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Assessing Energy Efficiency in the Greek Residential Sector: Policy Barriers, Effectiveness and Recommendations

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ΔΗΛΩΣΗ

Η εργασία αυτή είναι πρωτότυπη και εκπονήθηκε αποκλειστικά και μόνο για την απόκτηση του συγκεκριμένου μεταπτυχιακού τίτλου.

Τα πνευματικά δικαιώματα χρησιμοποίησης του μη πρωτότυπου υλικού της ΜΔΕ ανήκουν στον/στη μεταπτυχιακό/ή φοιτητή/τρια και στο επιβλέπον μέλος ΔΕΠ εις ολόκληρο, δηλαδή εκάτερος μπορεί να κάνει χρήση αυτών χωρίς τη συναίνεση άλλου. Τα πνευματικά δικαιώματα χρησιμοποίησης του πρωτότυπου μέρους της ΜΔΕ ανήκουν στον/στη μεταπτυχιακό/ή φοιτητή/τρια και στον/στην επιβλέποντα/ουσα από κοινού, δηλαδή δεν μπορεί ο ένας από τους δύο να κάνει χρήση αυτού χωρίς τη συναίνεση του άλλου. Κατ' εξαίρεση, επιτρέπεται η δημοσίευση του πρωτότυπου μέρους της διπλωματικής εργασίας σε επιστημονικό περιοδικό ή πρακτικά συνεδρίου από τον ένα εκ των δύο, με την προϋπόθεση ότι αναφέρονται τα ονόματα και των δύο (ή των τριών σε περίπτωση συνεπιβλέποντα/ουσας) ως συν-συγγραφέων. Στην περίπτωση αυτή προηγείται γραπτή ενημέρωση του/της μη συμμετέχοντα/ουσας στη συγγραφή του επιστημονικού άρθρου. Δεν επιτρέπεται η κατά οποιοδήποτε τρόπο δημοσιοποίηση υλικού το οποίο έχει δηλωθεί εγγράφως ως απόρρητο.

Η Φοιτήτρια	Ο Επιβλέπων
Ειρήνη Βασιλάκου	Αλέξανδρος Φλάμος
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Περίληψη

Η ενεργειακή απόδοση αποτελεί θεμελιώδη παράγοντα για τη βιώσιμη ανάπτυξη, ιδιαίτερα στον οικιακό τομέα, όπου τα κτίρια συμβάλλουν σημαντικά στη συνολική κατανάλωση ενέργειας και στις εκπομπές άνθρακα. Στην Ελλάδα, η βελτίωση της ενεργειακής αποδοτικότητας έχει καταστεί εθνική προτεραιότητα, λόγω των δεσμεύσεων της Ευρωπαϊκής Ένωσης για το κλίμα, της αύξησης του κόστους ενέργειας και της συνεχιζόμενης πρόκλησης της ενεργειακής φτώχειας. Η παρούσα διπλωματική εργασία, στηριζόμενη σε βιβλιογραφική τεκμηρίωση, εξετάζει κριτικά τις πολιτικές ενεργειακής απόδοσης που εφαρμόζονται στον ελληνικό οικιακό τομέα, αξιολογώντας (ex-post) την αποτελεσματικότητά τους, εντοπίζοντας εμπόδια στην εφαρμογή τους και διερευνώντας ευκαιρίες βελτίωσης.

Αναλύοντας βασικές πολιτικές, όπως οι κανονισμοί ενεργειακής απόδοσης κτιρίων, τα προγράμματα επιδοτήσεων και τα συστήματα ενεργειακής πιστοποίησης, η έρευνα αξιολογεί τον βαθμό στον οποίο αυτά τα μέτρα ευθυγραμμίζονται με τους ενεργειακούς και κλιματικούς στόχους της Ελλάδας. Επιπλέον, διερευνάται ο αντίκτυπος αυτών των πολιτικών στη μείωση της ενεργειακής κατανάλωσης και των εκπομπών άνθρακα, καθώς και στη βελτίωση της πρόσβασης και της αντοχής των παρεμβάσεων ενεργειακής αναβάθμισης στα νοικοκυριά. Η έρευνα αναλύει θεσμικά, οικονομικά και συμπεριφορικά εμπόδια που περιορίζουν την εφαρμογή των πολιτικών, όπως οικονομικοί περιορισμοί, πολύπλοκα ρυθμιστικά πλαίσια και ζητήματα ενημέρωσης του κοινού. Για να δωθεί μια πιο σφαιρική εικόνα, η εργασία συγκρίνει την ελληνική προσέγγιση με επιτυχημένες στρατηγικές ενεργειακής αποδοτικότητας σε άλλες ευρωπαϊκές χώρες, προσφέροντας προτάσεις για τη βελτίωση του σχεδιασμού των πολιτικών στην Ελλάδα.

Τα αποτελέσματα δείχνουν ότι, παρά την πρόοδο που έχει σημειωθεί, εξακολουθούν να υπάρχουν σημαντικά κενά στην εφαρμογή των πολιτικών και στη δημόσια συμμετοχή. Η αντιμετώπιση αυτών των προκλήσεων απαιτεί μια πιο ολοκληρωμένη και προσαρμοστική προσέγγιση, αξιοποιώντας τόσο οικονομικά κίνητρα όσο και ρυθμιστικά μέτρα για την επιτάχυνση της ενεργειακής αναβάθμισης. Η εργασία ολοκληρώνεται με μια σειρά πολιτικών επισημάνσεων που στοχεύουν στην βελτίωση της εφαρμογής των πολιτικών ενεργειακής απόδοσης και στην αντιμετώπιση κοινωνικών και οικονομικών προκλήσεων στον οικιακό τομέα.

Λέξεις-κλειδιά: Ενεργειακή αποδοτικότητα, Οικιακός Τομέας, Ενεργειακή και κλιματική πολιτική, Αξιολόγηση Πολιτικής

Abstract

Energy efficiency is one of the central pillars of sustainable development, particularly in the residential sector, since buildings account for a high portion of total energy consumption and greenhouse gases. In the case of Greece, energy efficiency improvement became a national priority due to the European Union's climate commitments, rising energy prices, and the long-term problem of energy poverty. This thesis critically analyses the energy efficiency policies implemented in the residential sector of Greece, examining effectiveness, barriers to implementation, and the improvement potential.

Through an examination of key policies, including building performance regulations, subsidy programs, and energy certification systems, this study assesses the extent to which these measures align with Greece's energy and climate goals. Additionally, it investigates their impact on reducing energy consumption, lowering carbon emissions, and enhancing the accessibility and sustainability of energy-efficient home upgrades. The research also explores institutional, economic, and behavioral barriers that hinder policy implementation, such as financial constraints, complex regulatory frameworks, and public awareness challenges. To provide a broader perspective, the thesis compares Greece's approach to successful energy efficiency strategies in other European countries, offering insights for policy enhancements tailored to the Greek context.

The findings show that while significant improvement has been registered by Greece, policy implementation and public participation have significant shortcomings. A more responsive and holistic policy with the application of economic instruments and regulatory mechanisms to accelerate energy efficiency gains is necessary to solve such problems. The thesis concludes with a set of policy implications aimed at improving the effectiveness of residential energy efficiency policies, addressing persistent energy poverty, and supporting Greece's transition toward a more sustainable and equitable built environment.

Keywords: Energy efficiency, Residential sector, Energy and climate policy, Policy evaluation

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Eirini Vasilakou

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Nomenclature

Acronym	Description
CRES	Centre for Renewable Energy Sources and Saving
DHW	domestic hot water
EED	Energy Efficiency Directive
EEOS	Energy Efficiency Obligation Scheme
EPBD	Energy Performance of Buildings Directive
EPCs	Energy performance certificates
ERDF	European Regional Development Fund
EU	European Union
FTE	Full-time equivalent
GHG	greenhouse gas
IEA	International Energy Agency
K.En.A.K	Regulation for Energy Performance in the Building Sector
MEPS	Minimum energy performance standards
MS	Member State
NECP	National Energy and Climate Plan
NZEB	nearly zero-energy building
PPC	Public Power Corporation
RES	Renewable energy sources
ROI	Return on investment
RRF	Recovery and Resilience Fund
SMEs	Small and medium-sized enterprises
TIBR	Thermal Insulation of Buildings Regulation

1. Setting the Stage—Energy Efficiency in the Greek Residential Sector

1.1.Why Energy Efficiency Matters

In the twenty-first century, sustainable buildings have become a growing priority for both developed and developing countries, as the built environment significantly influences global resource consumption. This urgency is amplified by demographic projections, which estimate that the world population will rise from 7.7 billion in 2019 to 9.7 billion by 2050, potentially exceeding 10.9 billion by the end of the century (Parant, 1990). Such growth is expected to increase the demand for energy, water, and raw materials, placing mounting pressure on natural ecosystems. This rising demand does not only strain ecosystems but also intensifies pressures within the built environment itself, as buildings increasingly drive global energy consumption. Studies indicate that the construction, maintenance, and operation of buildings currently account for approximately 30% to 40% of global energy usage (Amiri et al., 2019; Invidiata et al., 2018). Much of this energy still comes from fossil fuels, making the sector a significant contributor to greenhouse gas (GHG) emissions. As cities expand to accommodate this growing population, the construction and operation of buildings will represent an even greater share of global energy use—highlighting the need to adopt more efficient, sustainable practices in the way we design and manage our built environment.

Energy efficiency plays a significant role in both existing and newly constructed buildings as it can limit the economic, environmental and social challenges of the sector (Chen et al., 2015; Shi et al., 2016). Globally, it is acknowledged as one of the most cost-effective strategies to mitigate GHG emissions, reduce energy demand and lessen the adverse effects of climate change (World Economic Forum, 2021). From an economic standpoint, improving energy efficiency contributes to energy security by reducing dependence on imported fossil fuels. This is especially relevant for Greece, which has a significant reliance on energy imports (IEA, 2023). Energy efficiency also provides significant social advantages, including the reduction of energy poverty, which remains a critical issue in Greece, as many households in the country struggle with elevated energy expenses and inadequate living conditions (Halkos & Kostakis, 2023).

1.2. Energy Use and Characteristics of Greek Homes

What drives high energy consumption in Greek homes? The answer lies in a mix of climatic and socio-economic factors (Kotsila & Polychronidou, 2021). Historically, residential energy use has largely reflected the country's reliance on conventional heating methods and the widespread presence of poorly insulated buildings, particularly those constructed before 1980, which constitute around 55% of the housing stock (Greek Ministry of Environment and Energy, 2016; Iatridis et al., 2024). The inadequate insulation in these older residences leads to considerable heat loss during winter and inefficient cooling during summer. Additionally, due to the economic downturn of 2007–2008, only 1.5% of residential buildings used by households have been constructed after 2010 in compliance with the minimum insulation standards established by the national Regulation for Energy Performance in the Building Sector (K.En.A.K) (The iBRoad

Project, 2018). These structural and long-standing issues are clearly reflected in Greece's residential energy consumption patterns. In 2022, energy in Greek homes was primarily used for space heating (57%), lighting and electrical appliances (17%), water heating (15%), cooking (7%), and space cooling (4%). Compared to the European Union (EU) average for the same year, notable differences emerge: the EU average for space heating (63.5%) is higher than Greece's, whereas Greece demonstrates significantly higher energy use for cooling (4%) relative to the EU average (0.64%). This increased consumption for cooling highlights Greece's climatic distinctiveness, while slightly elevated usage for lighting, appliances, and water heating also indicates additional socio-economic factors -like the high rate of home-ownership and the limited uptake of efficient technologies- influencing energy use at the household level (Eurostat, 2022).

