece.

As clearly stated, the implementation of interventions on the envelope of the existing building stock is important in order to achieve the national energy efficiency targets. The importance of buildings envelope improvement has been also recognized by building owners in Greece and there is significant activity in that area the last decade. The most common measures applied include the implementation of external thermal insulation of walls and roofs and the replacement of windows. Another measure applied is the internal thermal insulation, which is mostly implemented in buildings where it is not technically feasible to be applied externally or it not permitted, as it is the case of historic buildings.

Table 2. Maximum U values allowed per structural element and climatic zone in Greece (TOTEE 20701-1/2017)

Structural Element	Maximum U value (W/m²K)			
	Zone A	Zone B	Zone C	Zone D
Horizontal roof	0.45	0.40	0.35	0.30
External wall	0.55	0.45	0.40	0.35
Pilotis	0.45	0.40	0.35	0.30
Floor	1.10	0.80	0.65	0.60
Window	2.80	2.60	2.40	2.20
Glazing	2.10	1.90	1.75	1.70

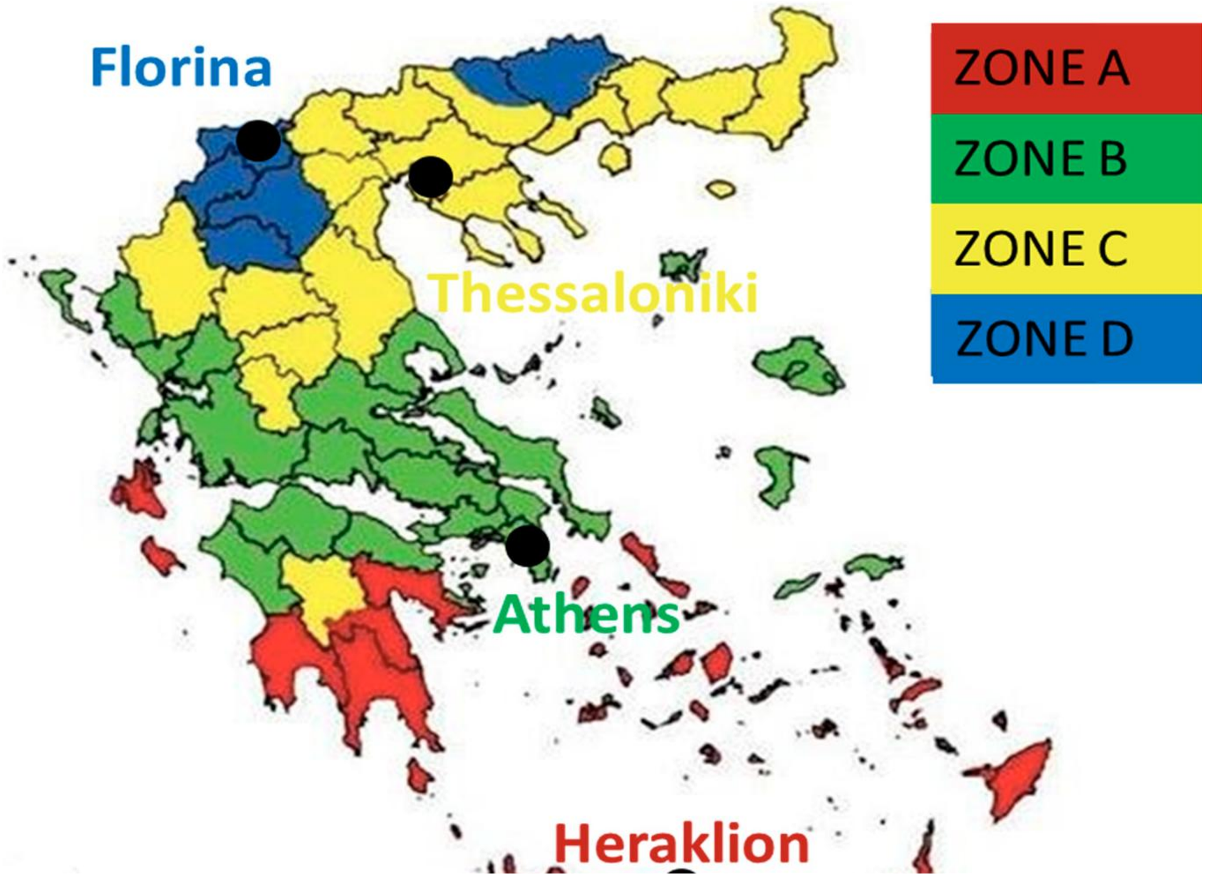

Figure 3. Climatic zones of Greece

As far as the external wall insulation is concerned, the most common yet effective method applied in building in Greece is the External Thermal Insulation Composite Systems (ETICS). The ETICS are used throughout Europe. The European

Organisation for Technical Approvals (EOTA) drafted the European Technical Approval Guide (ETAG 004) for the ETICs applied in walling constructions and concrete. The ETAG 004 describes ETICS as a series of construction elements consisting of specific prefabricated components:

- Adhesive material
- Insulation material
- Mechanical fixation sockets (if required)
- Main layer of coating
- Fiberglass reinforcement mesh
- Final coating
- Additional elements – components

The ETICS methodology is usually developed with white expanded polystyrene boards (EPS) or graphite expanded polystyrene boards (Graphite EPS). Extruded polystyrene boards (XPS) can also be used in ETICS.

