European residential building stock.
The importance of classification under the aspect of energy conservation.

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SCHOOL OF SCIENCE & TECHNOLOGY
A thesis submitted for the degree of
Master of Science (MSc) in Energy Building Design

DECEMBER 2017
THESSALONIKI – GREECE
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Abstract

This dissertation was written as a part of the MSc in Energy Building Design at the International Hellenic University. The focus of this thesis was the importance of the EU building stock classification and the help of the private and public sector in order to create moderate energy policies.

A review is presented, regarding various studies for the classification in selected European countries collated with each other. Data from major EU studies (BPIE, TABULA project, Think Topic 7) are adopted and examined.

Further, legislative, economic and social aspects for this aspect are studied. Energy Performance Certificates, private investment and companies, financing problems and initiatives as well as ownership status, energy poverty and vulnerable population are critical issues that are examined.

Continuously, best practice examples from particular EU countries are demonstrated and gathered in figures that help for a clear recommendation of energy policies that can be used in order to implement energy efficiency measures and help European Union achieve the energy related targets. The main outcome of the study is how the methodology suggested can be applied in a country like Greece.

Finally, i would like to express my gratitude to my supervisor Dr. Ifigenia Theodoridou for her support, advices and guidance throughout the dissertation period.

Christos Th. Margaritopoulos
18/12/2017
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1 Introduction

Energy efficiency background

In Europe, the majority of buildings is old and with poor energy performing standards. Therefore, they act as the right candidates for retrofitting. The first energy-related regulation was incorporated by the Energy Performance of Buildings Directive (EPBD, 2009/91/EC). First, it was implemented in 2002 and has been recast in 2010 (EPBD recast, 2010/31/EU) with more resourceful provisions. Via the EPBD implementation, requirements for certification, inspection, training and renovation are now set in the Member States earlier to which there were very few. The lack of previous requirements in most of the Member States meant that completely new legislative drives were required and for this reason the EPBD was typically implemented after a number of years from 2006 to 2010.

Nevertheless, EU legislation partly covers the field of building retrofit and promotes the implementation of energy efficiency measures only in case of deep renovations with no specification on the depth of the measures [2]. Furthermore BPIE suggests as a key driver for implementation of the measures the energy building codes through which energy-related requirements are incorporated during design or retrofit phase of a construction [2].

Construction is the leading financial sector of CO₂ emissions in Europe, contributing about 40% to the overall emissions [2]. According to Enerdata (2012), buildings are responsible for the largest share of European final energy consumption, and they represent the highest potential for energy savings. However, with new legislation in order and via energy retrofitting of the building stock, the building construction sector could turn the tables around and become a green energy champion. In 2007, the European Union introduced the “2020 climate and energy” package which was passed to legislation two years later. This law is binding and there to ensure that the Union does not fall short on its three primary goals [3]:

a. 20% cut in GHG emissions compared with the 1990’s levels
b. 20% of EU energy produced from RES
c. 20% improvement in energy efficiency

Furthermore, the new 2030 framework for climate and energy agreed by the EU members in 2014, sets even higher standards [3]:

a. 40% cut in GHG emissions compared to 1990 levels

b. at least 27% share of RES energy consumption

c. at least 27% energy savings compared with the business-as-usual scenario

The end goal of these standards is an 85-90% reduction of the CO₂ emissions compared to 1990 [3].

The European Commission also states that an enormous energy saving potential can be found in the building sector [4]. With constructions having such a central role in European GDP and employment, the energy renovation market is redefined to the point that drives national and European policies. Furthermore, more benefits will appear if the EU adds more member states and with extra investments towards research and modern ideas leading to a new European Renaissance (4th industrial revolution) [5].

Economic background

Building construction is one of the leading sectors of global economy [1]. A sub-sector of construction is the real estate industry. From an investor's point of view, an energy efficient property would not only improve the quality of life of the inhabitant but also enhance the value of the estate. For this purpose information about the energy consumption and other energy-related components of the property must be gathered and studied.

Funding for energy efficiency measures and significant renovation projects can be achieved by national programmes, by international organizations or institutions and lastly by raising investment through the private sector (REITs, ESCOs, commercial banks etc.). The European Commission states that private sector must take over around 50% of the investments and that is achieved by introducing preferential interest rates for leveraging private sector investments. Furthermore, there are also other individual financing models that must be explored.
**Social background**

Buildings are placed at the core of our lives from a sociological and economical point of view. We spent most of our time indoors, hence, the type of the buildings we live in drastically affect our day to day life. Furthermore, one can argue that the way we choose to construct our buildings is directly linked to both individual and collective productivity. A considerable degree of well-being would lead up to a more productive society and in turn in a fast-growing economy. Towards this direction, indoor thermal comfort growth is paramount.

Thus, grey domestic building stock not only presents poor energy efficiency but is responsible in a significant degree, for enhancing energy poverty in Europe as well. Energy or fuel poverty, according to BPIE, is a dominant issue in Europe, as it is estimated that between 50 and 125 million people are not able to afford a proper indoor thermal comfort.

Finally, many consistent issues have been recognised towards energy retrofitting of existing buildings. Energy efficiency problems in existing building stock, high rates of energy poverty in most of the EU countries, difficulties in national policies and legislative frameworks and many obstacles in funding and investment to overcome all these complications are some of these issues [1].

In this framework, the thesis is aiming to understand the building stock appropriately in Europe, by examining some European countries and their building typology classification and additionally, the legislative, economic and social aspects regarding the building stock. The goal of this thesis is to suggest some solutions to the policymakers regarding the energy retrofitting of the building stock.

Therefore, an analysis of some EU methodologies and policies is presented and by keeping the most useful parts of them, a proposal for a more extensive standard method is introduced. Lastly, a case study is performed, of how these suggestions can be implemented in Greece, a country that is high on the list with poor energy population and in need of important retrofitting projects (Figure 1).
Figure 1: Flow Diagram of the Dissertation structure

- Literature Review
  - BPIE study

- Examine EU Countries Building Typology

- Legislative Background
  - EPCs
  - Energy Building Codes

- Economic Background
  - Private Sector Investment
    - (REITs – ESCOs)

- Social Background
  - Energy Poverty - Vulnerable Population

- EU Methodologies Analysis

- EU Policies Analysis

- CASE STUDY
  Application of the proposed methodology in a EU country
  GREECE
2 Literature Review – State of the art

2.1 European Residential Building Stock Classification

Classification of the building stock is very fundamental for someone to emphasize in energy consumption, energy performance and energy efficiency measures of a dwelling. The typologies and categorisation of buildings can be used initially to give energy advice. Thus, making comparisons of a consumer’s property and a group of some example or reference buildings could be very instrumental in case of an evaluation of a property owner who wants to participate on a subsidy programme or take a grant to implement energy efficiency measures. Thus, the building classes with the lowest energy performance can be identified and could make a priority among others for subsidies. Moreover, the building categories can be found as beneficial for policymakers and for implementing national efficiency measures.

Analysis of the residential building stock is an issue that concerns the EU. Researchers from around the world are dealing with this topic and primarily are related to the energy classification of the building stocks. Some researchers study the energy consumption of building stocks, the hypothetical energy conservation after implementing energy retrofitting measures on a national, regional or local level. Undoubtedly, there are scientific studies that deal with the environmental and economic impact and the social costs of revitalizing of the current residential buildings [6].

In the European region, there are various climatic zones and different building typologies and architecture. According to a BPIE survey, the residential sector in Europe accounts for the 75% of the building stock out of which 64% is for single-family houses and 36% apartment blocks (multi-family dwellings).

It is estimated that the EU is appointed as the head of China and US concerning building density. There are 25 billion m$^2$ of useful floor area, a number that is increased by 1%, annually and so is the energy demand. This affects the need to improve the energy efficiency and energy conservation of the existing building stock [2].
The necessity to boost our knowledge on the characteristics of the building stock as well as the importance to relate this experience with different professions regarding residential sector (Kohler and Hassler, 2002), play an essential role concerning actions that are related to building retrofits. It is a fact, though, that all this expertise that exists on the building stock is translated differently between professionals and between countries [7]. In the above brief survey (Kohler and Hassler, 2002), it is stated that the longstanding behaviour of the building stock is of higher importance than newly constructed dwellings and moreover, that the concern of maintenance is critical.

Studies are supporting that the size and age of the building should be used as a criterion for renovating the building stock. Mastrucci et al. [8], developed a statistical methodology for 300,000 dwellings in the city of Rotterdam in which he analyzes the energy consumption and conservation of building stocks. In this method, it came clear that the older the building the highest the possibility for energy savings, depending of course by the type of the structure.

In other investigations, the socio-economic impact is taken into consideration and specifically the retrofitting damage for different tenure and income groups. Mangold M. et al. [9], suggests that dwellings with consumption equal or more than 150kWh/m²/year have priority for retrofitting but also that this could also be translated into energy usage per person and could be fairer. This Swedish study that will be met again at a further chapter, analyzes the potential of rent increasing after a renovation project and the impact on the low-income population and the tenure status.

The vast majority of building energy analyses, supply information considering the energy consumed for each square meter of the dwelling and does not give any information regarding the whole building. Thus, data for the entire building should be determined by the heating volume of the building, evidence that according to Peri et al. [6], could reflect the real priorities for interfering on the stock.

In this methodology, three criteria are taken into account,

a. the energy class which refers to the energy quality

b. the regular energy consumption of the buildings that incorporates the energy performance and the building size

c. the adjusted standard energy consumption, a more realistic energy consumption data using the actual height and the volume of the building.

- 6 -
Moreover, with high significance, it was investigated the influence of the building size on determining the hierarchical order of building stock which requires retrofitting. Building size appears to have an appropriate role, and it changes the priorities of revitalizing of existing residences. Finally, it is suggested to use as a criterion the dimension of the buildings. The energy consumption of the building seems to be the correct criterion for this purpose since it combines the energy performance and its size (surface, height). This gives the impression of a clearer criterion than the energy performance index which does not incorporate the building size [6].

Understanding the critical elements of housing energy consumption is very important to design and implement effective policies with a purpose to increase energy efficiency of the building stock. The variety of the quality of the building stock and the climatic circumstances in different countries globally increases the need for comparing the components of successful policy designs. Undergoing deep or major renovation (deep energy retrofitting) is or should be a matter of the utmost importance for the EU Member States.