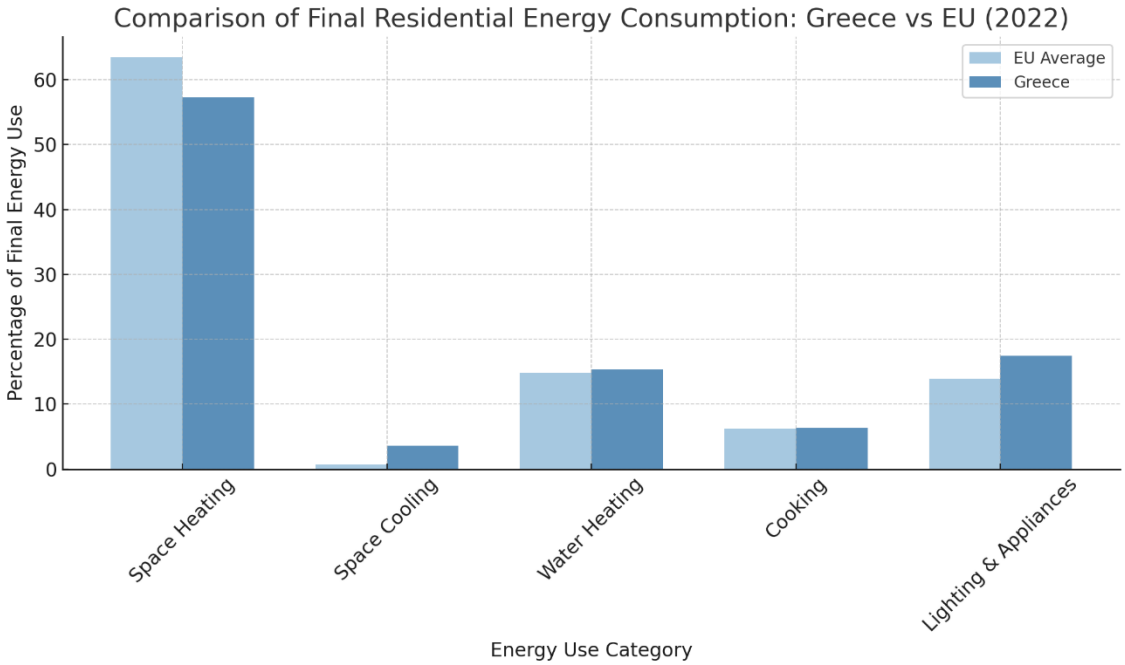

***Figure 1**: Comparison of residential energy use in Greece and the EU (2022)*

Recent patterns in energy consumption indicate an escalating dependence on electricity, especially for cooling needs (Eurostat, 2024). During the winter months, heating remains the dominant component of energy consumption in Greek households, accounting for approximately 57.1% of their total energy use. Heating oil, utilised by 46.7% of households, continues to have the highest penetration in the Greek market, followed by biomass such as wood (29.0%), primarily consumed in rural and less urbanised areas, and natural gas (16.9%), which is increasingly prevalent in major cities (Eurostat, 2024). The Mediterranean climate of Greece, marked by hot and arid summers, has resulted in a notable increase in the use of air conditioning systems, which now represent a significant portion of residential energy consumption, as is shown in **Figure 1** (Kotsila & Polychronidou, 2021).

However, recent years have seen a gradual transition toward Renewable Energy Sources (RES) and heat pumps, driven largely by increasing energy prices, especially significant spikes in oil and natural gas costs, exacerbated by the Russian invasion in Ukraine in early 2022. These geopolitical events disrupted global energy markets, drastically elevating energy costs across Europe, including Greece, and highlighting the vulnerabilities of

dependence on fossil fuels. Consequently, households have increasingly explored alternative, renewable solutions, supported by governmental incentives and subsidies aimed at reducing reliance on traditional fossil fuels. (Fameli et al., 2021). Nevertheless, ongoing economic challenges, initially triggered by the 2008 financial crisis and recently compounded by persistent inflation and rising living costs, have limited the capacity of many Greek households to invest in these energy-efficient upgrades (Chatzikonstantinou et al., 2023). The sustained high prices of oil and natural gas have deepened energy poverty among lower-income groups. As energy becomes less affordable, households are forced to reduce consumption, negatively impacting their overall living standards and economic well-being (Papada & Kaliampakos, 2020).

These economic pressures and energy affordability challenges are experienced differently across Greece, reflecting regional variations in housing and socioeconomic structures. Specifically, the diversity in housing types, urbanisation patterns, and socioeconomic conditions significantly shapes energy consumption behaviors and presents distinct challenges for policy implementation. In urban centers like Athens and Thessaloniki, one can observe a prevalence of closely situated apartment complexes that utilise shared energy systems (Chatzikonstantinou et al., 2022b). In contrast, rural regions are characterised by independent homes that typically employ individualised energy solutions (Fameli et al., 2021).

Additionally, socio-economic variables, including household income and energy pricing, significantly influence energy usage. Household income positively correlates with electricity demand, as higher income levels accelerate the purchase and use of electrical appliances and services, subsequently increasing overall electricity consumption (Poblete-Cazenave & Pachauri, 2021). Conversely, the price of electricity negatively affects demand, with higher prices prompting households to reduce their consumption to manage costs (Kotsila & Polychronidou, 2021). Energy poverty is a critical concern, as many low-income families struggle to afford sufficient heating or to invest in energy-efficient technologies (Chatzikonstantinou et al., 2022b). This situation highlights the necessity for targeted policy measures aimed at assisting vulnerable groups and fostering equitable advancements in energy efficiency, ultimately enabling households to achieve substantial reductions in their overall energy consumption, improve affordability, and enhance their quality of life. Finally, behavioural factors, particularly public awareness and perceptions regarding energy consumption, play a crucial role in influencing consumption patterns (Brown et al., 2023).

While these patterns highlight how energy is consumed in Greek households, they also point to deeper economic, structural and behavioural challenges. Understanding these factors is key to explaining why energy efficient practices are not widely adopted, despite their long-term savings. Even as awareness of the benefits of energy efficiency grows, behavioural inertia, habits, and scepticism towards new technologies and their effectiveness often prevent households from adopting energy-efficient solutions. Additionally, a lack of sufficient knowledge about available incentives and limited trust in institutional frameworks further hinder proactive engagement in energy-saving activities (Vogiatzi et al., 2018). Apart from behavioural factors, structural and financial barriers also significantly impede the adoption of energy-efficient technologies (Carlander & Thollander, 2023). High upfront costs associated with retrofitting homes and purchasing efficient appliances remain a significant obstacle, compounded by limited

access to affordable financing options. Furthermore, bureaucratic hurdles, including complex application processes and lengthy procedures to access governmental incentives, discourage households from undertaking energy efficiency upgrades (Peñasco, 2024).

1.2.1. Key Characteristics of Greece's Residential Sector

1.2.1.1. Energy production and demand in Greece

Understanding the national energy production and supply mix is essential for examining the energy performance of Greece's building sector. Greece's overall energy requirements are largely met through the importation of fossil fuels, including oil and natural gas, which remain widely used in all sectors, including residential and commercial buildings. In parallel, the country has historically depended on domestically produced lignite, especially for electricity generation. However, domestic lignite production has been in steady decline—from 314 petajoules (PJ) in 2011 to just 60 PJ in 2021—as part of Greece's ongoing decarbonisation strategy (**Figure 2**) (IEA, 2023). At the same time, domestic renewable energy production has seen significant growth, increasing from 86 PJ to 136 PJ between 2011 and 2021. This growth is primarily driven by the expansion of wind and solar photovoltaic (PV) capacity, which directly contributes to cleaner electricity available for the building sector.

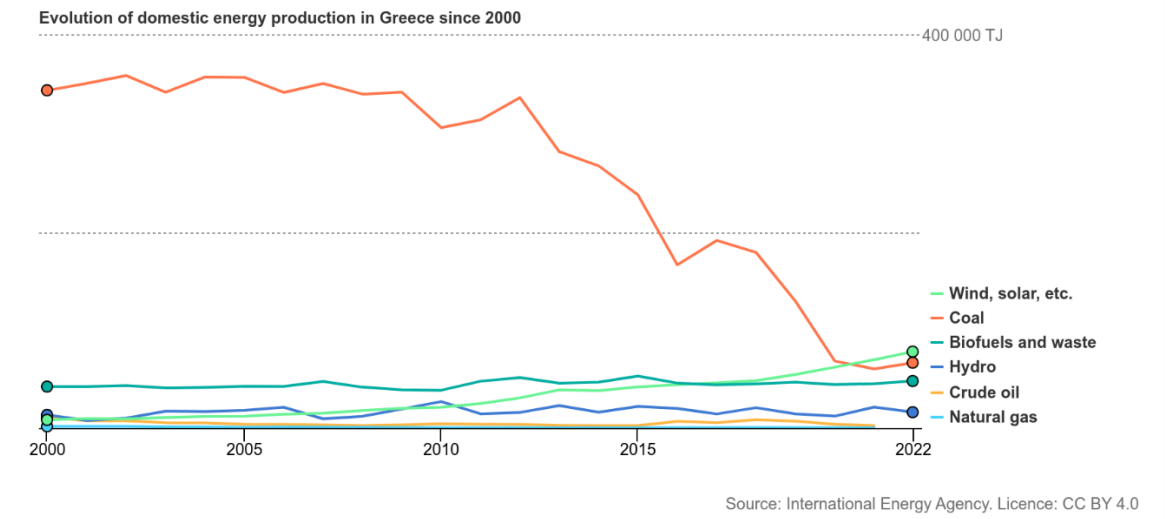

Figure 2: *Evolution of domestic energy production in Greece since 2000 (IEA Data Services)*

In 2021, the building sector ranked among the three most energy-intensive sectors in Greece—alongside transport and industry (**Figure 3**). Approximately 37% of energy consumption in buildings came from electricity, while oil remained a major source for space heating, covering 27.3% of the sector's energy demand (Eurostat, 2022). Notably, Greece has achieved considerable progress in integrating solar thermal systems in buildings, thanks to decades of favourable policies. As a result, 5.1% of building energy demand was met through solar thermal energy in 2021—substantially higher than the average of 0.6% among International Energy Agency (IEA) member countries[1]. These trends highlight the growing potential of cleaner energy sources in reducing the carbon footprint of buildings, but also underline the continued dependence on imported and carbon-intensive fuels, particularly in residential heating (IEA, 2023).

[1] As of April 2025, the IEA comprises 32 member countries: Australia, Austria, Belgium, Canada, Chile, Colombia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea (Republic of), Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

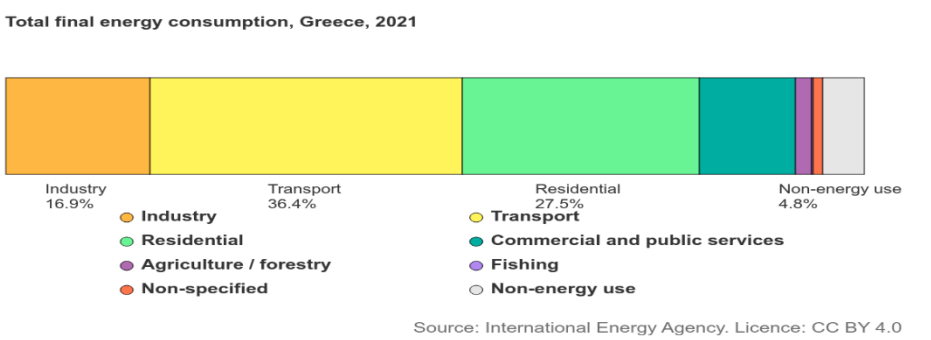

Figure 3: *The total final energy consumption in Greece for 2021*

1.2.1.2. The Greek Residential Sector

Residential structures are the predominant component of the Greek building stock, accounting for nearly 95% (**Table 1)** of the total number of buildings nationwide. This composition of the building stock is documented in the 2020 long-term building renovation strategy report for Greece—set to guide renovations through 2050—which uses 2015 as the reference year. According to the data, the remaining 5% of the building stock comprises non-residential buildings serving the tertiary sector, including retail spaces (1.4%), office buildings and other facilities (1.1%), healthcare establishments such as hospitals and clinics (0.8%), accommodations like hotels (0.5%), and educational institutions including schools (0.4%) (Hellenic Ministry of Environment and Energy, 2020). This strong residential dominance underscores the importance of prioritising energy efficiency improvements in homes as part of Greece's long-term renovation and sustainability efforts.