Extruded polystyrene boards are also used for rooftop thermal insulation applications supplemented with other materials regarding waterproofing and solar irradiation protection.

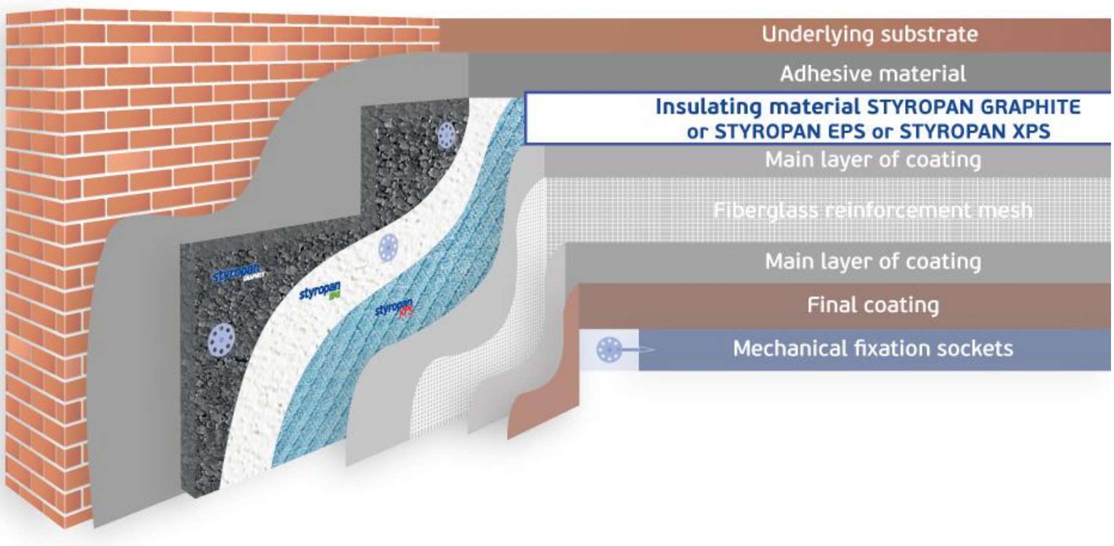

Figure 4. External wall thermal insulation ETICS by Styropan (www.styropan.gr)

Internal thermal insulation is generally considered as an easier way for construction and a more cost-efficient solution, compared to external thermal insulation systems. This is the case for products that provide thermal insulation panels with glued drywall on the inner side of the walls. Nevertheless, this method is not preferred by building owners mainly due to the requirement to reduce useful floor area. The insulation materials used are the same as the materials used at the external wall systems. Rockwool is also used both at external and internal thermal insulation methods.

Figure 5. Rockwool by FIBRAN (www.fibran.gr)

Replacement of windows is also an important energy efficiency measure in order to improve the efficiency of the building envelope. Double-glazed windows with PVC or aluminum frame are commonly used in such interventions in order to lower the U values of the windows. Wood is also a choice for the windows frames which is less common mainly due to its increased price. Glazing is filled with inert gas, which is usually argon in order to increase the thermal resistance. Argon gas is an innovative solution in the thermal insulation industry improving the double solar more energy-efficient glass pane thermal transmittance properties by 25% for each glass pane. Triple-glazed windows are also used in Greece, mostly in Northern parts of the country and in high altitude areas. Greek companies are mainly focused on aluminum windows, such as ALUMIL and ELVIAL, which offer innovatively constructed window frames that offer extremely low thermal transmittance coefficient values.

Internal insulation, such as the system proposed by Greek company STYROPAN, as well as window replacement or only glazing replacement can be adopted for energy efficiency measures in historic buildings throughout the Black Sea Basin countries.