In the European Union, the term “renovation” actually means “major deep energy renovation”. The Energy Efficiency Directive (EED) is an important European policy and includes the requirements below:

- EU countries make efficient renovations to at least 3% annually by floor area of buildings owned and occupied by central government
- EU countries must regularly draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans

Article 4 of the EED requires that “the Member States shall establish a long-term strategy for mobilizing investment in the renovation of the national stock of the residential and commercial buildings, both public and private”. Nevertheless, there is no formal definition of renovation or deep renovation in the EED and every EU country is free to use their terms on this point. In the recast of the EPBD in 2010 a definition exists for the term “major renovation”. It defines the cost of the renovation relating to the building envelope, or the technical building systems are higher than 25% of the building value or more than 25% of the surface of the building envelope undergoes renovation. The truth is that in the implementation of the Directives into the national regulations,
the definitions of “major” and “deep” renovation seem to be entirely dissimilar among the EU countries [10].

According to Brounen, D., Kok, N. and Quigley, J. M. (2012), in their research regarding The Netherlands, there is a secure connection between the vintage of the residences and their resource consumption. For example, buildings from this century use 65% less gas for heating than those built before 1945. On the other hand, electricity use was increased in post-war buildings and especially to recently constructed dwellings, and also differences noticed between detached or semi-detached homes than in row houses or apartments. Furthermore, when demographics are considered, it was found in the same research that families with children consume more gas than inhabitancies with couples although the per capita consumption is higher for couple households, houses with seniors consume more gas than other types of homes. Dwellings with children consume more electricity and add more variations in energy consumption is noticed according to the household income [11].

Naturally return on investment is the principal and most important motivation for dwelling owners. Availability and security of profitable energy efficiency investments are necessary for increasing energy retrofitting, and this depends on a lot of the energy policies that exist in the national regulations. The profitability of energy efficiency enhancement increases as energy prices are higher and higher. Of course, energy prices are not enough to enhance energy retrofitting in the rented dwelling sector because renters who pay energy bills have nothing to say in the efficiency of energy using equipment and this fact can be confronted increasing labeling of products which will help by providing information to the occupants. Information schemes and programs can be used as well, to support building owners and tenants to implement energy efficiency measures.

2.2 Building Performance Institute Europe (BPIE), data and methodology

Reducing GHG emissions and becoming a low carbon society is a commitment that has been taken by the European community. The “2030 climate and energy package” includes targets that can only be achieved by making solid actions and measures in the building sector.
Additionally, new relevant policies must support the targets and strategies set for goal achievement. Revising existing policies such as Energy Performance of Buildings Directive (EPBD) and Energy Efficiency Directive (EED) or enhancing new initiatives can lead to achieving those targets.

The Building Performance Institute Europe (BPIE), is a European not-for-profit organisation that supports all these actions by introducing a collection of projects and surveys, with a final purpose to make policymakers and stakeholders agree on particular and practical strategies. These projects mainly include the analysis progress on various issues like nearly-Zero Energy Buildings, keep track of existing buildings, the creation of new energy saving measures-strategies and many more.

A considerable amount of data was concentrated by a particular BPIE survey “Europe’s Building under the Microscope”. This review is concerned about the building stock of the European Union Member States along with Norway and Switzerland. Mainly residential building (single-family houses, apartment blocks) were measured, and the examined characteristics are the following:

- Typology
- Age
- Size
- Ownership profile (public-private)
- Tenure status (tenant-landlord)
- Energy performance
- Location

Furthermore, the survey considers some particular regions and gives the specific floor area distribution for each part (Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.). One specific methodology is used and analyzed by this BPIE survey, through which two main issues came to the surface:

a. The typical definition of the floor surface: Where it is found that there are various approaches between countries when floor surface measurement is recorded (e.g. external or internal gross). Plus, it is noticed that the same term may be used for different definitions. This makes comparing useful floor area between different countries problematic. Implementing a standard methodology including a specific calculation process for all Member States is suggested as the solution for this issue.

b. Typical building categories: This effect accounts for residential and non-residential building categories where most countries were unable to provide data in the necessary format. A perspective of a typical and commonly accepted set of building categories should be adapted from all EU countries.

2.2.1 Building Typology - Characteristics

According to the BPIE study, the residential building share accounts for the 75% of the total stock. 64% of the residential sector refers to single-family dwellings (e.g. detached, semi-detached and terraced houses) while the rest 36% relates to apartment blocks, starting from 2 and reaching even to 30 apartments for each block (Figure 3).

![Figure 3: EU share of residential – non-residential](image)
The age of the building construction is highly related to the energy consumption used especially when old buildings have not been refurbished in any way. BPIE uses a classification for residential constructions according to the year they were built. Three general categories proposed:

a. *Old*, constructions up to 1960
b. *Modern*, constructions from 1961 to 1990

It is noticed that during modern period the housing stock was more than doubled. Furthermore, many differences between countries are marked.

Concerning size, buildings present a high variation mostly in non-residential buildings, on which the existing energy policies apply for buildings with a floor area over 1000m$^2$. Moreover, the ownership status of the buildings highly relates to the rate of buildings energy renovation. A recommendation by the BPIE states that the public sector which possesses a low share on the building owner should get involved in deep retrofitting by giving motives to the private owners (80% of building stock) and provide correct guidance and relevant regulations as well.

Another classification of the residential building stock is the tenure status. The dwelling could be occupied by the property owner, a private individual or by public authorities. Unquestionably, tenure status has an essential influence on decision making for improving energy performance. Studies have shown that there is a considerable gap between the property owner and the occupant that rents the property. It is unlikely for the two parties to agree on the same path and motives need to be given to both sides to empower building retrofitting.

Lastly, another significant characteristic is the place of the building. *Location* is a component that can disturb the retrofitting rates. A separation between urban and rural areas is made. In the case of the local regions, large scale renovation project can be more likely to take place.

### 2.2.2 Energy Performance

Buildings account for a significant share of the final energy consumption and around 36% of the total CO$_2$ emissions. This is shown in this study and is crucial to understand that reducing energy demand will also reduce the consumption of the residential build-
ings. According to Eurostat, from 1990 to 2010 the building stock consumption is continuously increasing.

The energy performance of residential buildings relies upon some factors such as the heating system, building envelope, indoor-outdoor climatic conditions and some community issues. Although there is some development noticed in some of these elements (e.g. heating systems), there is, nevertheless, high potential for saving measures to be explored and developed. This development is easy to implement in newly constructed buildings, but the challenge is to apply them in existing households from which, the most prominent share, approximately 40% is built before the 1960s [2], and this is translated as low-performance housing and high consumption.

2.2.3 Improving Energy Efficiency

The European Union sets as an important issue the improvement of the energy performance and efficiency of buildings. In the end, the decision will be taken by the property owners, developers, investors and managers. Improving the information regarding the elements that affect the conclusion of the policy-makers is the first step towards high energy efficiency. BPIE also designates that some barriers and challenges exist that the countries will need to overcome.

However, the initial cost is usually significant enough to generate negativity on investing to the property owners. For the vast majority of the decision-policymakers, the price for renovating is the most significant barrier. Therefore, seeing the problem from the consumer’s eyes will help to conclude. Building energy savings is a cost-effective investment and European citizens, and property owners should stop being suspicious and hesitate to proceed with such investments.

In more details, the barriers that EU locates are separated to:

1. Financial obstacles which present the highest priority among the countries. Payback period and low prices play a significant role
2. Institutional and administrative barriers which can affect the estimation of the project’s schedule directly
3. Awareness, advice and skills barriers which are related to the level of expertise between counties or technicians and engineers. Moreover, this restriction is related to the lack of information for the decision makers as well
iv. Separation of expenditure and benefit, this barrier refers to the situation of rental housing, meaning that the landlord will pay, but the tenant will enjoy the benefits of energy efficiency.

Subsequently, challenges better connect with the market and the technical issues. Physically, the lack of activity is an obstacle to the enhancement of the industry. The BPIE recognises four challenges:

i. Supply chain
ii. Quality of craft
iii. Technical failure
iv. Disturbance.

An essential asset, helping improve energy efficiency in existing residential buildings is the Energy Performance Certificate (EPC). EPCs are implemented in most of the Member States and are a useful tool. It gathers data, examines the building stock, and educates the public and make proposals for improving the efficiency of the examined dwelling.

Moreover, implementing energy-related requirements during the design phase of a building into the building codes of a country seems to be an advantageous measure. This measure, through a cost-optimal methodology guided by the EPBD, is recorded as very profitable and could lead to nZEB standard requirements after 2020.

Regarding existing buildings, very few Member States have introduced any regulations in their building code for enhancing energy performance of the stock. Full renovation or even partially replacement of various components should have a performance-based requirement, some countries have applied that, and the rest are recommended to follow.

Despite the fact that the regulatory framework gives an advantage to new buildings through the building codes and puts aside the existing building stock, there is a high potential of improvement apart from the legislative framework of each EU country. This possibility is achieved by financial programmes (mostly publicly funded) which have been popularized and used since the 1970’s. Nowadays and during the economic crisis in Europe, these economic agenda may be the most legitimate tool that assists the rise of the building energy performance.
Finally, other programmes that are not yet exploited enough in EU give the impression of high potentials. Such applications could be:

- *information* to the public, technicians, engineers, investors etc. regarding the energy efficiency improvement and its benefits

- *training* provision to building energy efficiency professionals

- *research and development*, including funding for energy efficient buildings.

### 2.3 Think - Topic 7

According to Topic 7 of think.eui.eu (2012) *“How to refurbish all buildings by 2050”* buildings are also responsible for achieving the energy and climate targets of the European Union for 2020-2050.

If we consider that the average lifespan of a building is more than 50 years and refurbishing it could take almost a hundred years, it makes sense that investing in building energy refurbishment is critical for reducing energy consumption and greenhouse gas emissions. In this research, it is supposed that it is essential and necessary to refurbish all or almost all buildings by 2050 to achieve the 2050 targets.