Table 1: *Total number of buildings and their use (for the year 2015)*

Building Use	***Number of Buildings***
Residential Buildings (1)	
Residences	4.631.528
Tertiary Sector (2)	
Hotels and other accommodations	24.109
Educational Institutions	19.167
Office buildings and other facilities	53.064
Healthcare establishments	38.664
Others	86.639
Total (1) +(2)	**4.853.172**

1.2.1.3. Age Classification of Buildings in Greece

The classification of buildings in Greece is established in accordance with prevailing legislation and is segmented into four periods. This segmentation is based on (a) *the legislative framework* applicable at the time of construction and (b) the *technologies utilised* for electromechanical installations and building envelopes. The Thermal Insulation of Buildings Regulation (TIBR)[2], enacted in 1979, set forth Greece's first mandatory requirements for the thermal insulation of buildings, which had previously been left to the discretion of architects and builders. Specifically, the TIBR introduced prescriptive U-value limits for walls, roofs, floors, and windows, varying by climatic zone, along with basic guidelines for the design and placement of insulation materials. This marked a significant shift from prior construction practices, where thermal performance had not been codified. The TIBR became the basis for defining thermal adequacy in building design and is used to delineate building age categories. This framework was subsequently revised with the introduction of the Regulation on the Energy Performance of Buildings (K.EN.A.K), which came into effect in 2010 and was amended in 2017 to incorporate broader energy performance metrics. The initial categorisation spans a twenty-year period leading up to 2000, with subsequent decades being assessed thereafter. The current age classifications that encompass the entire building stock and are as follows:

- Buildings for which permits were **issued prior to 1980**, thus predating the TIBR.
- Buildings with permits **issued between 1981 and 2010**, before the establishment of the K.EN.AK.
- Buildings with permits **issued from 2011 to 2017**, under the initial version of K.EN.AK and before its revision.
- Buildings with permits **issued from 2018 onward**, following the revision of K.EN.AK (Hellenic Ministry of Environment and Energy, 2020).

According to the 2011 building census data, the bulk of the building stock was constructed before 1980, categorising these structures as thermally unprotected, as illustrated in **Figure 4**. The majority of these structures lack thermal insulation, with the exception of a few that feature insulation on the roof, leading to significant thermal losses and energy inefficiency, especially during the winter months. Furthermore, the electromechanical systems, unless updated, utilise outdated technology, resulting in suboptimal energy efficiency. The construction materials typically employed in these buildings, such as concrete and masonry, are known for their durability; however, they frequently do not conform to modern thermal performance standards (Technical Chamber of Greece, 2017; Theodoridou et al., 2011).

Buildings constructed before the introduction of thermal regulations continue to dominate the urban landscape and are characterised by disproportionately high heating demand. Although newer constructions—built under more stringent energy standards—tend to perform better in terms of final thermal energy consumption (kWh/m²·a), these gains are often undermined by a rise in electricity demand, primarily linked to increased use of air conditioning (Technical Chamber of Greece, 2017). Overall, the actual final specific heat energy consumption in Greek buildings exceeds the European average, despite Greece's

[2] https://www.elinyae.gr/sites/default/files/2019-07/362d_79.1317112513734.pdf

relatively mild climate. This discrepancy stems from both poor energy management practices and construction methods that fail to meet essential technical specifications (Technical Chamber of Greece, 2017).

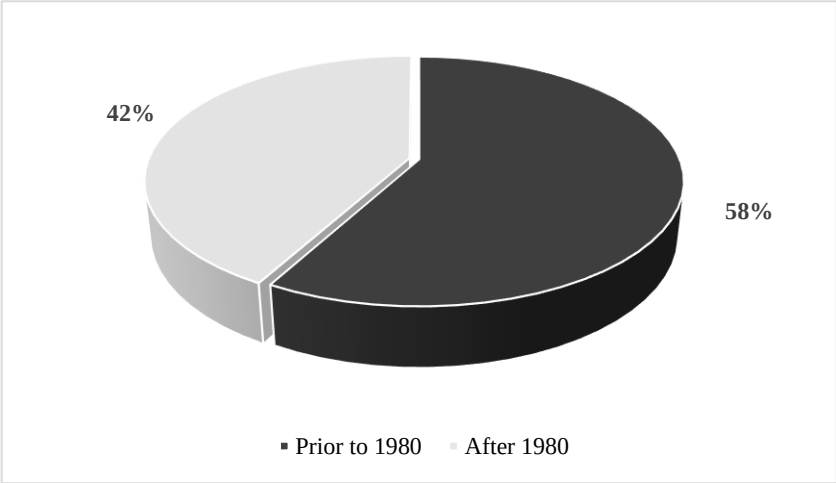

Figure 4: *Buildings by construction period (Technical Chamber of Greece, 2011)*

1.2.1.4 Climatic, Structural, and Socio-Economic Factors Influencing Residential Energy Use in Greece

The classification of Greece's climate highlights the intricate energy requirements within its residential sector. The nation is categorised into four climatic zones, labelled A through D, where Zone A includes the warmer areas and Zone D covers the colder, mountainous regions (**Figure 5**). This climatic diversity calls for tailored energy strategies; for instance, Zone D faces increased heating requirements in winter, whereas Zone A encounters substantial cooling demands in summer (Technical Chamber of Greece, 2017b).

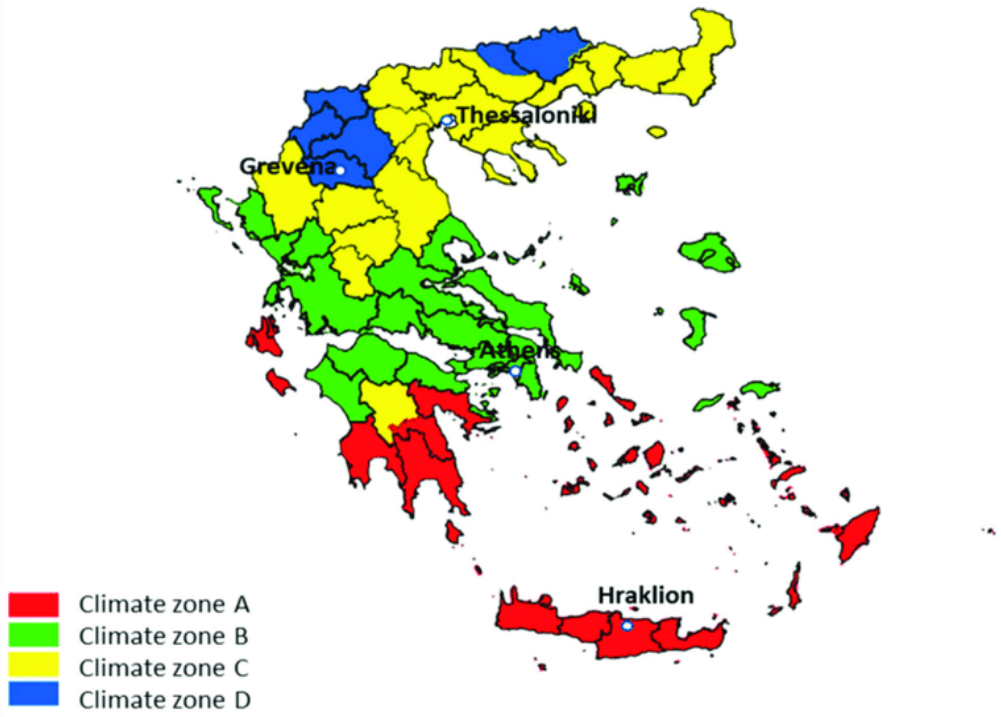

Figure 5*: Climate zones in Greece as defined by the national Regulation for Energy Performance of Buildings (K.EN.A.K)* ***(Tsoka et al., 2020)***

Structural and ownership patterns in Greek housing also influence how energy is consumed. In urban centers such as Athens and Thessaloniki, densely built apartment complexes are predominant, while rural and suburban areas consist largely of detached homes. These typologies significantly shape heating and cooling behaviours as well as the choice and configuration of energy systems. For example, apartment buildings often rely on shared or central heating systems, which can lead to underheating or inefficient operation when consensus among co-owners is lacking (Papada & Kaliampakos, 2020). Conversely, detached houses typically use individual heating and cooling systems, allowing for greater autonomy but often resulting in higher energy use if the building is poorly insulated. In rural areas, it is also more common to find biomass-based systems such as wood stoves, whereas urban dwellings more frequently use electricity or oil-based heating (Fameli et al., 2021). Moreover, Greece has one of the highest homeownership rates in Europe—exceeding 70% (Eurostat, 2021), —which can either facilitate or limit investments in energy-saving upgrades, depending on household income and awareness levels.

Socio-economic variables, especially the lingering impacts of the energy price crisis and persistent levels of energy poverty, further shape energy consumption. Households with limited financial resources often reduce heating or cooling use, leading to underconsumption and poorer living conditions (Papada & Kaliampakos, 2020). These realities highlight the importance of considering both climatic and socio-economic diversity when assessing energy usage patterns in the Greek residential sector.

2. Policies in Action: Reviewing Greece’s Residential Energy Efficiency Landscape

2.1.Evolution of Greece’s Energy Supply Landscape

In the last fifty years, Greece's energy system has undergone a significant change, moving away from a centralised, lignite-dependent model and toward one that increasingly embraces regional interconnections, market liberalisation, and RES. These shifts in Greece’s energy landscape have not only changed how energy is produced and distributed but have also created the conditions under which energy efficiency policies became increasingly relevant. As energy prices rose, environmental concerns intensified, and the energy mix diversified, improving end-use efficiency—especially in households—emerged as a necessary complement to broader supply-side reforms.

In the 1970s and 1980s, Greece's energy landscape was predominantly characterised by the utilisation of domestic lignite resources. This period saw the establishment of large-scale lignite-fired power plants, which provided an affordable and reliable energy source, fuelling industrial growth and supporting economic development. The Public Power Corporation (PPC), a state-owned entity, held a monopoly over electricity generation and distribution, ensuring centralised control over the energy sector (Sargentis et al., 2024).

The 1990s marked the beginning of significant policy reforms aimed at liberalising the energy market. In alignment with European Union directives, Greece began liberalising its electricity market with the enactment of Law 2773/1999, which transposed Directive 96/92/EC into national legislation (Danias et al., 2013; Iliadou, 2009). This reform aimed to create a competitive electricity market and led to the establishment of the Regulatory Authority for Energy (RAE) in 2000. It also introduced the Hellenic Transmission System Operator (HTSO) to ensure transparent and non-discriminatory grid access. Despite these legal reforms, the market remained highly concentrated, with the PPC continuing to dominate generation and retail markets for many years, limiting the practical impact of liberalisation. Legislative measures were introduced to unbundle the generation, transmission, and distribution segments, reducing PPC's dominance. During this decade, natural gas was introduced into the energy mix, primarily imported from Russia and Algeria, diversifying energy sources and reducing reliance on lignite (Agoris et al., 2004).

In the early 2000s, in line with EU directives, Greece set ambitious renewable energy targets—aiming for 20% of gross final energy consumption to come from RES by 2020, which was later increased under the EU's 2030 climate and energy framework. These targets aimed to reduce GHG emissions, improve energy security, and decrease dependence on imported fossil fuels. Greece implemented policies to promote wind, solar, and hydroelectric power (Iliadou, 2009). However, the economic crisis of 2008 posed challenges, resulting in reduced energy consumption and delays in infrastructure investments (the Bank of Greece, 2014).

Between 2010 and 2020, Greece implemented a series of policy reforms aimed at scaling up renewable energy deployment (Bitzenis et al., 2018). Notable changes included the replacement of fixed feed-in tariffs with feed-in premiums to better reflect market dynamics and reduce overcompensation (Doulos et al., 2019; Xydis & Vlachakis, 2019). National support schemes were also restructured to comply with the EU Renewable

Energy Directive, introducing competitive auctions for new RES capacity allocation. While economic instability slowed progress in some years, the post-2015 period saw renewed investment, particularly in small-scale solar PV systems and large-scale wind project (Norton Rose Fulbright, 2016).

In 2022, in response to soaring global energy prices—exacerbated by the Russian invasion in Ukraine—Greece introduced temporary fiscal interventions, such as a 90% windfall tax on energy companies' excess profits (European Commission, 2023b). Although not a structural policy tool, this measure aimed to shield consumers from price volatility and highlighted the increasing urgency of reducing household energy dependence on expensive fossil fuels.

The residential sector is directly impacted by these changes in energy production, supply, and market structure. The cost and carbon intensity of the supply have an effect on the affordability and environmental performance of homes as electricity becomes a more significant source of energy for households, especially for appliances, heating, and cooling.

2.2. Evolution and Implementation of Energy Efficiency Policies in the Greek Residential Sector

In parallel with supply-side reforms, Greece has steadily developed a comprehensive and increasingly sophisticated regulatory and policy framework for promoting energy efficiency particularly in the residential sector. This evolution has been shaped both by internal socio-economic and environmental priorities and by the requirements of successive EU directives. As part of its obligations under the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED), Greece has transposed key legislative provisions into national law, gradually shifting from basic thermal insulation standards to a more comprehensive, performance-based, and consumer-oriented approach.