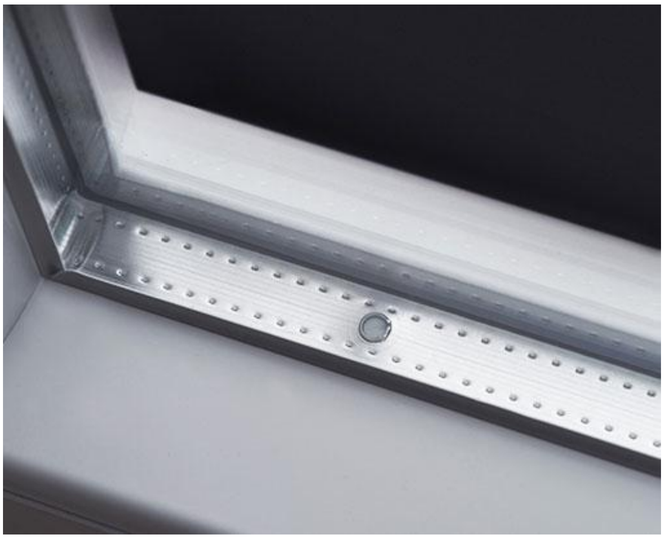

Figure 6. Double glazed window (www.thermoplastiki.gr)

Figure 7. Graphite EPS with gypsum board (www.styropan.gr)

The hot climatic conditions of Greece indicate the necessity for cooling of buildings, particularly of tertiary buildings. Natural cooling of buildings has been extensively studied by Greek engineers and applied to several buildings in Greece. The most common and effective passive cooling techniques are the following:

A. Solar control (shading) of the building. This is achieved by different technologies that include as natural vegetation, geometric projections of the building volume, permanent, fixed or moveable shading devices, glazing with specific coatings.

B. Natural ventilation. This is achieved through specific design and operation of windows and through vents on the top and bottom if internal partition walls that are used to allow the air movement through the interior of the building. Natural ventilation is performed usually at night that results in reduction of the thermal load of the building. Ceiling fans are also used to enhance the effectiveness of natural ventilation and are very common in office buildings in Greece.

The following techniques are also considered as natural cooling techniques that have been applied to buildings in Greece.

- Planted roofs, vented roofs, reflective surfaces of exterior surfaces, radiant barriers.
- Enhancement of natural ventilation by solar chimneys.
- Evaporative cooling techniques such as water surfaces, cooling tower, vegetation.
- Cooling by rejection of heat to the ground (e.g. underground cooling pipes, earth to air heat exchangers).

Natural lighting is also a measure that increased the energy efficiency of building since it accompanied with lower electricity consumption for the use of artificial lighting. Natural lighting refers to the use of daylight (sunlight) in most efficient ways and the following categories can be considered:

- Openings on vertical walls
- Roof openings
- Atria
- Light ducts

Due to the hot climatic conditions of Greece, natural lighting is usually in competition with cooling load and therefore detailed studies should be performed before proceeding with increased openings that increase the daylight availability. The most common daylighting technologies are glazing with particular properties, prismatic light transmitting elements, transparent insulation materials and reflectors (light shelves or reflective louvers).

As far as the historic buildings are concerned, it is obvious that is difficult to intervene to the façade in order to apply methods and techniques described previously. Underground cooling pipes and earth to air heat exchangers can be considered as innovative natural cooling solutions that may have the potential to be applied to historic buildings under certain conditions. On the contrary, natural lighting techniques are considered as very difficult to be applied to existing historic buildings.

As oppose to the European countries, district heating systems are not common in Greece. Individual boiler systems are the most common thermal energy generation systems for heating of buildings in Greece. As stated by the Hellenic Statistical Authority, only 0,6% of dwellings are connected to district heating system. Heating oil is the most common fuel used for heating (63.8%) followed by electricity (12.4%) and biomass (12.0%). Due to unavailability of natural gas network in most of the cities of Greece, natural gas is responsible for about 9% of the total consumption for heating. Regarding cooling, the Hellenic Statistical Authority states that 99.7% of dwellings used split air condition units for cooling. The average use of the cooling systems is about 3 to 5 hours during summer months. Taking the above into consideration, it can be derived that there is significant potential for improvements of the energy efficiency of heating and cooling systems. The most common energy renovation on the heating and cooling systems of buildings in Greece includes the installation of air-to-water heat pumps. Heat pumps offer about 60% reduction in consumption of primary energy, resulting in CO_2 emissions reduction and most importantly in lower energy bills for the building owners/users. Heat pumps can operate both in heating and cooling, however, they can be easily integrated only to existing heating systems. In order to utilize the cooling capacity of the heat pumps, a new distribution system is usually needed, since the majority of the buildings in Greece is equipped with conventional radiators and for cooling purposes fan coil units are obligatory. Moreover, in case of cooling, the existing piping system is not adequate for the operation of fan coil units and new installation is required. Under certain conditions, the replacement of existing boilers with air to water heat pumps can be applied to historic buildings.