The road to the 2050 EU building sector incorporates three challenging trade-offs:

1. On the one hand, increase the speed of substituting of the building stock with new constructions and from the other hand increase the investment in refurbishing buildings

2. Invest in building refurbishment either by retrofitting more frequently or by being more aggressive and determined when refurbishing them

3. Regarding the type and time of the investment, a linear path can be followed, or better efforts can take place at a further stage when technology is upgraded

It is estimated that an investment of 600-1800 billion is in need for the building sector until 2050 while the benefits of energy retrofitting in buildings are considered to be much higher than the costs.

Hence, the main problem of such a case should be described. Building retrofitting is a result of severe choices and selections that usually are taken by many sides such as, building owners, tenants, energy suppliers, financial service providers, energy service companies etc. The decision-makers need to realize that their investment depends on their individual decisions, and it is not absolute that it will lead to refurbishment [12].
Lastly, even if the sector achieves to overcome those initial difficulties, still there is a need public and private support.
3 European Member States Classification

3.1 Introduction

This chapter analyzes the residential building stock in specific state members of the European Union. The building stock classification is a significant research since it contributes to a holistic understanding of the urban residential sector, the building components.

Furthermore, the analysis of the building stock and its categorization will help this thesis and the scientific community as well, to propose energy efficiency measures, correct policies and better legislative framework towards achieving the EU energy targets.

3.2 TABULA Project

The main contributor for getting data and information is the Typology Approach for Building Stock Energy Assessment (TABULA) project which purpose is to define a methodology that describes the European building stock categories, and its goal is to enhance the performance of energy building analysis.

In general, “Building Typology” is a classification of parameters commonly found in buildings. In particular in the TABULA project, much emphasis is given on the assessment and improvement of the energy performance of the buildings, and it makes sense that the building typology concept mainly is directed to the building parameters that are related to its energy consumption. The most significant of those settings are:

- Construction period of the building
- Building size (single-family, multi-family, row houses, apartment blocks, etc.)

Some further parameters that are likely to be examined are:

- Regional location and climatic condition, since the energy-related building characteristics, vary from region to region.
- Type and age of the supply system (heating, cooling system etc.)
Furthermore, there is data from other scientific papers that help make comparisons and extend the TABULA project so that the classification of the building stock will be more extensive with a more precise outcome.

The following countries are studied regarding their typical building typology. The decision for these countries was made because their building typologies present many differences among each other (Figure 4)

- Greece
- Italy
- Denmark
- Bulgaria
- Czech Republic
- Germany

The selection of the abovementioned countries happened for various reasons. Firstly, they are all participating in the TABULA project. The following paragraphs analyze the reason for choosing the abovementioned countries which are divided into pairs.

For example, Czech Rep. and Bulgaria belong to the Eastern European countries, and the most significant share of their buildings was constructed during the Soviet era. The Czech Rep. though has influences from Austro-Hungarian Empire and is highly connected with Central Europe characteristics while Bulgaria has a connection with Balkan traits and Greece.

The next two countries that are examined are two Mediterranean countries, Greece and Italy, which present many similarities among each other. Thus, Greece, as mentioned before, has a connection with Bulgaria in building characteristics and Northern Italy has many similarities with Northeast Europe and Germany.

Finally, the last pair analyzed is Denmark and Germany, two countries located in Northeast Europe. Both are developed countries with advanced energy efficiency measure schemes and programs. Their building stock suits each other, and moreover Eastern Germany is profoundly affected by the Soviet Union and associated with the characteristics of Eastern European countries like Czech Rep.
Czech Rep. and Bulgaria were previously a part of the Soviet Union influence region. Eastern European countries, present many similarities among the residential stock, regarding their design, building envelope, ownership status and even the user habits. The most significant share of the existing buildings in Eastern European countries constructed during the Soviet era with very similar solutions and standards. These similarities in most cases dominated even after political changes occurred. Thus, a typical element of Eastern Europe is the massive residences and repetitive blocks of apartments, known as “panel buildings”, a symbol of the Soviet Union period.

Furthermore, the main difference among eastern countries can be found according to their climate. Czech Rep. location is in the Northwest of the Eastern European region, where the climate is in general colder and more humid than Bulgaria where is located in the Southeast of the same part, with hotter summers and milder winters.
Another climatic factor is the altitude where many mountains can be found in Bulgaria, and at the same time, Czech Rep. can be characterized as more hilly. Thus, in many of the Eastern European countries, Czech Rep. is one of them, can be found influences from the Austro-Hungary Empire, especially before the First World War. Modern Bulgaria, on the other hand, seems to have similarities with the Greek building stock.

Both in Czech Rep. and Bulgaria the vast majority of the dwellings are privately owned, 91% and 96% respectively. Combined with the many apartment and panel buildings, there is the main issue concerning funding and investment of energy retrofitting of those buildings since there are a lot of property owners and landlords with different incomes that have to take the decisions for the same purpose. The whole situation makes energy retrofitting in panel buildings almost impossible without significant subsidies.

To continue with, Greece is a country that is one of a kind in its building typology. Ancient Greece and Byzantium can still be found in building characteristics, along with influences from Ottoman, Italian and German ruling. Thus, from the post-war period, the construction of the so-called polykatoikia prevails. [14] Poly-katoikia is a Greek word which translation is “many-residences”, and represents the Greek multifamily building typology. The climate of Greece can be compared with that of Bulgaria and Italy but still has much hotter summers than Bulgaria, but milder winters than Italy.

It is a fact though, that both in Italy and Greece there are regions that present cold winters, and high humidity. Italy is a vast country with many climatic areas. In South Italy, high temperatures are noticed while in the North part, there are really severe winters. Buildings in Italy have many similarities with those in Greece. At the same time, in North Italy, someone can find many influences from Central Europe and many similar buildings like Germany.

In East Germany in particular, more than 2 million apartments in panel buildings exist today, and consequently, the connection between Germany and Czech Rep. building stock is observed. On the other hand, Denmark presents advanced policies regarding retrofitting the building stock, since it was the first country that implemented the EPBD for all building including single-family houses. Along with Germany private investment takes place and, some schemes are made from other countries as “best practice” examples.
<table>
<thead>
<tr>
<th>Country</th>
<th>Typology</th>
<th>Energy Poverty Rates</th>
<th>Dwellings built before 1980</th>
<th>Owner Occupied</th>
</tr>
</thead>
<tbody>
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<td>Greece</td>
<td></td>
<td>33%</td>
<td>63%</td>
<td>77%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td></td>
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<td>60%</td>
<td>97%</td>
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<td>Czech Rep.</td>
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<td>15%</td>
<td>70%</td>
<td>77%</td>
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<td>Germany</td>
<td></td>
<td>20%</td>
<td>71%</td>
<td>46%</td>
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<td>Italy</td>
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<td>30%</td>
<td>77%</td>
<td>61%</td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
<td>20%</td>
<td>78%</td>
<td>58%</td>
</tr>
</tbody>
</table>

Figure 5: Comparative rates among the examined countries
According to Figure 5, there are some interesting differences among the countries that are examined. For example, it is noticed that there is a considerable diversion on energy poverty rates between Czech Rep. (15%) and Bulgaria (50%). Furthermore, the ownership status seems to vary among Bulgaria (97%), Germany (46%) and the rest countries. Finally, what appears to be interesting is the fact that in all states the buildings are mainly built before 1980 (60-78%), and this is a reflection of the poor energy performance of the building stock since in the majority of the European countries the related regulations were introduced around that period. All these indicators are significant in many aspects, and they will be further analyzed later in this dissertation.

3.3 Greece
According to the Hellenic National Statistics Service, there are about 4.000.000 buildings in Greece with a total floor area of 552 million square meters. The majority of the residential sector consists of apartment buildings most of which are aged with old heating systems and low energy efficiency.

3.3.1 Building stock classification
In Greece, the majority of the building stock refers to residential buildings which represent 77% of the total stock [15]. Existing dwellings’ consumption is approximately at 36%. It is a fact, that although new buildings are constructed after 1980 they have lower consumption than previously, and consequently, after 2011 (implementation of KENAK), the consumption is even more economical along with the CO$_2$ emissions. Still the total energy consumption of the stock remains at high levels.

The implementation of important energy conservation measures in Greek legislation was initiated in 1979, with the Thermal Insulation Regulation. Other bills were also introduced but never implemented in practice. Furthermore, it worth mention that Greece’s obligation to apply the EPBD 2002/91/EC did not happen until 2010 after the implementation of the new Energy Regulation.

Moreover dwellings before 1980 offer essential opportunities to decrease the energy consumption and increase the levels of energy conservation. According to the Hellenic Statistical Authority, 45.6% of the residential stock affords no thermal insulation while the rest 54.5% presents some thermal insulation.
Greek buildings typology is rich and can be allocated in many categories. The existence of single or multistorey buildings, attached or detached, insulated or not, constructions with various materials for the building cell, year of manufacture, are some of the labels we can put onto buildings and help classify them.

Taking account that the high percentage of the building stock was built before the implementation of the first Thermal Insulation Regulation in 1979 [16] and that this regulation was applied years after that in practice, it is evident that there is a high potential for energy savings and energy conservation measures.

There is a need for a deep understanding of the building stock’s components, to apply energy retrofitting programmes and to make sure that the most suitable measures about energy conservation and saving will be taken [14].

The first classification of Greek residential buildings was created for the TABULA program and included 24 types of buildings. This was extended to the framework of EPISCOPE program and added the dwellings built after 2011 according to the KENAK specifications. TABULA program classifies the buildings according to their size, age and area’s climatic zone:

- **Size:** Discrimination among buildings up to two floors (monokatoikia, a Greek word that means one residence) and buildings with more than two storeys (polykatoikia, meaning many homes).
- **Age:** Determines the level of thermal insulation applied to a construction and the electromechanical installations.
  - Before 1980, most buildings are uninsulated
  - From 1981 to 2000, partially insulated buildings
  - From 2001 to 2010, fully insulated buildings
  - From 2011 until today, all buildings are considered fully insulated according to KENAK
- **Climatic zone:** Energy demand of dwellings is affected by the climatic conditions of the region they belong. Based on the heating and cooling degree days Greece is divided into four climatic zones.