The first milestone came in 1979 with the introduction of the TIR, enacted through **ΦΕΚ 362/Δ/1979**. This regulation for the first time introduced legally binding minimum requirements for the thermal transmittance (U-values) of key building components—walls, roofs, floors, and openings—tailored to four national climate zones. The TIR was Greece's first attempt to regulate building energy performance, despite uneven enforcement and the fact that many older buildings were still uninsulated.

Following the implementation of the **EU EPBD in 2002 (Directive 2002/91/EC),** a more organised policy framework started to take shape. **Law 3661/2008**, the result of the national response, established, among others, the framework for a performance-based assessment of buildings and mandated the issuance of Energy Performance Certificates (EPCs for all newly constructed, sold, or rented buildings, including residential properties over 50m², in line with the requirements of the EPBD. Although the legal framework was introduced in 2008, the obligation for EPCs became operational following the adoption of K.EN.A.K in 2010, which formalised performance benchmarks and assessment procedures. They categorised buildings into energy efficiency groups ranging from A+ to G after evaluating primary and final energy consumption.

In 2010, the implementation of the **K.EN.A.K** through **Ministerial Decision Δ6/Β/οικ. 5825/2010** marked a pivotal turning point. K.EN.A.K expanded on the TIR by adopting

a holistic energy efficiency model. It introduced detailed methodologies for calculating building energy performance, set minimum requirements for both the building envelope and electromechanical systems (HVAC, DHW, lighting), and required energy studies and simulations for new building permits. K.EN.A.K also formalised the reference building concept used in EPC benchmarking. In the years following its introduction, K.EN.A.K has been periodically updated to reflect changes in EU legislation, ensuring that national standards for building performance remain aligned with European energy efficiency objectives. In 2018, K.EN.A.K was revised to comply with the amended **EPBD (Directive 2010/31/EU)**. This update introduced binding requirements for Nearly Zero Energy Buildings (NZEB). More specifically from 2019, all new public buildings had to meet NZEB standards; from 2021, the same applied to all new residential buildings. The revised regulation tightened performance thresholds, mandated on-site renewable energy generation, and promoted the adoption of smart readiness technologies and advanced controls.

In parallel, Greece introduced the **Energy Efficiency Obligation Scheme (EEOS)** in 2017 to fulfil its national energy savings target under Article 7 of the **EED (2012/27/EU)**. The scheme requires energy providers to achieve specific annual savings by implementing or funding measures that improve energy efficiency in end-use sectors. These savings are primarily achieved through measures such as thermal insulation, boiler replacements, heat pump installations, and energy-efficient lighting — particularly in the residential sector.

The ongoing alignment of national policy with EU legislation is reflected in the **transposition of the revised EPBD (EU/2024/1275)** and **EED (EU/2023/1791)** into Greek law. The recast EED and EPBD establish ambitious targets for enhancing energy efficiency and decarbonising the building sector across the EU. Under the EED, Member States are mandated to significantly elevate their annual energy savings rate, progressively rising from the current 0.8% of final energy consumption to 1.9% by 2028 (EU/2023/1791). This progression represents an average annual increase of 1.49% over the period from 2024 to 2030, underscoring the urgency of implementing robust measures to achieve these targets. Greece's housing stock is dominated by older, inefficient buildings, so the EED's requirements highlight how urgent it is to expedite retrofitting and put energy-saving measures in place nationally. Along with introducing provisions for improved consumer empowerment through digital tools and advisory services, the directive also emphasises the significance of energy audits. In Greece, this legislative foundation has been directly incorporated into the updated **National Energy and Climate Plan (NECP)**.

2.3. The Updated NECP and National Implementation Framework

The revised NECP, published in August 2024, serves as the central planning document for Greece’s energy and climate strategy through 2030. While earlier versions focused on broad emissions reductions and renewable energy expansion, the 2024 update introduces a clearer sectoral focus—particularly on the building sector, one of the country’s largest energy consumers. The plan reaffirms Greece’s commitment to cutting GHG emissions by 55% by 2030 (compared to 1990 levels), while scaling up both renewable energy deployment and energy efficiency measures.

Within the residential sector, the NECP prioritises the reduction of final energy consumption, with a particular focus on buildings in the lowest EPC classes. It introduces mandatory MEPS for residential buildings, new obligations for energy suppliers under the EEOS, and enhanced financial support for low-income and energy-poor households. These efforts are supported by streamlined procedures, digital tools (such as EPC databases), and clear renovation targets—including the annual renovation of 3% of public building floor area and expanded deep renovation rates in the private housing stock (Hellenic Ministry of Energy and Environment, 2024).

In terms of implementation, the NECP recognises the central role of national schemes like ***Exoikonomo***, "***I Change My Water Heater***", and other appliance-focused initiatives. These programmes are designed to reduce household energy demand while improving indoor comfort, lowering energy bills, and addressing energy poverty—particularly in vulnerable or underserved communities.

The financial and economic underpinnings of the plan also highlight increased investment needs. Despite these measures, electricity costs are expected to remain relatively high in the near future due to significant investments in renewable technologies and infrastructure. (Hellenic Ministry of Environment and Energy, 2024). This revised plan represents a balancing act between ambition and practicality, reflecting both Greece's commitment to EU climate targets and the challenges of navigating financial and technological constraints. It provides a roadmap for Greece's transition toward a more sustainable and decarbonised energy system while acknowledging areas where goals had to be recalibrated.

2.4. An Overview of Policy Measures

Energy efficiency is recognised as the primary strategy for enhancing energy security and addressing climate change. In light of the recent energy crisis, Greece has a significant opportunity to prioritise the implementation of energy efficiency initiatives aimed at decreasing reliance on fossil fuels. This approach promises immediate advantages for energy security while also supporting the overarching objective of achieving carbon neutrality in the long run. In response to the global energy crisis of 2022, the Greek government unveiled exceptional measures in September 2022 aimed at reducing energy consumption by 10% in the short term and by 30% by 2030. These targets will be pursued through the introduction of new initiatives within the public sector, as well as the enhancement of existing programs (Mezartasoglou, 2024).

With an emphasis on different aspects of energy consumption and efficiency improvements, Greece's energy efficiency policies fall into a number of different categories. These regulations aim to address structural inefficiencies in the building industry, promote shifts in household consumer behavior, and ease the use of energy-efficient technologies. These policies fall into the primary areas listed below.

2.4.1. Building Codes and Performance Standards

A fundamental policy instrument for enhancing energy efficiency in Greece is the implementation of national building energy codes, aligned with EU legislation. The cornerstone of this framework is K.EN.AK, introduced in 2010 through Ministerial Decision Δ6/Β/οικ.5825/2010, which transposed the first EU EPBD 2002/91/EC into

Greek law. This regulation replaced the older TIR of 1979, which focused solely on heat transfer coefficients (U-values) of individual building components without a broader assessment of overall energy performance (Gaglia et al., 2019).

K.EN.AK introduced a comprehensive performance-based framework, establishing minimum energy performance requirements for new buildings and major renovations. These include standards for insulation, windows, HVAC systems, and lighting, all evaluated within a holistic building envelope. A key innovation introduced by K.EN.AK is the energy classification system, which categorises buildings into nine energy classes (A+, A, B+, B, C, D, E, F, G) based on their calculated primary energy consumption relative to a predefined reference building that meets the minimum legal performance requirements (Change, 2010). Both new constructions and buildings undergoing substantial renovation are required to meet at least a Class B rating, although specific exemptions may apply.

In the residential sector, this classification accounts for energy use associated with space heating, cooling, and domestic hot water (DHW). Most Greek buildings constructed before 1980—prior to any regulatory thermal standards—are typically rated in the G to D range, reflecting their poor envelope performance and outdated mechanical systems. Buildings constructed after the TIR but before K.EN.AK generally fall within Class E to C, depending on their construction quality and upgrades (Gaglia et al., 2019).

As part of Greece's compliance with the EPBD, K.EN.AK also introduced the EPC, which became mandatory for nearly all real estate transactions, including sales and new leases. EPCs serve as both compliance instruments and informational tools, displaying the building's energy class and identifying improvement recommendations. Initially, EPCs were required only for buildings over 50 m², but this threshold was gradually removed. As of 2016, approximately 13% of residential buildings in Greece had been issued an EPC (The iBRoad Project, 2018). EPCs are not required when a lease is renewed with the same tenant, though they are needed for new rental contracts.

2.4.2. Financial and Fiscal Incentives

2.4.2.1. The Exoikonomo programme

The "*Exoikonomo*" programme is Greece's flagship residential energy efficiency initiative, aligned with the EU's climate and energy objectives under directives such as the EED and the EPBD. The programme has been implemented in successive waves since 2011, supported through EU Structural Funds, national resources, and more recently the Recovery and Resilience Facility (RRF). Its objective is to reduce final energy consumption, GHG emissions, and energy poverty through targeted energy efficiency interventions in residential buildings.

Phase I – Exoikonomisi Kat' Oikon (2011–2013)

This initial phase was launched in February 2011 and targeted owner-occupied primary residences with low energy efficiency. It provided subsidies of up to 70% and interest-free loans, based on income eligibility (FEK/54/26.01/2011). Eligible interventions included:

- Thermal insulation (roofs, walls, floors)

- Window and door replacement
- Heating and cooling system upgrades
- Solar water heater installations

The programme was implemented through commercial banks, which co-financed two-thirds of the loan, and was financed by both national resources and ERDF, with a budget of €396 million. It was co-managed through the *Exoikonomo Kat' Oikon* Holding Fund (Hellenic Ministry of Environment and Energy, 2011). Applications exceeded available funding, prompting further reallocation of resources in 2016 to address thousands of pending submissions[3].

Phase II: Exoikonomisi Kat' Oikon II (2014–2020)

The second phase of the programme, officially launched under the name "*Save Energy at Home II*" (***"Exoikonomisi Kat' Oikon II")***, was designed as a refined continuation of the first, incorporating feedback and lessons from the 2011–2013 period. Its design reflected a stronger emphasis on strategic energy goals: the reduction of residential energy consumption, the mitigation of greenhouse gas emissions, and the promotion of environmental sustainability.

Eligibility criteria were broadened to include single-family homes, entire apartment buildings, and individual flats, provided they were used as primary residences and legally owned by private individuals. Vacation homes were excluded. The financial structure combined non-repayable grants with optional subsidised loans, disbursed under favourable conditions through the "*Saving II*" Fund, operated by the Hellenic Development Bank (HDB). Loans came with 100% interest subsidy, no mortgage requirement, and durations ranging from four to six years, although a personal guarantee could be required for higher risk categories (Iatridis et al., 2024).

A major innovation was the restructuring of the income classification system, expanding it from three categories in the previous phase to seven income brackets. This reclassification allowed for more equitable distribution of funds, offering higher grant rates to lower-income households. In contrast, wealthier households were incentivised through more ambitious energy savings targets (up to 70%) and conditional loan structures. Importantly, for most categories, the loan was optional—required only for Category 7—thus giving applicants greater flexibility in financing their share of the costs (European Commission, 2025).

All projects were required to undergo two energy inspections—before and after renovation—by licensed energy inspectors selected via lottery from the Technical Chamber of Greece. The costs of both EPCs were fully covered by the programme. Eligible interventions included insulation, window replacements, heating and cooling upgrades, and the installation of systems such as solar water heaters or heat pumps. Ceilings were introduced on cost coverage per type of intervention to control budget allocations (European Commission, 2025).

[3] https://www.taxheaven.gr/news/30694

To facilitate transparency and accelerate implementation, the programme required that contractors and suppliers be paid directly through participating banks, eliminating the need for beneficiaries to manage large payments themselves. Consultants' fees were also reimbursed under the programme. One of the most notable changes from the previous phase was the increase in the maximum eligible expenditure per household, rising from €15,000 to €25,000. This change was critical in making the programme more attractive and impactful, particularly for deeper renovations. Despite administrative advances, the complexity of the financial instrument and broader macroeconomic challenges—such as the COVID-19 pandemic—slowed project uptake. By early 2023, the absorption rate was reported at below 50%, prompting an extension of the implementation period (European Commission, 2025).

In summary, *Exoikonomisi Kat' Oikon II* marked a significant improvement in design, equity, and administrative efficiency, while continuing to serve as a cornerstone of Greece's strategy for decarbonising the residential sector.