Taking advantage of the recent developments in the Internet of Things sector, a massive potential for improvement in energy efficiency of buildings exists. Several companies have developed Building Energy Management Systems (BEMS) that can be applied to any kind of buildings, including the historical monuments. GFOSS company has developed an open-source BEMS called “Plegma OpenBMS”. There are several companies in Greece that provide services for BEMS installation in buildings with significant expertise and experience. In addition, KNX is considered as an important solution for building control. KNX devices can manage lighting, blinds and shutters, heating and cooling systems, security systems, and more providing with a number of solutions for improvements of buildings energy efficiency.

3.2 Renewables on building sector

Renewable Energy Sources (RES) play an important role in the efforts made for energy efficiency in buildings. Solar energy is without a doubt an important RES technology that supports the efforts towards low carbon economy. Solar energy can be categorized to photovoltaics and solar thermal technology, as well as hybrid solar thermal/PV technology, usually called “PV/T”. The conventional photovoltaic technology is based on crystalline silicone and consists of polycrystalline and monocrystalline PV panels. Thin film PV panels have also been developed, with commercial products to be based on Cadmium Telluride (CdTe), Copper indium gallium selenide (CIGS), amorphous thin silicium (a-Si, TF-Si).

In Greece, there is currently no PV manufacturer in operation. All five PV production units have unfortunately stopped their operation. The PV production capacity was about 100 MW and the technology of PVs produced was mainly crystalline silicone. Heliosphera was the first Greek company to produce PV panels and their technology was considered at that time as innovative. Heliosphera PV panels were thin-film micromorph panels.

Greek PV market was radically developed during the period 2009 to 2014. The market expansion was based on the feed-in-tariff system that provided very attractive financial incentives for investors. A specific program for the Greek government was developed for installations of PV on buildings with capacity up to 10 kWp. This program started with a feed-in-tariff scheme and has been changed later to a net-metering scheme. Autonomous PV systems are very rare in the Greek market and are only developed in regions were electricity from Grid is not available. An innovative scheme has been introduced to the Greek legislation that includes the possibility to develop a virtual net-metering PV system. This scheme allows the investors/building owners to develop a PV system in any place available and offset the electricity consumption of the facility/building. However, this scheme is currently available only for public entities and energy cooperative companies. Nevertheless, virtual net-metering can be an important solution for the integration of renewable electricity generation to historical buildings, since no actual intervention on the buildings is required.

Solar thermal systems and particularly solar water heaters are considered as very mature market for Greece. It has to be mentioned that Greece is very high at the list of installed solar thermal systems per capita of the world. In addition, there is significant number of Greek manufacturers of solar collectors and solar thermal systems in general. There are two main categories that solar thermal technology is distinguished to: stationary and concentrating (which is typically non-stationary). Stationary collectors are less expensive and characterized as low maintenance since they do not move. However, they can only achieve low to medium temperatures. On the contrary concentrating solar technologies are usually coupled with tracking systems and they can achieve higher temperatures. They are also more expensive and require more maintenance.

Flat-plate collectors are the simplest version of solar collectors. Flat plate collectors are usually permanently fixed in position and require no tracking of the sun. The orientation is towards the equator, facing south in the northern hemisphere and north in the southern. The tilt angle that is optimum for the maximum solar energy collection depends on the latitude of the location. They collect both direct and diffuse solar radiation. They are most commonly used to heat outdoor swimming pools and domestic water. They consist of an insulated metal box with a glass covering and an absorber plate inside. The absorber plate utilizes the sun’s radiation to warm an internal heat transfer fluid, usually water, oil or air. Flat-plate collectors can either glazed or unglazed.

A typical evacuated tube collector consists of a heat pipe inside a vacuum-sealed tube. The vacuum envelope reduces convection and conduction losses, so the collectors can operate at higher temperatures than flat-plate collectors. Like flat plate collectors they collect both direct and diffuse solar radiation. Evacuated tube collectors use liquid-vapour phase change materials to transfer heat at high efficiency. The heat pipe (inside the vacuum-sealed tube) contains a small amount of fluid that undergoes an evaporating-condensing cycle. Responsible for the evaporation of the liquid is the solar heat. The vapour travels to the heat sink region where it condenses and releases its latent heat. The condensed fluid return back to the solar collector and the process is repeated. A large number of variations of evacuated tube collectors are available on the market.

With the principle that heat losses can be decreased by decreasing the area from which they occur, the concentrating solar collectors were developed. Concentrating collectors present certain advantages as compared with the conventional flat plate collectors. Many designs have been developed in the category of concentrating collectors. Depending on the design the concentration ratio, i.e. the ratio of aperture to absorber areas, can vary over several orders of magnitude, from as low as unity to high values of the order of 10.000. The concentrating collectors can achieve the highest temperatures, but they are also the most expensive in terms of manufacturing and maintenance. Concentrating collectors are able to collect only the direct solar radiation, thus tracking the sun is a necessity for high efficiencies. The basic concepts of concentrating collectors include parabolic troughs, linear concentrating Fresnel collectors and parabolic dishes.