Moreover, it should be mentioned that buildings cell characteristics and heating/cooling systems and production of hot water are taken into account in this classification.
Accordingly, the Greek TABULA classification consists of 32 residential categories that result from combinations among the abovementioned categories. After studying buildings of each class, the primary outcome of TABULA tool is that after implementing the measures proposed, there will be energy savings and CO$_2$ emissions reductions at a rate between 30-88% for both two types of buildings according to size, monokatoikia and polykatoikia. Operating cost reduction ranges between 30-86% for monokatoikia and 34-84% for polykatoikia and lastly, the payback period is estimated 6-40 years for monokatoikia and 4-56 years for polykatoikia.

Another similar classification according to buildings’ typology and age is proposed (Theodoridou, Papadopoulos, Hegger, 2011), after analyzing data from the Hellenic Statistical Authority. The year of construction is significant because other characteristic conceal within this classification, such as typology, materials, components equipment and the techniques used at the construction stage.

In particular and for assorted reasons (historical, technical, geopolitical, social etc.), Greek building stock separates in six classes wherein each class some specific characteristics of the respective period are analyzed:

- **Class A (1919-1945):** High urbanization, refugees and need for housing. A vast development at this stage was the introduction of elevators that lead to rising the floors and height of buildings. Facades remain the same.

- **Class B1 (1946-1960):** Extensive use of reinforced concrete. Familiarize with new building materials and techniques. More multistory dwellings due to the higher need for accommodation. Working with a new legislative framework, concerning the building’s area forms. Introduction also of a General Construction Code defining the urban centers, suburbs and rural areas.

- **Class B2 (1961-1980):** Main characteristics that applied in this period are, typological elements, building services, bigger inhabitancies, oil-fired central heating systems, aluminium frames for glazing areas. Moreover, a very huge difference is the thermal insulation regulation, introduced in 1979. It is worthy to mention that the next step for this provision did not happen until 2010.

- **Class C (1981-1990):** The thermal insulation regulation was applied in practice in 1981 along with the new component in the buildings’ typology the ‘Pilotis’ (1985), an open space at the ground floor of multistory buildings used mainly as
parking. In most cases the building elements communicated with this free space are uninsulated.

- **Class D (1991-2010):** The new Greek seismic code affected the construction materials, their dimensions and the envelope components.

- **Class E (2010-Onwards):** In 2010 KENAK was activated and set new parameters by implementing the EPBD in the Greek legislation. Its purpose is to provide new standards regarding the energy efficiency of buildings.

Additionally, some critical statistical data can be examined. According to EL.STAT in 2011, the total number of buildings in Greece was 4,105,637 from which 75.5% represent residential buildings (72.8% autonomous with one or two floors and the rest 27.2% multistory buildings) [16].

![Figure 6: Share of the classes in Greek building stock](source)

**Figure 6** illustrates that Classes A, B1, B2 (1919-1980) represent 54.59% of the total building stock. It is important to say that the highest percentages of the year of construction are in Classes B1, B2, C (1940-1990) and account for almost 65% of the existing stock. Most of the building stock share is apparently built before the first insulation application in Greece which officially started at the end of the 1970’s but was implemented a decade later.
3.4 Italy

In Italy, the existing building stock represents the majority of the building stock and naturally it reflects the highest and most cost-effective possibility for energy savings. Italy’s legislation considers energy usage to be an issue to be solved by states or regions [17]. As in the rest of the European member states, and according to the European Energy Performance Building Directive, the legislation requires since 2019 the new public buildings and since 2021 all the new buildings to be nearly zero-energy buildings (nZEB). This challenge, upgrading the existing building stock into nZEB seems to be interesting regarding energy savings [18].

Regional laws are applied, and most of the regions have incorporated the EPBD. The whole Italian building stock consists of more than 11 million buildings with more than 27 million apartments. Another important fact to mention, is that the average floor area of an Italian dwelling is 96 square meters [17].

3.4.1 Building Stock Classification

According to the Italian TABULA project, the building typology classification is developed by trying to assess and improve the energy performance of the building stock. The structure focuses on the building parameters which are related to energy consumption. Below are the key criteria that helped this classification:

- Region/climatic area
- Building age
- Building Size

More specifically, Italy is typified by six different climatic zones according to the National Presidential Decree no.412/1993, and distinguishes from “A zone” to “F zone” taking account the heating degree-days. For TABULA research three climatic zones were used to classify the National building typology:

1. Mediterranean Zone (A,B,C,D Zone)
2. Middle Climatic Zone (E Zone)
3. Alpine Zone (F Zone)

The Italian peninsula is also categorized by eight construction age classes. Each one of them describes a specific historical period and reflects the major geometrical and construction typologies from the energy aspect. Below are the 8 age classes:
1. **Class I, until 1900 – Nineteenth Century**
2. **Class II, from 1901 to 1920 – Beginning of the Twentieth Century**
3. **Class III, from 1921 to 1945 – the period between the two World Wars**
4. **Class IV, from 1946 to 1960 – the Postwar period and the reconstruction**
5. **Class V, from 1961 to 1975 – the oil crisis**
6. **Class VI, from 1976 to 1990 – first Italian energy efficiency regulations**
7. **Class VII, from 1991 to 2005 – regulation regarding energy performance of the buildings**
8. **Class VIII, after 2005 – more restrictive energy performance requirements**

Lastly, each construction age class is depicted by building size classes. These classes refer to specific dimensional typologies (size and geometry).

1. **Single-family house**, one or two floors single flat, detached or semi-detached house
2. **Terraced house**, one or two floors single flat, terraced
3. **Multi-family house**, small building with a low number of apartments (2-5 floors and maximum 20 apartments)
4. **Apartment block**, big buildings with a high number of apartments (more than four floors and more than 15 apartments)

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### 3.5 Denmark

Denmark presents a high potential for energy retrofitting and energy savings since in the Danish residential building stock, 75% of the buildings were built before 1979 when the very first significant energy efficiency demands were introduced. Energy used for heating and cooling in buildings accounts for 30% of the total energy consumption in Denmark. As said before, the highest potential for energy savings hides in the existing building stock, and the primary reason for that is buildings’ long lifespan.

According to H. Tommerup, S. Svendsen (2006), Energy saving measures in Denmark was only carried out to a low scale despite their cost-effectiveness. This occurs mainly because there are not any attractive financial possibilities [19].
3.5.1 Building Stock Classification

TABULA project has established a Danish typology for residential building, where three different main building types were used. And each building type was divided into nine chronical periods representing traditional constructions and various insulation levels [30].

These three building types that were selected are the most ordinary residential construction types in Denmark, notably:

1. Single-family houses
2. Terraced-houses
3. Apartment blocks

The basis for choosing these categories comes from the Danish Energy Performance Certification data collection where the three classes are the leading building types.

Additionally, the construction periods were separated initially according to national building tradition adjustments, and in later and more recent times the energy requirements that are declared in the Danish Building Regulation was taken into consideration. The eight construction period are mentioned below:

1. Before 1820 – changes in building tradition
2. 1851-1930 – changes in building tradition
3. 1931-1950 – introduction of cavity walls
4. 1951-1960 – introduction of insulated cavity walls
5. 1961-1972 – initial energy requirements to the Building Regulations (BR61)
6. 1973-1978 – more intense energy requirements (BR72)
7. 1979-1998 – more intense energy requirements (BR78)
8. 1999-2007 – more intense energy requirements (BR98)
9. 2007-2011 – more intense energy requirements (BR06/08)

It is worthy to mention that for Denmark there is only one climate zone used in the energy performance calculations.

Energy Performance Certificates have been mandatory in Denmark since 1997. Owner-occupied residential buildings and flats need a genuine certificate when sold. Furthermore, all large structures are necessary to be certified for their energy performance on an annual basis.
While performing an energy audit for the EPCs, there were all kinds of information collected such as thermal envelope elements, heated floor area, type and efficiency of heating supply systems, efficiency and size of heating and DHW distribution systems, efficiency and areas of RES. Additionally the registered and the calculated energy consumption are measured and stored together along with the auditors’ suggestion for energy saving measures and investments. This data from EPCs was extracted and used for the needs of TABULA project in Denmark [20].

3.6 Bulgaria

In Bulgaria, standards regarding energy efficiency in buildings were initiated in the national legislation in 1964, and mandatory U-values were set for exterior walls, roofs and floors. By 1999, these U-values varied according to the outdoor temperature and in some cases explicitly for the external walls according to the construction weight. In 1999 mandatory U-values were implemented for doors and windows [21].

3.6.1 Building Stock Classification

There are over 1.5 million occupied residential buildings from which 641.000 are in urban areas, and 864.000 are placed in rural areas (Figure 7).

<table>
<thead>
<tr>
<th>Building type:</th>
<th>In Bulgaria</th>
<th>In towns</th>
<th>In villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houses</td>
<td>1 291 549</td>
<td>492 667</td>
<td>798 882</td>
</tr>
<tr>
<td>Multifamily residential buildings</td>
<td>66 865</td>
<td>64 476</td>
<td>2 389</td>
</tr>
<tr>
<td>Buildings of mixed type</td>
<td>6 465</td>
<td>5 025</td>
<td>1 440</td>
</tr>
<tr>
<td>Other residential buildings</td>
<td>141 066</td>
<td>79 082</td>
<td>61 984</td>
</tr>
<tr>
<td>... of which cottages</td>
<td>140 047</td>
<td>78 403</td>
<td>61 644</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1 505 945</td>
<td>641 250</td>
<td>864 695</td>
</tr>
</tbody>
</table>

Figure 7: Bulgarian building stock – Share of building types in urban and rural areas

Source: BPIE

Furthermore, many categorizations exist for the residential building stock of Bulgaria, and in this survey, they can be divided according to one of the following categories.
1. Residential building types in urban and rural areas and totally
2. Residential buildings according to their number of dwellings
3. Residential buildings regarding their age
4. Residential buildings distribution regarding their number of floors
5. Residential buildings according to the construction materials used
6. Residential buildings and the presence of solar collectors
7. Residential buildings regarding implementation energy efficiency measures
8. Residential buildings according to the heating source

The majority of the abovementioned categories are examined by both the building’s share and the building’s total useful living area perspective.