Phase III: Exoikonomo-Autonomo (2020–2021)

The third iteration of the programme, branded as "*Exoikonomo-Autonomo*," represented a strategic pivot toward not only improving energy efficiency but also fostering household energy autonomy. It was developed in response to growing EU-level emphasis on integrating RES into buildings and deploying smart energy solutions. In this context, the programme broadened its eligible interventions beyond traditional energy-saving measures to include the installation of photovoltaic systems, battery storage, smart meters, and other energy management systems. *Exoikonomo-Autonomo* targeted both urban and rural households, offering differentiated levels of financial support based on income, energy consumption, and social criteria. It introduced greater flexibility for beneficiaries to combine traditional building envelope improvements—such as insulation and window replacements—with more technologically advanced interventions (Hellenic Ministry of Environment and Energy, 2020).

The programme continued to be funded by national resources and RRF under the 2014–2020 programming period, but placed renewed emphasis on modernising the residential energy landscape, especially through the uptake of decentralised renewable energy systems. While the administrative platform remained largely consistent with the prior phase, the technical requirements were updated to reflect newer EU performance standards and encourage deeper, more comprehensive renovations.

Phase IV: Exoikonomo 2021 (under Greece 2.0 Recovery and Resilience Plan)

The ***Exoikonomo 2021*** programme marked a turning point in both scale and ambition. As part of Greece's National Recovery and Resilience Plan (Greece 2.0), it was co-financed by the RRF. This phase introduced a significantly larger budget—estimated at €957 million—with the aim of supporting a much broader segment of the population and achieving tangible progress toward EU energy and climate goals (Hellenic Ministry of Environment and Energy, 2021). Of this budget, €100 million were to be allocated exclusively to vulnerable households (Piraeus Group, 2021).

Unlike earlier iterations, *Exoikonomo 2021* placed a strong focus on social and geographic equity, offering priority access and increased support levels for vulnerable

households, disaster-affected regions, large families, and persons with disabilities. Beneficiaries could receive grants of up to 75%, combined with interest-free loans, while the programme also covered auxiliary costs such as EPC issuance, technical consulting, and project management services (Hellenic Ministry of Environment and Energy, 2021).

The scheme also introduced several procedural improvements, including the option of advance payments to suppliers, covering up to 70% of project costs (Hellenic Ministry of Environment and Energy, 2021). This aimed to alleviate liquidity constraints often faced by households and contractors, thereby accelerating implementation timelines. In line with EU guidance, the programme reinforced the requirement for post-intervention EPCs, enabling performance tracking and aligning the disbursement of funds with demonstrated energy improvements. *Exoikonomo 2021* underscored a deeper integration of climate, social, and economic policy, making it a flagship initiative not just for building renovation, but for Greece's post-pandemic recovery and green transition.

Current Phase: Exoikonomo 2025

The most recent iteration, *Exoikonomo 2025*, builds on the infrastructure and lessons of previous programmes while incorporating new strategic priorities and digital tools. With the *Exoikonomo 2025* programs, an additional 15,000 homes are expected to be upgraded in 2025. The total approved budget for *Exoikonomo 2025* is €434 million, with €396.1 million allocated for direct financial aid to beneficiaries. Of this, €27.38 million is earmarked for households with disabled members, €91.27 million for households in disaster-affected regions, with €54.76 million specifically allocated to vulnerable households in these regions. Additionally, €18.25 million is designated for large families with three or more dependent children. Beyond direct grants, the program also allocates €34 million for interest rate subsidies on loans for beneficiaries, further supporting energy efficiency investments (Hellenic Ministry of Environment and Energy, 2025).

The programme maintains the structure of grants combined with interest-free loans, but places a stronger emphasis on transparency, simplification, and digitalisation. The application process is fully hosted on a dedicated platform (https://exoikonomo2025.gov.gr/), which includes tools for budget estimation, contractor matching, and real-time progress tracking. Eligibility continues to be based on income tiers, energy demand, and property characteristics. In addition to traditional interventions—such as insulation, energy-efficient windows and doors, heating/cooling system upgrades, and solar water heaters—Exoikonomo 2025 also encourages integrated packages that combine multiple interventions for deeper renovations. Particular care has been given to avoid overpricing, ensure use of certified products, and discourage undeclared labor, thus reinforcing accountability across all stages of implementation (Hellenic Ministry of Environment and Energy, 2025).

The programme supports Greece's updated NECP and is expected to play a key role in delivering residential sector targets under the European Green Deal and the Renovation Wave initiative.

2.4.2.2. Complementary Programmes: Appliance and Equipment Replacement Schemes

In addition to the core *Exoikonomo* programme, the Greek government has introduced several targeted subsidy schemes aimed at improving household energy efficiency through appliance and equipment replacement. These programmes serve as low-barrier entry points for energy savings, particularly for households unable to undertake large-scale renovations.

One such initiative is the "***Recycle – Replace Your Appliance***", which subsidises the replacement of energy-intensive household appliances such as refrigerators, air conditioners, and freezers with newer, more energy-efficient models. Applicants are selected based on income criteria and household composition, with priority given to vulnerable groups. The programme not only promotes energy savings but also supports the circular economy by requiring recycling of the old appliance as a condition for receiving the subsidy (Hellenic Ministry of Environment and Energy, 2023).

Another targeted residential energy efficiency initiative is the "***I Change My Water Heater***" programme, which provides direct subsidies for the replacement of conventional electric water heaters with solar thermal systems. With a total budget of €223.2 million, the scheme is part of Greece's wider strategy to curb electricity demand and accelerate the adoption of renewable energy technologies at the household level. Applicants must be Greek residents whose primary residence currently uses an electric water heater, and they must meet defined income-based eligibility criteria. The programme prioritises vulnerable and low-income households, offering subsidies of 60% to 65% of eligible costs, with higher support granted to larger families, recipients of social welfare benefits, and energy-poor households. The subsidies cover both the purchase and installation of certified solar water heaters (minimum capacity: 150 litres), provided that all technical specifications regarding energy efficiency and safety are met. Additionally, participation requires the proper disposal and documented recycling of the old electric water heater, a measure aimed at preventing secondary market recirculation and supporting environmental goals. Applications are submitted through a dedicated digital platform and are processed on a first-come, first-served basis. By promoting decentralised solar heating and reducing dependence on electric water heating — a major component of residential electricity demand in Greece — the programme supports national decarbonisation goals and complements broader efforts such as the Exoikonomo and the EEOS (Hellenic Ministry of Environment and Energy, 2024c).

Both programmes are co-financed by national resources and European Union funds, including the RRF. They are implemented through dedicated digital platforms and supported by certified supplier networks to ensure transparency, quality assurance, and equitable access. By complementing the *Exoikonomo* framework, these schemes expand the reach of energy efficiency policy to households that might otherwise be excluded due to financial, structural, or administrative barriers.

2.4.2.3. The Tax Deduction Mechanism

To complement subsidy schemes such as *Exoikonomo*, the Greek government introduced **a tax deduction mechanism** to encourage private investment in energy-efficient building

upgrades. This measure, established through **Article 39B of the Income Tax Code**[4], provides an additional fiscal incentive targeting homeowners undertaking renovations not already supported by public funding programs.

1. Introduction of the Measure – Law 4646/2019

The tax deduction was initially introduced by **Article 16 of Law 4646/2019**[5] adding Article 39B to the Income Tax Code. Under this framework, 40% of eligible renovation costs related to the energy, functional, or aesthetic upgrading of residential buildings could be deducted from personal income tax, evenly distributed over four years. The deduction was capped at €16,000 per property, and only applied to works not already covered by other incentive programs. To qualify, all expenses had to be paid electronically and documented with legal invoices in accordance with Law 4308/2014.

2. Extension and Update – Law 5073/2023

In December 2023, **Law 5073/2023 (Article 31)**[6] updated the terms of Article 39B. The revised regulation maintained the €16,000 expense ceiling but extended the distribution period from four to five years, thus modifying the annual tax relief structure. It also specified that only one-third of eligible expenditure may derive from the purchase of materials, while the rest must come from services (e.g., labor, installation). This change was designed to prioritise professional services over do-it-yourself upgrades, supporting employment and quality assurance in the renovation sector. Homeowners can claim the tax deduction by declaring the expenses in their annual income tax return. The relief is spread evenly over five years and cannot exceed the income tax owed for each tax year. Any unused balance does not carry forward. The tax deduction promotes private-sector engagement in sustainable renovations beyond the scope of public programs, thereby supporting Greece's broader decarbonisation objectives[7]. It complements Greece's national energy efficiency strategy by reaching segments of the population less likely to engage.

2.4.3. Market-based mechanisms

Greece's **EEOS**, initiated in 2017, constitutes the national transposition of Article 7 of the **Energy Efficiency Directive (EED 2012/27/EU)** and was formally established through **Ministerial Decision ΔΕΠΕΑ/οικ.185116/2017**. The scheme mandates energy providers—specifically electricity, gas, and oil product suppliers with a market share exceeding 1%—to achieve specific energy savings by investing in end-use efficiency measures across various sectors, including residential, industrial, and transport. Managed by the Centre for Renewable Energy Sources and Saving (CRES), the EEOS has been instrumental in promoting energy efficiency nationwide. Since its inception, it has demonstrated significant progress (Hellenic Republic, 2022). Between 2017 and 2020, it surpassed its cumulative energy savings target of 14 PJ, achieving 61.4 PJ, thereby contributing substantially to Greece's overall energy savings goals under the EU EED. The number of obligated parties increased to 35 by 2022, reflecting the scheme's expanding influence. Overall, the EEOS has played a vital role in advancing Greece's

[4] https://www.opengov.gr/minfin/?p=12149
[5] https://www.taxheaven.gr/law/4646/2019
[6] https://www.taxlive.gr/
7 https://green-estate.gr/en/sellernews/real-estate-40-tax-bonus-for-renovation-begins

energy efficiency objectives. During the 2021–2030 period, it is expected to account for approximately 24% of the country's total cumulative energy savings target, with the remaining 76% to be achieved through ten alternative policy measures, as outlined in the revised NECP.

Under Greece's EEOS, a wide range of measures has been implemented to enhance energy efficiency in the residential sector, given its significant contribution to national energy consumption. Thermal insulation for walls, roofs, and windows has been a priority, reducing heat loss in winter and minimising cooling demands in summer. The scheme has also incentivised the installation of high-efficiency boilers, heat pumps, and solar water heaters to replace older, less efficient systems. Additionally, there has been a strong push towards replacing conventional lighting with LED technology, alongside programs encouraging energy-efficient home appliances like refrigerators, washing machines, and air conditioners (Hellenic Republic, 2022).

2.4.4. Energy Labelling and Appliance Standards

Energy Labelling and Certification are critical tools in Greece's strategy to improve energy efficiency across both the residential and consumer product sectors. By fostering transparency and raising awareness about energy consumption, these measures encourage informed decisions and drive investments in energy-efficient solutions. They align closely with EU directives, ensuring Greece remains compliant with broader EU energy goals.

EPCs, as mentioned above, are mandatory for all property sales, rentals, and significant renovations in Greece, ensuring that energy efficiency is an integral part of real estate transactions. These certificates classify buildings on a scale from **A+ (most efficient)** to **G (least efficient)** (**Figure 6**) based on their energy performance. The introduction of EPCs aims to provide consumers with clear and standardised information about the energy characteristics of properties, such as thermal insulation, heating, cooling systems, and overall energy consumption. This transparency not only helps prospective buyers or renters make informed decisions but also incentivises property owners to invest in energy upgrades to improve their building's rating and market value. Over time, this system has become a driving force for energy-efficient renovations, aligning Greece's housing sector with EU energy efficiency targets.