Solar thermal systems, as it is the case with PV systems, require significant space for their installation. Therefore, their application on historical buildings is usually not feasible. Thus, although the technology is relatively mature and techno-economically feasible for Greece it is not considered as a RES technology that could be applied to for the energy renovation of historical buildings.

As far as wind energy is concerned, small wind turbines have been considered as a solution for urban installations. Wind turbines can be categorized to two main types, Horizontal Axis Wind Turbine (HAWT) and Vertical Axis Wind Turbines (VAWT). Currently, the Greek legislation does not allow the installation of wind turbines on buildings located within villages with more than 2,000 people. Therefore, their application is very limited and mostly in buildings located in the countryside and with no available electricity grid. An innovative solution has been developed by AIR-SUN that provides with a solution for urban wind turbine, as presented in figure 8.

Figure 8. Air-turbo Vertical Axis Urban Wind Turbine by AIR-SUN (www.air-sun.gr)

The use of heat pumps in buildings has been discussed in section 3.1. Besides the air-to-water heat pumps, water-to-water heat pumps can be applied for heating and cooling of buildings. This technology is known as Geothermal Heat Pumps or Ground Source Heat Pumps and utilizes the available underground heat/cool. These systems operate with increase efficiency as opposed to air-to-water heat pumps due to the fact that they use the normal ground or groundwater temperatures (between 5 to 30oC), which are available in all countries of the world. There are two main configurations regarding the Ground Source Heat Pumps (GHPs), the closed loop and the open loop systems. Closed loop systems are then divided to horizontal and vertical (figure 9). An innovative technology has been developed by Greek company “AM Constructions” that includes a patent coaxial geothermal heat exchanger. The advantages of this technology include lower initial costs and optimum efficiency.

As also mentioned in section 3.1., heat pumps can be a solution for heating and cooling of historical buildings. In case there is available space for the development of geothermal heat exchangers, GHPs can also be a techno-economically feasible solution for replacement of conventional heating and cooling systems of historical buildings in Greece and BSB region in general.

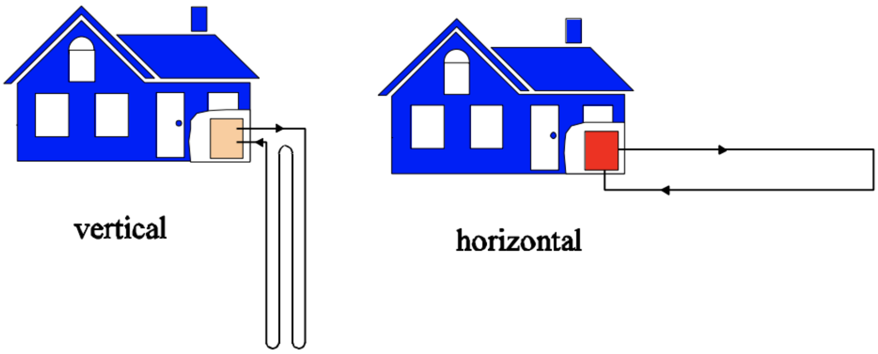

Figure 9. Closed loop heat pump systems

Biomass is considered as the most common Renewable Energy Source (RES) that is widely available. Biomass utilisation is strongly promoted by the EU policy for climate change mitigation, energy security and green growth. However, it is accompanied by exploitation disadvantages that arise from the low energy density, the high dispersion, the high moisture content and the heterogeneity. The issues of conventional utilisation of biomass are reduced by the use of biomass pellets, which are characterized by stable quality, high level of automation in their use in heating systems and wide application range.

Biomass boilers are considered as conventional technology and there are several manufacturers in Greece that produce biomass boilers with wide range of capacity or even tailored made. The main issue that is related to the use of biomass for heating of buildings is found on the large storage areas that are required, as well as for the limited automation on biomass feeding systems. These issues limit the feasibility of biomass boilers to replace heating oil boiler systems in historical buildings.

3.3 Mobility

Since 2000 to 2009, the final energy consumption in transport of Greece has increased by 26%. Due to economic recession and the energy efficiency measures that were implemented after 2007, the total energy consumption of transport sector reduced by

32% in the period 2009-2013. A slight increase is observed from 2013 onwards. As shown in figure 19, biofuel and LPG consumption has increased as a result of the measures introduced by the Greek government. Nevertheless, petroleum products still dominated the energy mix of the transport sector.