Figure 8: Bulgarian building stock – Distribution according to numbers and floor area space

Source: BPIE

The building types are divided into seven categories, but for the BPIE analysis, the types of buildings that are taken into account are divided into four. More specifically the classes are the following (Figure 8):

1. Houses
2. Multifamily residential buildings
3. Buildings of mixed type
4. Other residential buildings

From the seven categories, dormitories, buildings for collective housing, summer kitchens and cottages are all included in a single group and tagged as “other residential
buildings”. This occurs because dormitories and buildings for collective housing present deficient numbers and the two rest categories have insufficient functions and consequently they are not serving as primary dwellings for living. The following table presents the data of the various types of Bulgarian residential buildings.

The standard category in Bulgaria’s residential buildings is the Houses, which represent around 86% of the existing building stock. Especially in rural areas, this percentage reaches 93% while multifamily residential buildings represent less than 0.5%.

Considering the useful floor area (Figure 9), it is noticed that multifamily buildings have a total useful area similar to houses, despite their significant differences in the numbers of constructions.

![Figure 9: Bulgarian building stock – Useful floor area](image)

*Source: BPIE*

Thus, considering the number of dwellings in each House, it is noticeable that 70.5% of the occupied residential buildings have one dwelling, while 14.4% have two and 15.1% have more than two dwellings. The total number of buildings that have only one residence is about 1.27 million, of which 452,000 are in urban areas and 818,000 in villages. Regarding useful floor area, there is a different distribution. Those building that consists of one dwelling makes up 39.1% of the total useful area. High differences are also observed among urban and rural areas.

Regarding the building age of the Bulgarian stock, it is recorded that the highest rate of residential buildings constructed during the period between 1960 and 1969 and low-
est rate is in the period 2000-2011. Nevertheless, the most significant total useful area was built during the times 1970-1979 and 1980-1989.

Furthermore, with respect the number of floors, the research shows that the majority number of residential buildings has either one or two levels, but at the same time the highest useful area of residences is found in buildings with six floors or more.

The average annual income in 2014 for Bulgarian households was 11,489 BGN of which 12.6% represents the yearly cost of energy, water and maintenance. Data from www.nsi.bg show that from 1999 to 2014 the total expenditures of the households are more than full income except for two years (2010-2011). Furthermore, it is noticed an annual rise in the expenses for heating, cooling, water and fuels for the same period. It is bright and unrealistic to expect many household and building owners to allocate their annual income to proceed to investments in deep energy retrofitting for their buildings.

3.7 Czech Republic

According to the “2011 Population and Housing Census”, in the Czech Republic, the residential building stock was estimated at 4,756,572 dwellings, almost 90% of which are occupied. Furthermore, 55.9% of the occupied houses are held by their owners, and at the same time, 22.4% are occupied by tenants [22].

3.7.1 Building Stock Classification

The TABULA project regarding the Czech building typology presents 24 building typologies divided into six construction periods and four building size groups.

1. Before 1920 – The most common structural system was solid masonry for this time. The load-bearing and thermal insulating functions were separated, and window sills had appropriate for the period insulating properties.

2. From 1921 to 1945 – In the newly formed Czechoslovakia, there was a considerable construction development which stimulated new possibilities of financing the construction sector and also resulted in simplifying the building regulations. There is an estimation that 745,000 dwellings were constructed that period. The types of windows changed and worsen the thermal conditions of the houses due to moisture.
3. From 1946 to 1960 – After the Second World War, there was an extensive development in social (public) housing constructions. And the standards were kept the same as the pre-war period.


5. From 1981 to 1994 – Mainly constructed blocks of flats till the early nineties. After 1982 the demand for insulation thickness got stricter to eliminate cold bridges. In 1992 the technical standard was revised and begun to influence the design and construction phase

6. From 1994 to 2005 – Building materials with better functional and thermal properties are in use for this period.

Additionally, there are four categories regarding the size of the buildings:

1. Single Family House
2. Terraced House
3. Multi-Family House
4. Apartment Block

### 3.8 Germany

In Germany, the most significant economy in the EU, the building sector accounts for 40% of the final energy use and at the same time represents 30% of the GHG emissions.

A first version of the German residential building typology was developed in 1990, based on the energy saving audit reports and various scenario analyses applied to determine the energy saving potentials of the German building stock.

For the classification of the building stock in Germany, the year of construction plays a vital role and is a significant criterion. During the pass of periods different building principles, materials and techniques were used, and typical geometrical elements changed such as windows area.

The TABULA classification scheme in Germany is based on past projects. According to TABULA, the categories of the construction year are guided by historical
changes and changes in the energy building codes. The classes of the different time periods and their characterization are listed below [23]:

1. **Until 1859** – pre-industrial period, characterized by handcraft, experience and with no requirements

2. **1860-1918** – period of promoterism, high expansion of the cities, industrializations, standardization of construction principles on regional level

3. **1919-1948** – increased production of building materials, use cost-efficient constructions, standardization of construction principles on national level

4. **1949-1957** – simple building techniques of the post-war period, use of debris material, development of construction standards, introduction of social housing

5. **1958-1968** – requirements on thermal insulation, further industrialization, development of panel buildings

6. **1969-1978** – new industrial building techniques, prefabricated single-family dwelling, the first oil crisis and becomes the thermal insulation more relevant

7. **1979-1983** – first thermal protection ordinance

8. **1984-1994** – second thermal protection ordinance, improved insulation, introducing low-energy houses


10. **2002-2009** – energy savings ordinance, considering building and heat supply system

11. **2011-Onwards** – new requirements of the energy saving ordinance on the level of low energy buildings
4 Legislative, economic and social background

At the end of the 70s and after the results of the oil crisis, concerns about energy dependence initiated the first wave of policies that aimed to enhance residential energy efficiency. Likewise, forty years later, there is a renewed attention for residential energy efficiency, but this time it is triggered by concerns about pollution, global warming and fossil fuel depletion.

Moreover, 54% of the population globally is living in urban areas a number that is expected to reach 66% by 2050, along with the rise of world’s population and the need for more housing, it is a necessity for existing buildings to proceed to deep retrofitting. Historically, in Europe and most of the Member States, the building stock increased at a rapid pace between 1950 and 1975. These decrepit buildings come to the point that calls for renovation to be reused again to cover the increased urbanization demand for inhabitancy.

Despite the fact that energy retrofitting of the building stock has been identified as a critical point area to achieve energy and climate goals many studies have revealed the financial challenges related to those energy retrofitting activities.

In general, there are signs that show positive economic effects related to better environmental performance. It makes sense that buildings with higher energy efficiency are noticed to have superior rents, steadier occupancy rates and higher prices than ordinary buildings. At the same time building stock presenting lower levels of energy efficiency is related to high risk of disuse [24].

Under those circumstances, building stock property owners have to obtain the capital that is needed to proceed with retrofitting and upgrade of the stock’s environmental performance. Providing the correct information to consumers regarding their energy consumption can result in a high reduce on energy bills [11]. More specifically, supplying feedback to private consumers regarding their energy consumption can be accounted for a decisive “push” towards improving energy efficiency.

Nevertheless, significant gaps exist between actual investments in energy efficiency and ventures that appear to be in the consumers’ interest. Energy retrofitting
and deep renovations are costly despite the fact that they are cost-effective, new and original ideas are in need. The capital necessary at the beginning of a retrofitting project is the greatest obstruction. Various financial methodologies and mechanisms have been applied and currently designed since it is an urgency to give incentives to improve building stocks’ energy efficiency [24].

Furthermore, energy retrofitting and labeling can provide financial benefits for both the real estate investor and the tenants, since energy savings coming from more efficient buildings lead to higher selling prices and lower operational costs respectively [26]. This activity can provide substantial economic and employment opportunities.

4.1 Legislative

4.1.1 Energy Performance Certificates and the value of energy labeling

In the early 00's, the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) was introduced and became the leading guide influencing energy use in buildings. It also sets out the following critical requirements for the Member States:

- Minimum standards on the energy performance of all new buildings and large (over 1000m2) existing buildings undergoing a major renovation
- A general framework for a methodology to calculate the integrated energy performance of buildings
- Energy certification for both modern and old buildings whenever they are constructed, sold or rent out
- Implement an inspection and assessment regime for air conditioning and medium and large size heating systems

Furthermore, the implementation of the EPBD anticipates the adoption of the Energy Performance Certificates (EPCs), inspections and all impacts. Those requirements were absent previously in most Member States, and naturally, they brought utterly new legislative instruments. EPBD was typically implemented in various stages over some years from 2006 to 2010, and most European Member States already had a form of min-
imum requirements regarding building envelopes before the introduction and activation of the EPBD.

The implementation of the EPCs has been gradual in most EU Member States due to the nature of the application of the certificates. Although in most countries EPCs were set up to be related to new buildings, their design for renovated and existing buildings was left for later implementation.

Also, the recast of the EPBD added further new and powerful requirements such as:

- **Nearly Zero Energy Buildings requirements** – by the end of 2020 all newly constructed buildings will have to consume “nearly zero” energy and this energy will have to be to a considerable extent, coming from renewable energy sources. Regarding new buildings owned and occupied by public authorities, this requirement must be met from the beginning of 2019.

- **National planning for increasing the number of nZEB buildings** – national plans are expected to be drawn by the Member States for increasing the number of nZEB buildings. In this programs there are different targets included regarding the building’s category and also include information on national policies, measures and targets on nearly Zero energy Buildings.

- **Elimination of the 1000 m² threshold for major renovations** – the 1000 m² threshold is now eliminated since it was excluded 72% of the existing building stock. For every current building, the same applies, meaning that when an existing structure is subjected to a significant refurbishment, its energy performance should be enhanced to meet the minimum energy performance requirements. New policies were developed which were following the leading example of the public sector to achieve the transformation of the buildings that are under renovation into nZEB.

- **Setting up energy performance requirements at the cost-optimum levels** – Member States have to ensure the minimum energy performance requirements for buildings and to them at cost-optimum levels. This standard shall be calculated based on a comparative methodology framework which is defined by the European Commission.

- **Independent control systems for EPC and inspection reports** – the authorities that are responsible for the implementation of EPCs’ control system should
make a random sampling check of the quality of the energy performance certificates and the inspection reports circulated annually.

- **Requiring an inspection report for heating and air-conditioning systems** – an inspection report shall be issued for each heating or air-conditioning system inspection and should contain the results of it along with recommendations for the cost-effective improvements of the energy performance of the inspected system and handed over to the owner or the tenant of the building.