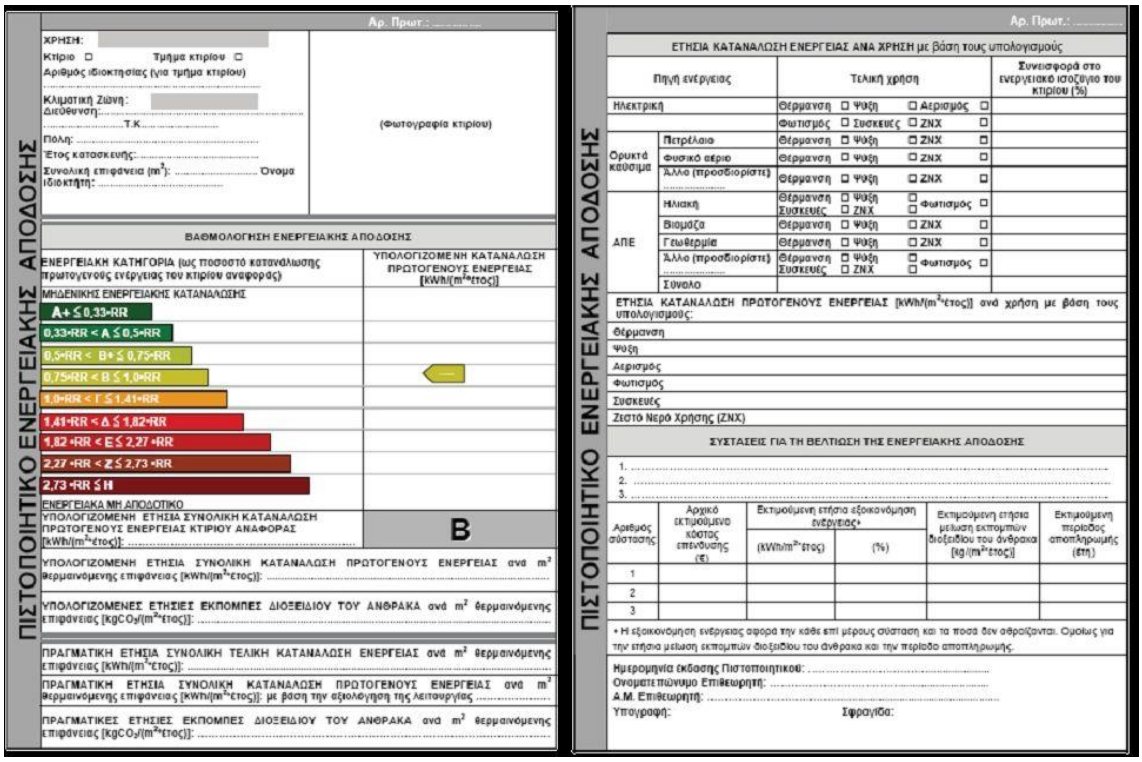

Figure 6: *The building EPC format (https://www.andrianos.gr/en/services/engineering-services/energy-certificates)*

EPCs also play a critical role in broader policy implementation, as they are often prerequisites for participation in energy efficiency subsidy programs like "*Exoikonomo*" (Hellenic Ministry of Environment, 2021). By requiring EPCs before and after energy renovation projects, the government ensures accountability and measures the real impact of interventions on energy consumption and carbon emissions. Additionally, these certificates contribute valuable data for tracking national progress towards energy efficiency goals.

Aligned with the EU's **Energy Labelling Directive**, household appliances sold in Greece are required to display standardised ***energy labels*** that rate their efficiency on a scale ranging from **A (most efficient)** to **G (least efficient)**. These labels provide essential information about an appliance's energy consumption, helping consumers identify and choose products that reduce energy use and lower utility costs. By promoting awareness about the energy efficiency of everyday items such as refrigerators, washing machines, dishwashers, and air conditioners, the labelling system supports sustainable consumer behaviour (European Union, 2022). The appliance labelling framework also drives innovation within the manufacturing sector by encouraging companies to produce more energy-efficient products to remain competitive. Furthermore, the Greek government supports these efforts with public awareness campaigns that educate consumers on the long-term cost savings and environmental benefits of energy-efficient appliances. This system, in conjunction with financial incentives like tax deductions for energy upgrades, contributes to Greece's broader goals of reducing energy consumption and transitioning to a low-carbon economy. By integrating these two mechanisms—EPCs for properties and energy labelling for appliances—Greece ensures a comprehensive approach to promoting energy efficiency across multiple sectors, ultimately supporting its national and EU-mandated sustainability objectives.

The various policy measures collectively tackle the technical, financial, and behavioural aspects of energy efficiency within Greece's residential sector. Although notable advancements have been made, obstacles such as insufficient funding, administrative inefficiencies, and fragmented property ownership continue to exist. An integrated and cohesive policy framework, along with improved financial instruments, could significantly expedite Greece's shift towards a more energy-efficient residential sector.

2.4.5. Mobilising EU Investment for Greece's Building Renovation Strategy

Greece has effectively leveraged **EU Structural and Investment Funds**, including the **European Regional Development Fund (ERDF)** and the **Cohesion Fund**, to support its ambitious energy efficiency goals. These funds play a pivotal role in financing large-scale residential energy efficiency projects, particularly focusing on urban renewal initiatives and the retrofitting of older buildings. Through these programs, Greece addresses the dual challenges of improving energy performance in its building stock and revitalising urban areas, many of which consist of aging structures with high energy demands (European Commission, 2015).

The **ERDF** plays a pivotal role in Greece's strategy to enhance energy efficiency, particularly through large-scale residential renovation programs like the Energy Savings in Existing Housing Programme (commonly known as *"Exoikonomo"*). Initially launched in 2011, the program was renewed and expanded during the 2014–2020 programming period, with a total financial envelope of €896 million—of which €567 million was ERDF funding, €117 million came from resources, and €212 million from private financial intermediaries (European Commission, 2025).

Meanwhile, the **Cohesion Fund** has played a critical role in addressing regional disparities in building energy performance by financing retrofitting projects in less-developed and economically vulnerable areas, including Western Macedonia, Eastern Macedonia and Thrace, and parts of the Aegean islands. Under the 2014–2020 programming period, Greece allocated approximately €861 million specifically to energy efficiency measures, according to a European Commission ex-post evaluation. These measures were supported through a mix of financial instruments and grants, with a unique focus on individual households rather than housing associations, distinguishing Greece's approach from other Member States. As a result, the average loan contribution was just €1,500, compared to €50,000 in countries where funds were directed primarily to housing entities (European Commission, 2023a). Looking ahead, the Cohesion Fund continues to underpin Greece's climate and energy transition goals. In alignment with RePowerEU objectives, a new investment package worth approximately €1.5 billion has been earmarked to reduce energy consumption and greenhouse gas emissions in both residential and public buildings, replace fossil fuel systems with renewable energy sources, and enhance energy autonomy at the national and regional levels.

Collectively, the ERDF and Cohesion Fund not only finance technical upgrades but also drive economic development by creating jobs in construction and energy sectors. These efforts showcase Greece's strategic use of EU funding to catalyse its transition toward a sustainable and energy-efficient future (European Commission, 2021a).

3. Evaluating the Effectiveness of Greece's Residential Energy Efficiency Policies

3.1 The Need for Policy Assessment

The implementation of energy efficiency policies in the residential sector is a crucial step toward reducing energy consumption, cutting GHG emissions, and alleviating energy poverty. However, the mere existence of policies does not guarantee their success (Belaïd et al., 2021). To ensure that these initiatives achieve their intended goals, a robust policy assessment process is necessary. Evaluating the effectiveness of Greece's residential energy efficiency policies provides insight into whether public resources are being allocated efficiently, whether the policies are producing tangible environmental benefits, and whether they are addressing socio-economic disparities in energy access (Boustan et al., 2017). A well-structured assessment also helps policymakers identify weaknesses, adjust strategies, and optimise future energy efficiency programs (Hafez et al., 2023) to better serve national and EU climate objectives.

This chapter systematically evaluates the effectiveness of Greece's residential energy efficiency policies by analysing their economic performance, environmental impact, and social implications. It examines whether financial incentives and subsidies offer tangible benefits, whether energy-saving measures are effectively reducing emissions, and whether energy efficiency programs are successfully reaching the households most in need.

3.2 Economic Performance: Are Policies Cost-Effective?

Energy efficiency policies in the residential sector are most effective when they deliver long-term economic benefits while ensuring optimal use of public funds (Wattenbach, 2024). The economic success of these policies depends on factors such as cost-effectiveness of subsidies, private sector engagement, return on investment (ROI) for homeowners, and overall market impact (Pollitt Hector, Eva Alexandri, 2017). In Greece, key financial mechanisms, including the *Exoikonomo* program, tax incentives, and EEOS, have aimed to reduce energy costs, stimulate private investment, and improve the energy performance of buildings. However, evaluating whether these policies have been truly cost-effective requires an analysis of public spending efficiency, private sector participation, and affordability for households.

Since its initial launch in 2011, the *Exoikonomo* programme has become the cornerstone of Greece's residential energy efficiency strategy. Structured across several implementation periods, it has supported the renovation and energy upgrade of over 140,000 homes, offering varying combinations of direct grants and subsidised loans tailored to income levels, regional needs, and energy consumption profiles (Hellenic Ministry of Environment and Energy, 2021). Each phase of the programme brought refinements in design, administrative processes, and financial tools, aimed at improving accessibility and efficiency.

The first two phases of the *Exoikonomo Kat' Oikon* programme demonstrated a relatively high level of cost-effectiveness, particularly in light of Greece's constrained fiscal environment during the economic crisis. The initial programme (2011–2013), with a total revised budget of €396 million (**Figure 7**), achieved full absorption of allocated ERDF

resources and financed renovations in over 50,000 homes. This phase delivered an average cost of €0.78 per kWh saved, with beneficiaries primarily located in colder climatic zones and from lower energy classes (such as G and F), where the energy-saving potential was highest (European Commission, 2025b).

The second major phase of the programme, *Exoikonomisi Kat' Oikon II* (2014–2020)**,** significantly expanded the scale and ambition of Greece's energy efficiency strategy in the residential sector. By mid-2021, the programme had supported 47,075 completed household renovations at a total cost of over €721 million, with a final target of 60,058 households to be reached by the end of its cycle. The average cost of energy saved during this phase dropped significantly to €0.57 per kWh, reflecting improved cost-efficiency relative to the earlier cycle. As a result, *Exoikonomisi Kat' Oikon II* not only expanded the programme's reach but also delivered clear economic gains, particularly for low-income households, many of which would have otherwise lacked the resources to undertake such renovations. (European Commission, 2025b; Katsoulakos & Tsabras, 2019).

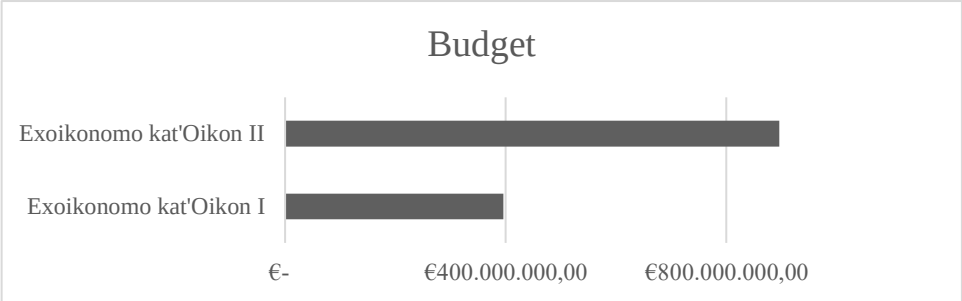

***Figure** 7 Graph comparing the total allocated budgets across the two phases of the Exoikonomo Kat' Oikon programme*

Ultimately, while Greece's energy efficiency policies have generated economic benefits in the form of lower household energy costs and reduced energy imports, their cost-effectiveness remains mixed (Iatridis et al., 2024). The reliance on direct subsidies rather than scalable financing models has limited broader market participation, while administrative inefficiencies have hindered optimal allocation of resources (Zioutou & Sideris, 2018). Moving forward, integrating more flexible financing mechanisms, expanding access to low-cost credit, and improving subsidy targeting could significantly enhance the economic impact of energy efficiency policies in Greece's residential sector.

3.3 Environmental Impact: Are Policies Reducing Energy Use and Emissions?

One of the primary objectives of residential energy efficiency policies is to reduce energy consumption and lower GHG emissions, contributing to Greece's climate commitments and EU targets. Effective policies should lead to measurable decreases in energy demand, improved energy performance in buildings, and a transition away from fossil fuel reliance (Bakhsh et al., 2024). Greece's energy efficiency initiatives, such as the K.EN.AK building regulations, *Exoikonomo* subsidy program, and the EEOS, have played a role in achieving gradual improvements in building energy performance. However, a critical assessment is needed to determine whether these policies have generated significant

reductions in energy use and emissions, or if gaps remain that hinder their environmental effectiveness.