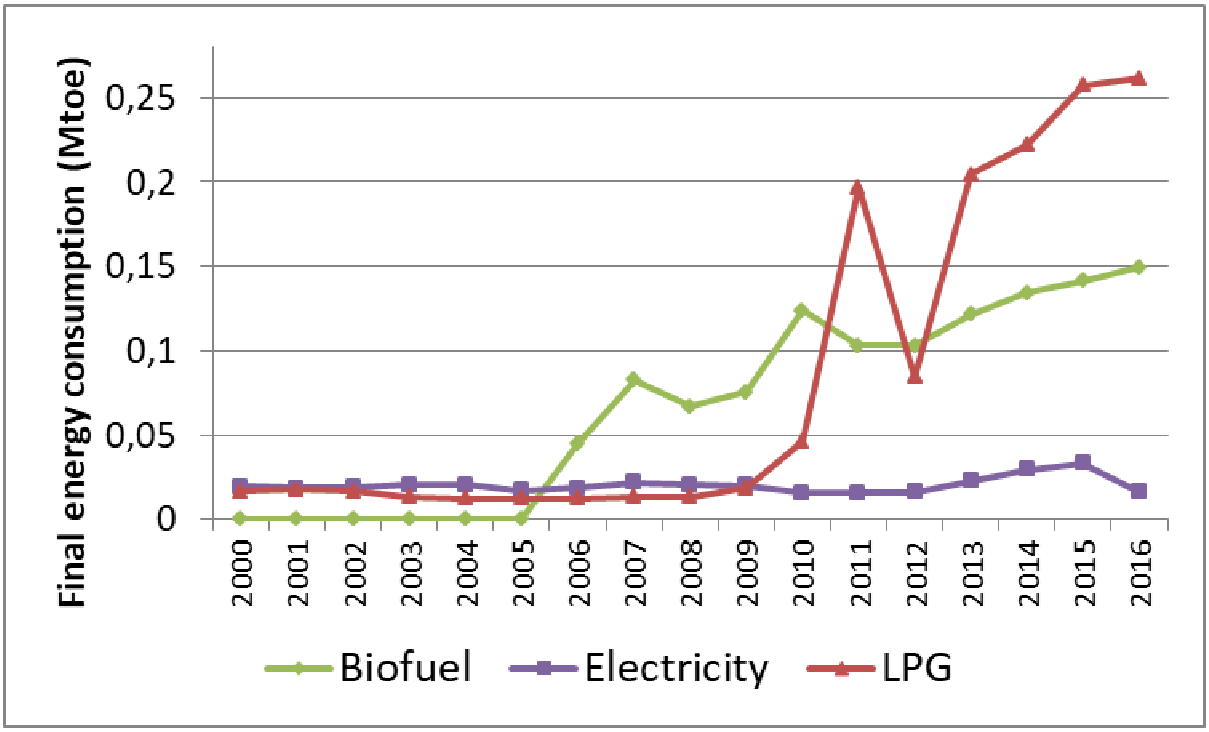

Figure 10. Final energy consumption of transport sector Greece (source: ODYSSEE)

Reshaping of the public transport system has been introduced by the Greek government as a policy measure to improve energy efficiency of the transport sector. Activities in this area include the improvement of public transport route planning, the linking of new routes to existing ones, the creation of organized parking spaces near bus stops and metro stations and the information systems for travelling public. Other actions include the improvement of public transport through the use of smart control and management, the improvement of connectivity and functionality of existing transport networks and the monitoring of the quality of service provided by public transport.

The development of transport infrastructure projects also improves the energy efficiency of the transport sector. Such projects include the extension of metro and suburban railways, the creation of low traffic circulation streets and pavements/cycling paths, the replacement of street lighting with LED lighting, as well as the use of RES in urban and municipal transport remote service points. Many cities have also proceeded to the development of Sustainable Urban Mobility Plans (SUMPS) that provide a strategic plan towards sustainable transport.

Optimisation of private car use through car-sharing has been in pilot basis developed in Greece. The promotion of low carbon cars such as natural-gas fired cars and electric cars through policy measures such taxation correlation with CO2 emissions has also selected by the Greek government for the reduction of energy consumption of the transport sector.

4 Proposals on the use of energy efficient technologies on examples of historical objects in Greece

According to the latest National Energy and Climate Plan of Greece (2019), within the energy efficiency dimension, the objective is to achieve energy savings in final energy consumption of at least 32,5% compared to the projected evolution of final energy consumption by 2030. As far as the residential buildings is concerned, the target is to upgrade or replace with new energy-efficient ones at least 40,000 homes per year. In general, building sector plays an important role in the efforts made towards the increase of energy efficiency. Therefore, as stated in this report, a number of technologies and solutions has been developed to improve energy efficiency of buildings.