- **Reinforcement of the energy certification of the buildings** – EPCs were initially foreseen in the first version of the Directive, but there was experienced an unacceptable level of implementation among the Member States. In the new Directive, it requires the energy performance certificates to be issued for all new buildings and for any structure that is sold or rented and to include in a recommendation regarding the energy performance improvement also based on cost-effective consideration.

Generally, in the literature, it is found that properties which are certified to have low energy demand present higher sale prices and rents. Energy Performance Certificates are not entirely mandatory in Europe and range from “A++” for exceptional energy-efficient buildings to “G” for inefficient buildings. It also contains advice on how to improve the building’s performance. This information may boost energy conservation in the building stock sector [24].

According to Brounen and Kok (2011) in The Netherlands, in a sample of properties that were sold between 2008 and 2009 and with a label from A++ to G, where A++ represents the highest energy efficiency, it was found that “A” label homes were sold 10.2% higher compared to “D” label houses. Respectively “B” and “C” label houses were sold 5.5 and 2.1% more than “D” label.

Additionally, it is reported that prospective homebuyers are willing to pay more money to stocks that have been labeled as more energy efficient or green. The selling prices are different among the label classes that characterize the building stock. EPCs create transparency and emit signals which are translated into property prices. EPC is the right path for improving energy efficiency and receive immediate economic benefits from lower energy bills and even better at the time of property sale.

The Danish energy labeling program (EMO), is a part of the EPBD national implementation. The recommended improvements in the certificate should list energy effi-
ciency measures and suggestions to be applied through significant renovations and enhance the building envelope and elements.

The purpose of labeling is for the building owner, the tenant or the potential buyer to understand without any doubts the real condition of the residence, regarding energy efficiency. Moreover, another goal of the Energy Performance Certificate is to give incentives for energy retrofitting and improvements.

Undoubtedly, the highest potential for improvements is hidden in older buildings and not in new constructions. Through energy labeling, the upgrades can be presented to the public and inform what their benefits and effects are.

Nevertheless, there are other effective ways to take advantage of labelling and motivate building stock owners to choose the right measures. Making it obligatory to give motive to landlords, taxing houses based on the certificate label and the CO2 emissions calculated in it could activate building stock energy retrofitting and by taking into account income taxes, low-income occupants could benefit more.

The process of building labeling and building certification through the guidance of the EPBD gives a unique opportunity to collect information on the characteristics and components of the existing building stock and its energy performance on a National and European level. The high variety of the building stock makes the creation of their classification important.

Responding to their needs, there is a joint effort in Europe that developed the infrastructure for exploring all the data collected by the national energy performance certificates, building energy audits, and system energy audits. These data are kept in nationally authorized electronic databases. The expectations of this try include a well-organized database and a set of an analysis tool for better organize and monitor the data collected and further deal with it by using different criteria.

Collecting and organizing the correct data is the first step towards the reveal of information that is necessary and can be used to improve the energy performance of the existing building stock [24].

According to BPIE, 97% of the buildings in the EU need to be upgraded. It states, that to present a decarbonised building stock by 2050, it is required for the vast majority of buildings inside the EU to be advanced energy efficient, complying at least, with an Energy Performance Certificate label “A”.

- 39 -
An analysis that was made by the BPIE illustrates that only a 3% of the building stock in the European Union entitles the A label. National data coming from Energy Performance Certificates is the time being the only available source of detailed information regarding the energy performance of the existing building stock. The analysis of data from 16 countries (66% of the European total floor area), shows that more 97% of the building stock must be upgraded to earn the A-label and comply with the 2050 decarbonisation vision (Figure 10).

![Figure 10: EU distribution of the building stock per EPC class](image)

*Source: BPIE*

Considering that 75% of the buildings were constructed before 1990 and before any energy performance regulation are inefficient. At the same time buildings built after 1990 cannot be considered as highly efficient. The figure that follows, it illustrates that although building performance is steadily improving in the EU, only the constructions after 2010 can be considered as highly efficient. Representing around 3% of the whole building stock validates the conclusion coming from the EPC analysis that only 3% (Figure 11) of the existing stock qualifies the A-label [25].
4.1.2 Energy Building Codes

In order to reduce CO$_2$ emissions and attain the energy saving potential of the stock, including energy-related requirement for the design or retrofit phase of a building is an essential driver for implementing energy saving measures which consecutively focus on the role of energy building codes. Many Member States introduced building codes relates with the thermal performance of buildings after the oil crisis in the 1970s.

The Energy Performance of Buildings Directive (EPBD, 2002/91/EC) was the first effort, which required all Member States to introduce a general framework for setting building energy code requirements. The Member States were required to introduce a methodology for the calculation of the energy performance of the buildings in a national or regional level with the help of the EPBD. Implementation of minimum requirements on the energy performance of new buildings and large existing construction undergoing major renovation is essential.

By the recast of the EPBD in 2010 (2010/31/EU), Member States are required to set their national legislation according to the cost optimal levels by applying an adjusted calculation methodology. This will probably present an important impact in many Members, with enhanced requirements. The cost optimal levels will converge to nearly zero energy standards as well [2].
Due to these changes building energy codes will be placed in an active phase during the next years. An expertise level is required for understanding building codes along with strictness, accuracy and attention to detail, making the codes necessary when applying energy conservation measures.

4.2 Economic

4.2.1 REITs (Real Estate Investment Trusts)

REITs appeared in the 1960s in the United States but have only been observed with a high growth from 1992 and afterwards. Europe’s market holds 18.2% of the global market. These property companies are a natural result of the relation between building retrofitting expenditures and advantages.

In precise terms, a REIT is a company that invests in real estate and owns specific tax advantages, noticeably privileges from general corporate income tax. The justification for this right is that REITs can be translated as an investment or flow-through vehicles. The higher share of the rental income of property investments (minus the operating expenses) flows through the company, untaxed as dividends to the property investor. In the majority of the countries, the investor avoids double taxation and pays taxes only once at the dividend level.

A significant advantage of REITs is that they offer to all investors and not only strong investment companies a liquid way to invest in property with no need to spend large amounts of money. Furthermore, they are managed by professional teams that theoretically can create higher returns than private real estate investors [4]. Equally essential benefits are: a. High functioning efficiency through lower operational costs. b. Wider and steadier inhabitancy rates c. Higher property prices.

REITs gradually acquire more top weight in the international investment market of real estate. Their function framework is similar for the most countries with high tax incentives, and Europe takes quick steps for the rapid spreading of this institution. Property investment companies like REITs provide an excellent tool for empirical research on the economic significance of the energy and environmental performance of the buildings portfolios [24].
4.2.2 ESCOs (Energy Service Companies) -
EPC (Energy Performance Contracting)

There is a rising interest in providing energy services as in to achieve energy and envi-
ronmental goals. More specific, there are companies which offer energy services to the
final energy consumers, and these services include the supply and installations of ener-
gy efficient equipment, and the renovation of the building stock.

Opposite to the usual energy consultants and equipment suppliers, ESCOs can also
finance or arrange to fund this operation, and their payment is directly connected to the
energy savings that are achieved. As a result, ESCOs take the risk of improving energy
efficiency in a property (building stock), and their payment as mentioned before is deli-
vered based on achieving those energy efficiency improvements. Their three main cha-
acteristics according to European Commission are [26]:

- Assurance of energy savings and/or provision of the same level of energy ser-
  vice at a lower cost.
- Compensation is directly connected to the energy savings achieved
- Finance or assist in arranging finance for the operation of the energy system by
  providing assurances.

According to the European Association of Energy Service Companies and the Euro-
pean legislation (Directive 2012/27/EU), Energy Performance Contracting (EPC) is a
legal agreement between the one who benefits and the one who provides the energy im-
provement measure. EPCs are verified and monitored during the whole period of the
contract where investments are paid for about an agreed level of energy efficiency im-
provement or other accepted energy performance criterion (Figure 12).

EPC has been in the EU since the 1980s, but it is used in Austria, Germany, Czech
Republic and Scandinavia, started in some extent in UK and France and is not used at
all in the other European Member States.
In effect, under an Energy Performance Certificate, an ESCO can deliver an extensive building retrofit, including among others, replacement of HVAC systems, insulation, building automation, Building Management Systems and RES. The Energy Service Company takes the full risk and responsibility, covering all aspects of the project from the beginning to the end. Acting as a project manager splits the renovation project into particular areas, and these areas are contracted to local partners. For that reason, EPCs are using Small and Medium Enterprises (SMEs) and simultaneously they contribute to the enhancement of the local unemployment.

Furthermore, ESCO takes for granted the risk of the project in the form of a long-term financial guarantee, and in this way ensures the materialization of the energy and cost savings. If what was agreed is not achieved then the ESCO pays the difference to the building owner [27].

In Denmark, ESCO projects are limited and present many challenges. ESCOs seem to be unenthusiastic on making sure the energy savings in residential buildings
since it is challenging and costly to control the factor that is called human actions. There is an effort to try and take the concept closer to the residential sector with ESCO-light, an idea to make energy retrofitting effortless and give assurance to building owners and investors for stable costs and energy savings. This approach can work by introducing new role-players in the market such as financial institutions, energy suppliers etc., and make them join their abilities and offer full packed services to landlords. Moreover, further interest exists in Danish social housing market. In this case, the retrofitting has to be profitable for both the occupants and the administration of the social housing department. Great considerations exist because people live in social houses are sensitive to rent increases since they have a limited income and requires high communication between the administration and the tenants [28].

4.2.3 Financing Options

There are three extensive financing options:

1. Customer financing: Usually, in this case, the customer uses internal funds to finance the ESCO that provides the savings guarantee.

2. ESCO financing: Involves own capital and domestic monies of the ESCO

3. Third-Party Financing (TPF): It refers to debt financing, and there are two different TPF arrangements, and the main difference between them is who borrows the money, the ESCO or the customer.

TPF with ESCO borrowing the necessary funds from a third party (bank) to proceed to the energy renovation project (Figure 13).