A key measure of policy success is energy consumption trends in the residential sector (Fuinhas et al., 2022). Data from the Hellenic Statistical Authority and EU energy reports indicate that Greece's residential energy demand has seen modest reductions, primarily due to building retrofits, increased efficiency awareness, and stricter energy codes (European Commission, 2021b). The implementation of K.EN.AK in 2010 and its subsequent updates in 2018 introduced higher efficiency requirements for new and renovated buildings, leading to improved insulation, better heating and cooling systems, and increased use of energy-efficient appliances. However, the rate of deep renovations—where buildings achieve substantial energy savings—remains low at just 0.2% (European Commission, 2019a). Many households opt for partial efficiency upgrades rather than comprehensive improvements, limiting the full potential of energy demand reduction (Ozgunes & Vrantsis, 2022).

In terms of GHG emissions reductions, Greece has made progress in aligning with EU climate targets, but challenges remain (Hellenic Ministry of Environment and Energy, 2024). The shift away from oil-based heating and inefficient appliances has contributed to lower carbon emissions per household, yet the residential sector still accounts for a significant share of Greece's total energy-related emissions (Hellenic Ministry of Environment and Energy, 2024). Flagship programmes like Exoikonomo Kat' Oikon II have played a significant role in this transition. Between 2014 and 2020, the programme supported the renovation of over 47,000 homes, resulting in 534.47 GWh of annual primary energy savings and an estimated reduction of 106,416 tonnes of CO_2 equivalents per year—comparable to the annual emissions of more than 10,000 households. These outcomes reflect both the environmental and economic value of well-structured retrofit schemes. While electrification has been accelerated through increased adoption of heat pumps, solar water heaters, and high-efficiency systems, fossil-fuel-based heating systems—especially in older buildings—remain widely used. Compared to countries like Italy and Spain, where stronger regulatory enforcement has driven a faster decarbonisation of the building stock, Greece's transition has been relatively slower. This lag is due in part to financial constraints, inconsistent enforcement, and fragmented implementation at the local level (The European Parliament, 2024b, 2024a)—Greece's transition has been slower, partly due to market hesitancy, financial constraints, and fragmented policy implementation (Tsagkari, 2022).

While Greece's energy efficiency policies have contributed to environmental improvements, their impact remains uneven due to low renovation rates, slow phase-out of fossil fuel heating, and limited adoption of renewable energy integration in residential buildings. Strengthening compliance with energy performance standards, expanding financial incentives for deep renovations, and accelerating the transition to renewable-powered residential energy systems will be crucial to achieving greater energy savings and emissions reductions in the coming years.

3.4 Social Impact: Are Policies Reducing Energy Poverty?

Energy efficiency policies play a crucial role in alleviating energy poverty, ensuring that low-income and vulnerable households have access to affordable and sustainable energy solutions (Heller et al., 2024). In Greece, energy poverty remains one of the highest in the

EU, with a significant portion of the population struggling to afford adequate heating and cooling (Andreosatou, 2024). Structural factors—such as low disposable income, a high proportion of inefficient housing stock, and persistently high energy prices—have exacerbated the problem, making targeted and accessible energy efficiency measures essential for improving living conditions.

In Greece, there has been a growing recognition of the need to accompany financial tools with information campaigns tailored to energy-poor households**.** Flagship programmes such as *Exoikonomo*, and the EEOS have sought to address this issue by supporting energy upgrades and reducing household costs. Greece's NECP explicitly recognises the importance of information and training measures to promote behavioural change and encourage more rational energy use in buildings. Specifically, under Measure M7 of the NECP, obligated parties under the EEOS are tasked with delivering tailor-made outreach and technical advisory services to energy-poor households. These actions, which are to be implemented between 2021 and 2030, aim to improve energy management skills, promote cost-saving behaviours, and empower citizens with practical knowledge to reduce consumption (Hellenic Ministry of Environment and Energy, 2024b) Evidence from earlier initiatives, such as the *"Exoikonomisi kat 'Oikon"* programme, also highlights the role of communication efforts. This phase included a large-scale national campaign and outreach by participating banks, which provided green loans alongside public subsidies. These banks were also active in disseminating information about available funding and energy-efficient renovation practices, contributing to increased awareness and participation among middle-income households (Rivas et al., 2016).

Although awareness is a necessary first step, it must be coupled with meaningful opportunities for participation. As such, future energy poverty strategies in Greece should not only expand direct financial support but also invest in the design and assessment of targeted, community-level information campaigns—ideally tailored to social and regional contexts—to help overcome social norms, distrust, and lack of knowledge that still prevent many households from acting. While these policies have delivered some improvements, they have not yet reduced energy poverty at the scale required (Chatzikonstantinou et al., 2022a).

Many low-income households continue to face high upfront costs, administrative complexity, and limited access to financing, leaving them effectively excluded from large-scale renovation initiatives. In contrast, countries such as Portugal and Spain have introduced simplified grant mechanisms and automatic eligibility for vulnerable groups, enabling broader participation without complex application processes (Castle et al., 2023).

4 Barriers to Policy Implementation: Institutional, Economic, and Behavioural Factors

Despite the notable successes of energy efficiency policies in the Greek residential sector, their full potential remains unfulfilled due to a range of persistent barriers, as absorption rates of the funds remain quite low (Antoniou et al., 2022; Vrantsis, 2022). This limited uptake is largely attributed to administrative complexity, delayed disbursement of grants, and insufficient public awareness of program benefits and procedures, particularly in relation to K.EN.A.K compliance requirements (Antoniou et al., 2022). One of the most cost-effective methods to remove obstacles to energy efficiency is to implement relevant policies (Ntouros et al., 2023). Since the late 1970s, energy efficiency policies have been crucial components of energy sector reform in many nations. However, there are studies highlighting the ongoing need for robust policy frameworks that ensure capital resources are accessible and address the high upfront investment costs (Yeatts et al., 2017). Barriers to energy-efficient renovation exist throughout the value chain—from the decision to initiate renovations to financing and project execution. For example, the benefits of energy savings may not be clear or well-communicated to end users, making it difficult to quantify and monetise their long-term value (Paci & Shnapp, 2021). Moreover, renovations are often expensive, complex to plan, and time-intensive to carry out. Financing remains a core issue, especially at local and regional levels, where funding is limited and public-private coordination is weak. Regulatory hurdles and limited administrative capacity within local governments further exacerbate the problem (Ntouros et al., 2023).

The widely recognised "*energy efficiency gap*" or "*energy paradox*," conceptualises the discrepancy between the potential of cost-effective energy efficiency measures and their actual implementation. This gap arises from barriers that inhibit investments in energy-efficient and economically viable technologies, including challenges rooted in mainstream economics, organisational structures, behavioural theories, and institutional frameworks (Bagaini et al., 2020). Identifying and addressing these barriers is essential for narrowing this gap and maximising policy effectiveness. This chapter explores these barriers in detail, categorising them into institutional, economic, and behavioural.

4.1 Institutional Barriers: Regulatory and Administrative Challenges

The implementation of energy efficiency policies in Greece's residential sector faces several institutional barriers that undermine their effectiveness. These challenges stem from coordination issues, bureaucratic hurdles, financial constraints, and regulatory complexities. Programs like *Exoikonomo* require complex paperwork and lengthy approval processes, which discourage participation. Homeowners face significant administrative hurdles when applying for subsidies or loans, including the submission of numerous documents and navigating convoluted application systems (Antoniou & Mageiropoulos, 2024). Additionally, political instability and shifting government priorities in past years have hindered the long-term planning and institutional capacity needed to streamline procedures and remove barriers. For instance, during periods of economic hardship—such as the financial crisis and the COVID-19 pandemic—policy emphasis shifted away from long-term energy upgrades toward immediate fiscal measures, including reducing labour costs and increasing taxes on construction materials.

These different priorities diluted the momentum for implementing stricter efficiency standards or enforcing existing regulations. However, the recent surge in global energy prices following the war in Ukraine has renewed political and public focus on energy consumption, as a result, there is now a noticeable shift in political and public focus toward strengthening energy efficiency efforts (Antoniou & Mageiropoulos, 2024).

Complex and inadequate regulatory procedures further hinder the implementation of energy efficiency policies in Greece. The regulatory framework for energy efficiency is subject to frequent changes, which creates uncertainty among homeowners and contractors (Bagaini et al., 2020). Unstable policies reduce confidence in long-term investments in energy efficiency and renewable energy installations (Seetharaman et al., 2019).

Furthermore, insufficient technical expertise and human resources pose significant challenges. Public institutions and local authorities often lack the technical capacity and adequately trained personnel required to support, monitor, and enforce energy efficiency policies. This institutional weakness extends to the limited availability of certified energy professionals—including auditors, consultants, and engineers—who are essential for energy assessments, project verification, and guiding households through the subsidy application and renovation process. The shortage of such professionals not only delays the implementation of energy-efficient upgrades but also undermines the credibility and accessibility of programs like *Exoikonomo*. Without adequate institutional support structures and a skilled workforce, even well-designed policy frameworks may struggle to deliver meaningful outcomes (Karkanias et al., 2010). Addressing these issues requires streamlined administrative processes and better coordination across governmental levels.

4.2 Economic Barriers: Financial Constraints and Market Limitations

The adoption of energy efficiency measures in the Greek residential sector is significantly influenced by various economic factors that limit their widespread implementation. One of the most critical barriers is the socio-economic status of building users, which affects their ability to invest in energy-saving technologies (Bagaini et al., 2020). Greece has one of the highest rates of energy poverty in Europe, with many households struggling to meet basic heating and cooling needs due to financial constraints (European Parliamentary Research Service, 2023). Lower-income households are often unable to allocate resources for energy efficiency upgrades, as immediate survival needs take precedence over long-term benefits. Additionally, limited financial literacy and lack of awareness about available subsidies and incentives further hinder their participation in energy efficiency programs (Andreosatou, 2024). These socio-economic disparities create a significant gap between those who can afford energy efficiency improvements and those who remain locked in energy-inefficient living conditions. A related and equally significant economic constraint is the lack of funds, high capital costs, and financial risk associated with energy efficiency investments (Koutsandreas et al., 2022). Retrofitting older buildings with insulation, high-performance windows, or renewable energy systems requires substantial upfront capital, which many homeowners are unable or unwilling to finance (Obinna Iwuanyanwu et al., 2024). While subsidies and financial incentives exist, they often require homeowners to cover a portion of the costs, which remains a barrier for many. Moreover, financial institutions may perceive energy efficiency investments as risky, due to uncertainties in energy savings projections and long payback periods leading to limited

access to affordable loans (Bagaini et al., 2020). The economic crisis in Greece, followed by the COVID-19 pandemic, has further constrained household budgets and the availability of financing for such improvements, delaying necessary upgrades in the residential sector.

Another challenge lies in limited payback expectations and short investment horizons among homeowners and landlords. Many property owners, particularly in Greece, have conservative financial approaches and prioritise investments with rapid financial returns. Energy efficiency measures, while beneficial in the long run, often have payback periods extending beyond a decade, making them less attractive compared to other investments with quicker returns (Fowlie et al., 2018). Additionally, fluctuating energy prices and regulatory uncertainty contribute to hesitation in investing in efficiency upgrades, as future financial benefits remain uncertain (Figus et al., 2020). This reluctance is compounded by a general lack of trust in government policies and subsidy programs—an issue that reflects both financial risk perceptions and behavioural skepticism toward administrative reliability(Goren et al., 2022; Zahariadis et al., 2023) .

The characteristics of the Greek building stock further complicate the implementation of energy efficiency policies. A significant portion of Greece's residential buildings were constructed before the introduction of modern energy efficiency standards, leading to a stock dominated by aging, inefficient structures. Many of these buildings require extensive retrofits, including structural reinforcements, before energy efficiency measures can even be considered. The cost and complexity of such deep renovations discourage homeowners from undertaking them, especially in multi-family buildings where collective decision-making is required (Triantafyllopoulos, 2024). Additionally, informal property ownership structures and legal complications related to inheritance laws make it difficult to secure financing or subsidies for energy efficiency projects (Siatitsa, 2019). Finally, the split incentive problem presents a major barrier, particularly in the rental housing market. This occurs when landlords, who own properties, are responsible for funding energy efficiency improvements, but tenants, who pay the energy bills, receive the financial benefits (Papantonis et al., 2022). In Greece, where a large proportion of households live in rental properties (Kapopoulos et al., 2020), landlords have little motivation to invest in energy efficiency measures since they do not directly benefit from reduced energy costs. Tenants, on the other hand, have no authority to make structural changes to improve energy performance. This misalignment of incentives leads to a cycle of inaction, where neither landlords nor tenants take responsibility for improving energy efficiency, thereby perpetuating high energy consumption and poor living conditions in rental housing (Melvin, 2018). Addressing this issue would require regulatory interventions, such as mandatory energy performance requirements for rental properties or financial mechanisms that distribute costs and benefits more equitably. These economic barriers collectively limit the effectiveness of energy efficiency policies in the Greek residential sector.