As far as historical buildings are concerned, their energy efficiency upgrade constitutes a complex work due to the many issues that need to be addressed. This is why the obligations set by the Greek EPB regulation are not applied to historical buildings. Besides the officially protected historical buildings, Greece also has a group of pre-1955 building stock that comprises representatives of local architectural traditions with usually remarkable elements that may interfere with energy renovation activities. Alexandrou et al (2018) provide a methodology for implementation of energy efficiency interventions in buildings constructed before 1955 in Greece. They provide with a suggestion for classification of buildings constructed pre-1955 into five distinct categories based on the heritage value and construction characteristics of each building. A specific category is suggested for buildings listed as monuments and for listed buildings. A third category includes buildings in listed traditional settlements and the last two categories refer to the pre-1955 buildings with or without particular architectural value. Following the classification, technical guidelines have been developed for the application of energy efficiency measures and their implementation consists of four distinct stages: a) building inspection and evaluation stage, b) concept-design stage, c) approval of evaluation and design proposal including in-situ audit-procedures by authorities and d) final design and issuance of building permit stage, followed by site inspection and supervision of the implementation works.

Energy efficient interventions in historical monuments and buildings requires a multidisciplinary approach, expert knowledge and proper guidance. The limitations set by the preservation regulations, as well as the uniqueness of each building increase the difficulty of implementing energy saving measures. It is therefore hard to classify and dictate appropriate common solutions for such buildings even in the same country, since in addition to the above, monuments and listed buildings were built under different historic and socioeconomic circumstances.

Until today, several restoration and conservation projects on historical monuments and buildings have been completed within the Region of East Macedonia and Thrace, Greece. However, their goal is not directly related to energy efficiency and the only measures applied in this area include the installation of new energy efficient electromechanical equipment and more less usually the replacement of windows. Examples of such projects include the renovation of tobacco warehouse of Drama that is now a five star hotel (Hydrama Grand Hotel) (figure 11), the renovation of tobacco warehouse of Alexadroupolis that operates now as the municipal library and the renovation of several listed private buildings in the old city of Xanthi. Hydrama Grand Hotel includes new wooden framed, double-glazed windows, as well as low energy consumption air-chilled heat pumps for heating and cooling of the building.

Figure 11. Hydrama Grand Hotel, a renovated old tobacco warehouse

Municipal Library of Alexandroupolis also includes new wooden framed, double-glazed windows. The renovation of building included also installation of natural gas boilers for heating, which will be installed upon the availability of natural gas in Alexandroupolis.

Figure 12. Municipal library of Alexandroupolis, a renovated old tobacco warehouse

5 List of technologies, producers and distributors available and operating in Greece

Name of organisation	**Contact details (website, phone number, address, contact person)**	**Description of the organization**	**Field of activity /*energy efficient measures, lighting, transport, BMS* (building management system), *energy services*, RES (*solar systems, heat pumps, biomass, geothermal*)**	**Examples of good practice (Link to access the example)**
STYROPAN	https://www.styropan.gr/en/	The company was established in 1982, in Thessaloniki by Mr. Ioannis Katsaounidis with the main activity of manufacturing expanded polystyrene insulating products. In 2003 expand the product range by adding the Styropan Graphite expanded graphite polystyrene manufacturing line, using BASF raw material. In 2009 next to the existing production facilities, a new, state-of-the-art, privately owned Styropan XPS extruded polystyrene	Energy efficiency of building envelope	https://www.styropan.gr/en/applications.html

		production unit, spanning over 5,000 m^2 was constructed.		
FIBRAN S.A.	https://fibran.gr/	FIBRAN SA was founded in Greece, Thessaloniki, in 1974 by its current Chairman Dimitrios Anastasiadis.Ever since, FIBRAN SA has been designing and manufacturing products and solutions for the thermal insulation, acoustic insulation and fire protection in building, industrial and marine applications. FIBRAN*xps* (extruded polystyrene foam boards), produced in Greece, Bulgaria, Slovenia and Portugal, FIBRAN*geo* (stonewool boards and rolls) produced in Greece and FIBRAN*gyps* (dry construction systems) produced in Italy have placed FIBRAN among the important European producers of insulation. Purpose of FIBRAN*products* and solutions is to bring energy efficiency in building, industrial and marine applications. FIBRAN*products* bring the ENERGYSHIELD in buildings, industrial sites and marine applications.	Energy efficiency of building envelope	https://fibran.gr/efarmoges/oikodomikes/toixopoiia/
INTERPLAST S.A.	https://www.interplast.gr/	Interplast manufactures plastic pipes and fittings to the very highest specifications, for use in water supply, heating and sewerage systems and covering a broad range of applications in the areas of house construction, technical projects and industrial facilities. The company aims to design, develop and market products and integrated solutions that cover the needs of modern construction and improve quality of life, by building a relationship of trust between the technical world and the consumer public. The Group's central offices are located in Komotini, coordinating the day-to-day manufacturing activity of the industrial units. Plastic pipes and fittings are manufactured at facilities covering 40,000 sq m located in the industrial area of Komotini, and Interplast's Customer Services for South Greece are located in an area of 6,000 sq	Energy efficiency of heating systems	https://www.interplast.gr/en/proionta/endodapedia/leitoyrgia-pleonektimata