Third party financing with the client borrowing the money (Figure 14) from the third party after having the support and the agreement of an energy savings guarantee with an ESCO. This deal exhibits to the bank that the fund the customer borrows creates a positive cash flow. If a TPF is arranged, then the ESCO’s risk is lower [27].
4.2.4 Performance contracting models – Shared savings

This model refers to the cost of the saving energy. The cost savings are split for a period that the customer and the ESCO have agreed and for a percentage they have arranged. The share is not standard and depends on the cost, the length of the project, and from
the risks, the ESCO and the customer have taken as well. This model is suitable for markets that are developing, and this is due to the new financial risk of the client.

![Diagram showing the process of shared savings contracting model](image)

**Figure 15: Performance contracting models - Shared savings**

*Source: European Commission, Energy Service Companies in Europe*

The process for the shared savings contracting model is the following (Figure 15):

1. ESCO adopts performance and credit risk.
2. The client takes over some of the performance risks.
3. Possible to be linked with TPF, with ESCO financing or with a mixed situation where the funds come from both the client and the ESCO from which the ESCO repays the loan and adopts the credit risk.
4. High risk for ESCO since there is the possibility that the client goes out of business resulting no more revenues from the project.
5. In the case where the client and the ESCO come to the situation where savings exceed expectations, this might create opposing relations considering that the ESCO may try to drop the energy savings estimation and receive more from the excess savings.
6. The above situations can be handled by stating in the contract a stable energy price and none of the two sides’ gains or losses from the energy price fluctuations.
4.2.5 Performance contracting models – Guaranteed savings

For this model of performance contracting the level of energy saved is measured. The ESCO guaranteed a particular level of energy savings and shelters the client from any performance risk [26].

Likewise, the process for the guaranteed savings contracting model is analyzed through the following steps (Figure 16):

1. ESCO takes over the entire design, installation and performance risks.
2. ESCO does not adopt credit risk of repayment by the client.
3. Project financed by the customers who can borrow money banks or other TPF organizations.
4. Lowest financing cost due to the limitation of the bank or TPF risk who assess and handle the client’s risk.
5. The client repays the loan to the TPF and adopts the investment repayment risk.
6. If the energy savings are lower than expected and cannot cover the debt, then the ESCO covers the difference.
7. If the energy savings exceed the expectations, then the client grants a pre-agreed percentage of the exceeded savings to the ESCO.
8. The guarantee is useful if the energy saved is enough for the client to meet the dept.
9. Payment schedule is based on the level of savings and this means that the more the savings are the faster the repayment.

4.2.6 Main problems on various investments

In what concerns building retrofitting investments the main difficulties are the following:

1. *Changing energy prices* – Energy prices are not aligned with energy and GHG emissions potential savings and in this way they contribute to improving the costs of energy retrofitting investments. The taxation should take into consideration the building and not the electricity of the building and also incorporate carbon taxation as well.

2. *Inadequate decision making* – The decision action includes many actors (building owners, tenants, energy service companies etc.) which frequently do not possess the right skills and/or the correct information to take the appropriate decision intelligently. Actors prefer to save money upfront than saving through future energy bills.

3. *Simple market failures* – Investors usually duel with information problems and high transaction costs. There is a high imbalance of information regarding the quality of materials, and generally, lack of knowledge creates a low performing energy retrofitting market.

Moreover, the building sector presents a lot of diversions, and the degree on which the principal difficulties apply to a particular investment can depend on the following.

1. *Building ownership* – A building may be publicly or privately owned. According to statistical data in most cases and most member states, they are privately owned. In the case of publicly owned buildings, the investor may be challenged with additional institutional failures like “not my business” issues. From the other hand, in privately owned buildings and when the owner is not the occupant, the refurbishment will not be beneficial for him and does not have the motive to pay for such an investment and vice versa.

2. *Building use* – Buildings are separated in residential and commercial. Energy use in residential buildings is usually not well monitored compared to commercial buildings. Thus, it is not that easy for the energy experts to choose the right energy retrofitting measures.
3. **Housing arrangement** – There are various kinds of inhabitancy arrangements. There are buildings with a single owner and user (e.g. detached house), buildings with a sole owner and multiple users (e.g. social houses), buildings with numerous owners and users (e.g. apartment blocks).

4. **Type of refurbishment** – There might be various options to reduce energy consumption and GHG emissions. These possibilities can differ depending on the initial capital cost, the payback period or the technical complexities. For example, during the renovation of building it could be more comfortable from a technical point of view to install RES and create a well known net-zero energy building than to upgrade and invest in the envelope of the building and replacing heating and cooling systems.

5. **The time that the refurbishment occurs** – These difficulties can be entirely different, and they depend on whether the retrofitting investment is connected with alternative maintenance works or is made separately. For example, in a replacement and improvement of a wall insulation, the payback period can be much less if it is combined with generic retrofitting measures.

Researchers from the EU, believe that by making the development of national action plans mandatory and at the same time oversee their implementation is a path in which the European institutions can ensure commitment to the problem on a national level.

For this development to come there is a need for the member states to create a survey regarding the energy performance of the existing building stock in Europe (TABULA) and inventory for the energy and GHG savings potential. This plan shall also include a set of middle targets and some milestones along with their definitions.

### 4.3 Social

#### 4.3.1 Ownership status - Tenants and Landlords

As stated before, minimizing buildings’ energy consumption is essential, for the environment and the reduction of energy dependency as well. There is a wide range of opportunities to take cost-effective measures and improve energy efficiency.

Additionally, growing energy prices physically increase the economic importance of energy consumption. Nevertheless, the most significant problem is to gain the confidence of the decision makers (building owners, property investors and facility manag-
ers) and assure them for the cost-effectiveness of energy renovation. Therefore the following questions arise:

1. How can decision makers be motivated to proceed to renovation projects for higher energy performance?
2. How can sustainable retrofitting and renovation be brought to the market and be driven by economic reasons?
3. What happens in the case the property is rented? Should the landlord proceed to the retrofitting despite the tenant’s use?

There are no correct or wrong answers to these questions but there are answers that depend on the owners, the buildings use and typology, the regional or national legislation etc. Moreover, there is no single solution for the tenant/landlord problem. Essential barriers to this issue seem to be economical and informational and not technical since there are many solutions developed from the technical point of view.

The tenant-landlord complication [28] takes place when there are obstacles and differences between the two sides on agreeing upon a parallel strategy for the energy refurbishment of the dwelling. The landlord provides the tenant with the housing, appliances and installations but the tenant pays the energy bills. It is evident that the owner does not want to invest in energy efficiency and at the same time the resident pays the rent and wants to lower the energy expenditures, by reducing the energy consumption which depends on the condition of the property.

In most cases in Europe, the tenant pays for the energy bills and is reasonable for the landlord to have no incentives to invest in the energy performance of the property. In Denmark’s case and whole Europe as well, sooner or later, energy renovation will be mandatory, and landlords will make the investments. This is complex though because the improvement is financed by the tenants and through rent increase.

Equally important to mention, is that tenants’ feel that since they do not own any property, it is unrealistic the fact that they compensate and finance landlords’ obligation to enhance the property’s energy performance.

On the contrary, the property owners use as an excuse that most of the energy refurbishment benefits are delivered at a high degree to the tenants, and use this assertion for increasing the property leash. The correct balance has to be found for this issue, and high significance arises on forecasting the money that both parts gain and share after the completion of a building stock refurbishment.
According to IEA, the barriers like economic, informational and excitement for new constructions create a difference between the level of actual energy efficiency and the possible level of cost-effective higher efficiency, and this difference is called the efficiency gap. This gap, along with the drawbacks as mentioned above and benefits is illustrated Figure 17 create the tenant-landlord issue.

* B. Astmarsson et al. state that improving legislation regarding rents is necessary to overcome the tenant/landlord issues in the Danish residential market. The law should explain precisely how much the building owners are allowed to increase the rent and give the right to the tenants to accept or reject the rent increase.
4.3.2 **Energy Poverty - Vulnerable population**

According to BPIE, energy poverty is a massive problem in Europe. It is estimated that between 50 and 125 million people are unable to afford to keep a proper indoor thermal comfort in their households. It is a fact though that there is not a typical definition in the European Union for energy or fuel poverty.

Furthermore, despite the full range of the problem, the EU does not have a logical approach to identify people living in fuel poverty. Nevertheless, the significance of this issue as well as the severe health impacts caused by fuel poverty such as winter deaths, mental disability, respiratory and circulatory problems, are in a wide range recognized and affected by energy poverty.

Additionally, a way to assess the length of the problem according to BPIE study “Alleviating Fuel Poverty” is to describe the current situation of fuel poverty in Europe by using data from Eurostat and specific indicators that show the extension of energy poverty issue [29].

4.3.3 **Statistical Data**

Energy or fuel poverty and general economic poverty are two different situations, but they are well connected. Since 2009, the public financial crisis plays an essential role in increasing the number of people living close to poverty limits.

Researches show that 10% of the Europeans are energy poor. Thus, half of the poor people in Europe live within the four most abundant Member States (Italy, Germany, UK, Spain), but the countries that present the highest rate of poor people as a percentage of their population are Bulgaria, Romania, Latvia and Greece. Furthermore, 10.8% of the total population in Europe was unable to keep their households in an adequate thermal comfort condition, a percentage that grows to 24.4% concerning vulnerable and low-income people.
Furthermore, in 2012, almost 25% of the poor people in the European Union is not able to keep their households warm enough, also with an extra 8% of the people who are not considered weak but face the same problem (Figure 18).

After 2009 and until 2012 (Figure 19), Greece, Cyprus, Italy and Spain present the highest increase in rates of energy poverty in Europe, while at the same time only six countries among the 28 Members show a decrease. Bulgaria and Lithuania are the two countries with the highest rates of households that are unable to be kept adequately warm and are followed by Mediterranean countries (Greece, Cyprus, and Portugal). On the other hand, in cold northern nations, we would expect a high percentage of the fuel poverty in households, but it is noticed that the rates are falling.
4.3.4 Definition

The first official definition came from the UK in 1991 and stated that “a household is considered to be fuel poor when it needs to spend more than 10% of its income to fuel or energy to maintain an adequate level of warmth”. Globally the term energy poverty illustrates the lack of access to essential energy services. At the same time, in the EU the problem of accessibility to energy services has been solved, but the affordability of energy services remains [29].