4.3 Behavioural Barriers: Public Awareness and Adoption Challenges

Behavioural factors significantly influence the implementation of energy efficiency measures in Greek residential buildings. While past policies have often focused on financial incentives and regulatory requirements, recent evidence suggests that

psychological, social, and informational dynamics are equally crucial in determining whether households engage in energy-saving renovations (Della Valle & Bertoldi, 2021).

In Greece, low awareness and limited understanding of energy efficiency benefits and available support schemes remain key barriers. According to Karytsas & Theodoropoulou (2023), awareness of national incentive programs like "*Exoikonomo*" is strongly associated with education level, environmental consciousness, and household characteristics such as age and income. Despite significant financial incentives, only a fraction of eligible homeowners—approximately 5% according to their survey—reported using the program between 2011 and 2019. This reflects a broader gap between program availability and public engagement, attributed to both informational barriers and a lack of targeted outreach.

Recent evaluations have shown that public awareness campaigns in Greece can be effective, but their reach remains uneven. It has been shown that awareness-raising campaigns under the EEOS between 2017 and 2020 led to measurable behavioural impacts, accounting for 23.2% of total energy savings in the residential sector. While these campaigns influenced intent—84% of recipients said they were likely to follow energy-saving advice from distributed materials—their actual implementation rates remain unclear. This suggests that awareness is necessary but not sufficient; behavioural inertia, cognitive overload, and decision fatigue often prevent action even when information is available (Tourkolias, 2024) .

Behavioural inertia and habitual energy use further impede progress, as many households continue using outdated, inefficient systems out of familiarity and convenience (Lades et al., 2021). Trust in technology and institutions is another key factor, as scepticism regarding the reliability of energy-efficient solutions or doubts about government programs can reduce adoption rates (Schuitema et al., 2020). Energy poverty compounds these challenges, with vulnerable households prioritising short-term affordability over long-term efficiency gains (Mei & Seo, 2024).

To address these factors, Greece's NECP has included measures such as information campaigns and financial support mechanisms like the "*Energy Savings in Existing Housing Programme*," which combined awareness efforts with renovation funds to target those most hesitant to act. The program significantly enhanced energy efficiency awareness across Greece, fostering a shift in how individuals approached energy efficiency investments by leveraging financial instruments. As a result, homeowners became increasingly inclined to invest in improving the energy performance of their homes. Furthermore, construction companies participating in the program utilised materials certified for their energy efficiency characteristics, ensuring adherence to high standards. This practice not only bolstered consumer confidence but also contributed to the development and establishment of robust energy efficiency standards within Greece's construction industry (European Commission, 2019b).

Social norms and cultural influences also shape behaviours[8], with some households hesitating to adopt new technologies due to a perceived lack of social acceptance or community endorsement (Frederiks et al., 2015; Horne & Kennedy, 2017; Muwanga et al., 2024). For many households, reluctance to adopt new technologies stems from a lack of visible. These findings are echoed in Greek qualitative surveys where trust in

[8] https://energy.sustainability-directory.com/question/how-does-culture-influence-energy-consumption/

contractors and the long-term reliability of systems emerged as critical adoption factors (Karasmanaki et al., 2025).

Furthermore, low institutional trust and regulatory uncertainty continue to deter participation. Some households doubt the longevity of subsidies or fear mid-program rule changes. In the same surveys, participants cited bureaucratic overload and poor clarity of information as reasons for not engaging in retrofit programs—even when financially viable (Karytsas & Theodoropoulou 2023). These behavioural dynamics compound economic and administrative barriers discussed in previous sections.

To address these barriers more effectively, Greece must continue to invest in integrated behavioural interventions, such as tailored communication campaigns, trusted local advisors, and simplified decision tools. According to the NECP and recent EU reforms, Article 22 of the EED requires Member States to adopt national strategies for awareness raising, incorporating tools like one-stop shops and targeted outreach to vulnerable populations. Greece has already made progress in this direction through the *"Exoikonomo"* program's online portal and advisor network, but further development is needed to ensure accessibility and trust across all demographic groups (European Commission, 2023c).

5 Discussion and Conclusions

5.1 Key Takeaways from International Best Practices

Energy efficiency policies across Europe have demonstrated diverse and effective strategies for improving the sustainability of the residential sector, particularly in countries with economic and climatic conditions similar to those of Greece, such as Italy, Spain, and Portugal. These economies have successfully implemented policies that have addressed key issues of economic access, energy poverty, regulatory compliance, and public engagement. Their experiences provide lessons that Greece can adapt to enhance its own policies, ensuring a more equitable and impactful energy transition. The best practices and lessons that follow present successful strategies that have encouraged participation, reduced energy consumption, and assisted overall climate goals.

1. **Financial Accessibility and Design of Incentives**

One of the most critical factors in the success of energy efficiency policies is the provision of generous, flexible, and accessible financial incentives. Italy's *Superbonus 110%* scheme is a prime example: it fully covers the cost of energy efficiency upgrades and allows for the transfer of tax credits to banks or contractors, eliminating upfront costs and encouraging deep renovations (Faccioli et al., 2024; The EnOcean Alliance, 2021). Greece's *Exoikonomo* program, while impactful, could benefit from adopting similar flexibility—such as credit transfer mechanisms, simplified application processes, and higher subsidy rates for deep renovations (Wishlade et al., 2017). Importantly, *Exoikonomo 2025* includes provisions for vulnerable households, offering increased support levels and prioritised funding. While these are positive developments, further emphasis on eliminating bureaucratic barriers and creating tailored schemes for low-income groups could maximise equity and impact.

2. **Targeted Strategies for Energy Poverty**

Tackling energy poverty directly within policy design is a hallmark of effective programs in Southern Europe. Spain's National Strategy Against Energy Poverty combines financial assistance with energy vouchers to support disadvantaged households while Portugal's initiatives incorporate social tariffs and targeted energy savings measures (Rodríguez-Cabrero & Marbán, 2020; The SocialWatt Project, 2023). In Greece, energy poverty remains a systemic challenge. Although the *Exoikonomo* program includes means-tested components, Greece could strengthen its social targeting by expanding zero-cost financing for low-income groups, scaling up public housing retrofits, and integrating social welfare indicators into eligibility assessments.

3. **Regulatory Enforcement and Monitoring**

Robust enforcement mechanisms are essential to ensure program integrity and performance. Italy's *Superbonus* links financial disbursement to measurable energy performance improvements, while Spain mandates pre- and post-renovation energy audits (Macchiaroli et al., 2023). Spain has reinforced its monitoring mechanisms by requiring energy audits before and after renovations, creating greater accountability (Hernandez-Cruz et al., 2024). Although EPCs are required at key transaction points and are also issued both before and after interventions under the *Exoikonomo* program, the use of these certificates as enforcement or monitoring tools remains limited. While the requirement for an updated EPC (from EPC A to EPC B) reflects a step toward performance-based

verification, there is currently no systematic auditing of post-renovation EPC accuracy or consistency, nor are the energy savings claims independently validated. Strengthening this process—through randomised inspections, centralised data tracking, or third-party verification—would help ensure that public funds are directed toward truly effective energy-saving measures and that EPC data informs future policy design.

4. **Public Awareness and Behavioural Engagement**

Public engagement is a crucial determinant of participation in energy programs. Portugal's *Casa Eficiente 2020* initiative successfully leveraged national campaigns and user-friendly platforms to increase understanding and uptake of renovation measures (Gouveia & Palma, 2021). In Greece, awareness campaigns under the EEOS and *Exoikonomo* have achieved some success, but evaluations suggest that their impact is uneven and often limited by complexity and administrative opacity (Tourkolias, 2024). To improve reach and trust, Greece should consider expanding digital outreach tools, community-based advisors, and local one-stop shops. These approaches can demystify the renovation process and offer tailored guidance to households—especially those with limited access to technical expertise.

5.2 Translating Insights into Action: Policy Implications for Greece

Policy design is a dynamic process that requires well-established procedures for monitoring and evaluation to identify effective practices and inform policy redesign (van Geet et al., 2019). To effectively achieve energy efficiency goals in Greece's residential sector, a comprehensive and multi-faceted policy approach is required. Greece faces unique challenges, including a high proportion of older, inefficient buildings, persistent energy poverty, and limited public awareness of energy efficiency benefits, as was made evident in previous chapters. Drawing from successful strategies implemented in similar Mediterranean countries, a combination of financial incentives, regulatory enforcement, public engagement initiatives, and innovative financing tools would create a robust framework for accelerating energy-efficient renovations (IEA, 2023).

A **stronger financial support framework** is essential to encourage household participation in energy efficiency upgrades (Tucker & Díaz, 2022). To facilitate access to financing, Greece could introduce transferable tax credits, similar to Italy's *Superbonus 110%*, allowing homeowners to transfer credits to banks or contractors to offset upfront costs. Beyond subsidies, **innovative tax-based incentives and mortgage schemes** can further stimulate private investment in energy efficiency. Greece could introduce **green mortgages** with preferential interest rates for energy-efficient homes and renovations, encouraging long-term energy performance improvements (CRES, 2020). Expanding **tax deductions** for homeowners investing in efficiency upgrades, as seen in Italy and Spain, would create an additional financial incentive for middle-income households (Villca-Pozo & Gonzales-Bustos, 2019). These instruments could be broadened through state-backed guarantees for energy-efficient loans, or by integrating energy criteria into mortgage risk assessments to reward energy-resilient properties. Similarly, tax incentives specifically aimed at landlords who invest in rental property upgrades would help mitigate the split incentive barrier and improve conditions for renters(Castellazzi et al., 2017).

Regulatory enforcement and **strengthening compliance mechanisms** must also be prioritised to ensure that energy efficiency standards are met across the housing sector

(Falzon et al., 2024). Additionally, Greece could introduce **performance-based incentives**, rewarding homeowners with additional financial support if post-renovation audits confirm significant energy savings (Tzani et al., 2022).

5.3 Final Reflections and Future Directions

As Greece continues its transition toward a more energy-efficient and sustainable residential sector, future policy efforts must address existing challenges to maximise impact. While progress has been made in implementing financial incentives, regulatory frameworks, and public awareness initiatives, significant gaps remain in terms of accessibility, effectiveness, and long-term sustainability. The next phase of research and policy development should focus on optimising financial mechanisms, refining behavioral strategies, and integrating RES to create a more comprehensive and inclusive energy efficiency framework. By addressing these aspects, Greece could enhance the effectiveness of its policies, reduce energy poverty, and accelerate the decarbonisation of its residential sector.

The evaluation of financial incentive structures and their influence on household decision-making is an important topic for further study. Existing programs, such as *"Exoikonomo"*, have demonstrated some success, yet their accessibility remains limited due to bureaucratic inefficiencies and rigid eligibility criteria. Assessing the efficacy of alternative financing models, such as green mortgages, tax credits, and zero-interest loans, could aid in increasing participation, especially among low-income and energy-poor households. Moreover, exploring performance-based incentives, where subsidies are linked to actual energy savings, could enhance cost-effectiveness and ensure that funds are directed toward impactful upgrades.

In addition, addressing barriers to deep renovations in older buildings is essential for achieving meaningful energy savings. Many Greek homes were constructed before modern energy codes, making them difficult and costly to retrofit. Research into modular renovation techniques, innovative insulation materials, and bundled renovation packages could help reduce costs and streamline the upgrade process. Similarly, exploring policy solutions to resolve split incentives in rental properties, such as tax deductions for landlords or mandatory efficiency requirements in rental agreements, could expand the impact of energy policies to include renters—an often-overlooked demographic in current efficiency initiatives.

Ultimately, the future of Greece's residential energy efficiency policies lies in the development of a more adaptive, inclusive, and data-driven approach. By leveraging research to refine financial models, enhance behavioral interventions, and address systemic barriers, Greece can build a policy framework that not only meets EU climate targets but also ensures equitable access to energy savings. Ongoing evaluation of policy outcomes—such as measuring real-world energy savings, participation rates, and user satisfaction—should be embedded in the design of future programmes to support continuous improvement and inform future iterations of national strategies. Strengthening collaboration between policymakers, financial institutions, and research organisations will be key to driving sustained progress in this sector.

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