		m in Menidi, Attica, together with the brass fittings plant of its subsidiary company, ELVIOM.		
NOBEL SOLAR INNOVATIONS	https://nobel.gr/	The company was established with the aim to manufacture water heating systems, setting high aims as far as quality in all sectors is concerned: production process, product and services. With inspired radical change and innovations in the established design methods, production process and products, the company have achieved high standards of professionalism, using all resources, dedicated to the systematic study for the production of high specification, modern products. As of 2013, the company manufacture products at the new ultra-modern facilities of a total area of 31.000m².	Solar systems	https://nobel.bg/products/
EUNICE ENERGY GROUP	http://eunice-group.com/	EUNICE ENERGY GROUP (EEG) is currently the sole energy company in Greece that generates and supplies electricity to the customers, EXCLUSIVELY from Renewable Energy Sources. In-house developed S4S, a state-of-art Energy Management System that integrates energy storage with various renewable energy sources and electricity consumption. The first installation of S4S was successfully implemented in hybrid power station in Tilos Island, making the island largely fossil-free in electricity generation Manufacturer of a small 50kW wind turbine, EW16 Thetis. EW16 Thetis is particularly designed for remote locations, energy communities and smart grid applications. The turbine is manufactured in Eunice Wind production facility and it is the first wind energy generator ever produced in Greece Electricity trader and supplier through EEG's "WE ENERGY" retail arm. WE ENERGY is the only Greek solution-driven electricity retailer that exclusively supplies electricity with renewable energy origin.	Wind turbines RES electricity retailer	http://eunice-group.com/projects/eunice-wind/

ECOSUN LTD	https://ecosun.gr/?lang=en	A specialized company of research, design, development, manufacture, distribution and installation of systems for the conversion of solar energy and other renewable energy sources into electricity. The company has entered its third decade of solar energy applications and over the years, have acquired high-tech expertise as well as extensive experience and knowhow, characteristics that together with reliability and integrity help the company to stand out as an ideal business partner and supplier. The company researches, designs, manufactures, sales, guarantees and puts into operation systems both at a residential and industrial level, such as: Production of electricity using photovoltaics Generation of electricity using wind air turbines Back up systems Power generating pairs Automation of Energy Systems Solar Pumps Electric Cars	Photovoltaics Electric Cars	https://ecosun.gr/projects/?lang=en
DASTERI S.A.	http://dasterisystems.gr/en/home/	By constantly investing in highly qualified staff and new technologies the company is, today, an established European company that exports its products to 47 sales and distribution points around the world. Dasteri's products are manufactured according to the specifications of the Quality Management System ISO 9001:2008 and fully meet the requirements of European and international markets. Within the context of dynamic development in innovative solutions for green energy Dasteri expanded in 2007 its activity in the manufacture of LED lighting for indoor and outdoor spaces thus creating new production units in order to fully meet the production requirements of high technology products. Today, Dasteri possesses the necessary experience and expertise since it has completed a large variety of projects with utter success through open and	LED lighting	http://dasterisystems.gr/en/products/categories/&tid=64

		international tenders. With a commitment to research and planning for innovative services and products Dasteri continues to make large investments in terms of means and efforts to meet the market requirements in the best possible way. Dasteri's success is the result of continuous research for quality at every stage of production. The company has a large number of professionals who have the know-how in design, production and marketing in order to service our customers		

6 Conclusions

Energy efficiency is considered as one of the most important challenges towards low carbon economy. The efficient and immediate adoption of European Directives on that matter is important and crucial for the achievement of targets set. The promotion of energy efficiency in the building sector is recognized by the Greek government and until today several successful policy measures have been implemented. Policy measures and regulations on energy efficiency, as well as the increase of the conventional fuel prices (e.g. heating oil) drove in the recent years the development of the Greek market on technologies and solutions for buildings' energy renovation. The implementation of energy efficiency measures on buildings is not currently always techno-economically feasible, mainly due to the increased capital cost. Therefore, grants are usually needed in order to enhance the economic feasibility and promote energy efficiency. This usually the case for the innovative technologies and solutions due to low market penetration.

Energy efficient interventions in historical monuments and buildings requires a multidisciplinary approach, expert knowledge and proper guidance. The limitations set by the preservation regulations, as well as the uniqueness of each building increase the difficulty of implementing energy saving measures. Knowledge exchange can be significantly helpful for the improvement of energy efficiency of historical buildings across the Black Sea Basin, taking into consideration the adaptability of the technologies and solutions for energy retrofitting.