Even though there is an absence of a standard European definition, the European Council Directive 2009/72/EC recognizes, not only the existence of the problem but that is an evolving issue that needs a straightforward handling. The same Directive mentions the connection that exists between fuel poverty and vulnerable consumers since it states that “each Member State shall define the concept of vulnerable consumers which may refer to energy poverty and, among other things, to the prohibition of disconnection of electricity to such consumers in critical times”.

4.3.5 Vulnerability, older adults, health impact

Since vulnerability and energy poverty share similar directions like low income and the poor quality of the existing building stock, energy poor people are likely to face oth-
er aspects of vulnerability as well, like housing status, individual circumstances, market conditions and social context (Figure 20).

![Figure 20: Further aspects of vulnerability through fuel poverty](source: BPIE – Alleviating fuel poverty)

Moreover, even though there is an unclear connection between fuel poverty and vulnerability, the European Commission, clearly explains through its study “Energy roadmap 2050” that dealing energy poverty should be a mandatory assignment at a national level. Thus, vulnerable consumers might need a further straightforward assistance: “*Vulnerable consumers are best protected from energy poverty through a full implementation by Member States of the existing EU energy legislation and use of innovative energy efficiency solutions*”.

European Union statistics (Figure 21 - Figure 22) make use of three variables that are commonly used as proxies of fuel poverty and can be used to describe and measure the problem:

- *inability to keep home adequately warm*
- *dept of utility bills*
- *presence of leaking roofs, damp walls, floors or foundation, rot in window frames or floor*
Additionally, it is found that financial interventions are crucial indicators for the short-term protection of vulnerable people. In the long-term, energy efficiency measures that mainly focus on retrofitting buildings are the main component of addressing energy poverty. There is also the need for robust motivation so that low-income households are encouraged to implement energy efficiency measures. Moreover, raising awareness, transparent energy bills and information on prices and their comparison are essential to make the best energy-related choices. After taking into account many descriptions of the issue, and using the previous indicators to measure it, the conclusion arises that energy poverty is mainly created by:
- low household income (relative to the property’s size)
- high energy pricing
- low energy efficiency of the inhabitancy

It is also significant to mention that a number of countries do not currently identify or quantify vulnerable consumers and cannot adequately take any measures for energy poverty. As mentioned before, less than 33% of the EU countries officially recognize energy poverty and even fewer have an official definition on their national legislation.

One of the latest publications by the European Commission (2015) presented that although many European countries have implemented measures to protect the sensitive population, almost 11% of the EU’s population is in a position where they are facing the fuel poverty phenomenon. This situation is estimated that will affect around 54 million people in Europe and is related with rising energy prices, low income and poor energy efficient homes.

Energy poverty is also well connected with human health, older adults and children. An important fact regarding this issue is the estimation that in 2050 there will be twice as many seniors (above 65 years old) compared to 1990. Older adults considered as a group that are the most exposed to fuel poverty due to the fact they have lower income than the young and active teams, they usually need higher indoor temperatures, and they are more exposed and sensitive to diseases, and they have enhanced risks and lower desire for investing in their households. There are also studies showing that “the infants living in fuel poor homes are associated with a 30% higher risk of admission to hospital of primary care facilities”.

As an extension, low indoor temperatures are determined by low energy efficiency of the building design or the heating systems, low household income and high fuel prices. Various studies have illustrated and examined the connection between fuel poverty and health impacts, like:

- indoor cold and mortality
- indoor dampness, mould problems and childhood asthma
- housing quality and mental health

4.3.6 Solutions
It makes sense, and there are also studies showing that if fuel prices increase faster than income, the energy poverty rises and consequently Europe will move further low into
energy poverty. One main reason is the economic crisis that has extended the imbalances in income distribution and also the rise of the vulnerable population.

Energy pricing regulation and financial support to low-income households are a brief solution since they are active measures and have a high dependence on various economic factors. Social tariffs and energy subsidies are not sustainable and efficient measures, and these solutions do not help to tackle the problem.

On the other hand, many studies have illustrated that possibly the only long-term and sustainable solution is to enhance the energy efficiency and the energy performance of the building stocks that belong or occupied by the energy poor people. This solution will result in reduced energy bills and improvement of the indoor thermal comfort. Moreover, it is estimated that enhancing energy performance will benefit in improving social aspects as well, the values of the properties will be improved energy subsidies will not be needed at the same level (Figure 23).

![Figure 23: Benefits of building stock energy efficiency](image)

*Source: BPIE – Alleviating fuel poverty*

Therefore, the most correct and effective solution and answer to the energy poverty problem is given by improving buildings energy efficiency and enhancing their energy performance. Assistance in the form of fuel and income should be viewed as filling measures for poor energy households and temporary circumstances or maybe for emergencies. Furthermore, public budgets would be considered more cost-effective if they
are progressively shifted for delivering improvements of the buildings' energy performance. The European Commission working group on vulnerable consumers has agreed that “measures such as homes’ insulation or the replacement of inefficient heating systems represent both long-term supports to move consumers out of energy poverty and a concrete step towards Member States meeting the EU 2020 energy efficiency targets”.

Nonetheless, energy efficiency measures which improve the energy performance of the building stock require compelling investments. Consequently, inhabitants that are property owners dealing with energy poverty have lower probabilities of possessing the capital needed, but on the other hand, in the case of private renters, landlords usually lack incentives to invest on the property as analyzed in a previous chapter. It is clear now that measures depend on the availability of national financial schemes and supervisory authorities that can provide sufficient means to the earlier problems.

There is a need for modernized strategies to assure adequate funding for deep energy retrofitting on the European urban building stock. Planning both on private and public investments and taking account the best practice examples from all over Europe. New and modern ideas are necessary since deep retrofitting although its cost-effectiveness is intensely costly and the high up-front cost required, is typically the most critical barrier.

4.3.7 Reducing Energy Poverty
There are some European Member States that have developed long-term renovation strategies. Those strategies are an excellent opportunity to reduce energy poverty by activating deep retrofitting of buildings. BPIE’s policy factsheet, “Reducing Energy Poverty with National Renovation Strategies: A Unique Opportunity” describes that the Member States the chance of achieving the triple goal of increasing the rate and depth of renovation, delivering energy savings targets and enhancing the thermal comfort conditions of vulnerable citizens should not be missed. The policy recommendations of the BPIE factsheet are the following:

- Article 2a of the EPBD should demand the Member States to establish specific measures and financing instruments into their retrofitting strategies to decrease energy demand and to assist in the mitigation of energy poverty.
- Implementing national schemes for renovating low income and energy poor households can be intensely cost-effective taking in mind the spread health, so-
cietal and economic benefits that arise through renovation. The budgets from energy allowances to the energy poor should be changed into energy retrofitting strategies.

Lastly, deep retrofitting or deep renovation presents extensive benefits for society and the public spending. Enhancing indoor thermal comfort and indoor air quality, illnesses and premature deaths connected with living in cold and damp homes can be bypassed and mitigate the pressures in the healthcare and social services. Furthermore, the construction sector will also gain from increased renovation activities, and further new jobs will be created [30].

4.3.8 Private Sector and energy poverty

Energy costs of a household are growing faster than household income. Receiving a social allowance as a boost, or regulating energy prices are used to tackle the energy poverty problem and is not an efficient way to do so. The public money is spent and not invested in a permanent and sustainable solution. A viable solution is the deep energy retrofitting of the existing building stock, taking the problem back into its roots. Energy retrofitting of the building stock in Europe will bring results such as “increasing the warmth and the thermal comfort of the households, decreasing energy bills, improving the quality of the inhabitancy, meeting EU environmental and energy targets”.

It would be a proper solution for this problem to get help from the private sector since public policies are not efficient enough and there are not much funding coming from governments. Stimulating private companies like REITs, ESCOs and commercial banks etc. by giving them the right tax incentives for investing in the energy efficiency of the urban building stock could be the way to go for the next years. By funding retrofitting, new jobs will be created. Thus, income will increase, energy performance of the buildings will grow so will be the indoor thermal comfort, and the energy bills will fall. All the above contribute to deal and try to alleviate energy poverty.
5 Policies from EU countries

There are various policies implemented in most of the European countries. In this subchapter, some of them will be illustrated to examine and understand their advantages and disadvantages. Data were mostly taken from BPIE survey in 2012 and other scientific papers as well, and the vast majority of these schemes and policies take into consideration fuel poverty. Third party financing is incorporated in the following policies as well.

United Kingdom is a country that first defined energy poverty in its legislation and implemented support schemes for income subsidies. Still, the first energy efficiency plan which should be more effective regarding energy poverty did not work and mistakes occurred. Nevertheless, UK is the first Member to implement strict measures in the building energy codes.

In Germany, private sector contributes at a significant level for implementing energy efficiency measures. More specifically, collaboration exists between private KfW Bank and the government. Furthermore, the classification of the building stock is significant in order to carry on calculation methods regarding the energy performance of the stock. Application occurs through the building energy codes, and the higher the calculated performance of a renovation project is the higher the grant or loan will be given. Nonetheless, higher incentives for the stakeholders need to be given in order to increase the renovation rates.

Moreover, Ireland is a country that has suffered from the general economic crisis and energy poverty as well exhibiting high rates. Through effective energy efficiency schemes, energy poverty rates were significantly reduced, but after a point, the budget was mainly allocated to income subsidies. However, a new scheme was initiated in 2017, giving many incentives to citizens and especially to the energy-poor.

Lastly, the Netherlands illustrates a holistic scheme which is adopted by other Member States as well. This scheme incorporates an energy coordination team with a purpose to organize all the stakeholders of a building retrofitting. It gives many incentives, works together with governments to improve energy building codes, involves a funding model which eliminates the costs and secures the investments and the energy performance of the building stock. Also, it is essential to examine building typologies
and building stock classification in each country, since the programme starts with a specific group of buildings (usually social housing) for achieving better prices from industry and then continues to other classes.

5.1 United Kingdom

In the UK, a country that recognizes fuel poverty, income support programmes represent 70% of the overall fuel poverty budget, and at the same time, energy efficiency measures represent only a tiny percentage. The total budget opposing fuel poverty has been decreasing since 2011, and this decrease mainly reflects energy efficiency measures which nevertheless as mentioned before are confirmed as the most efficient (Figure 24) [29].

![Figure 24: Total fuel poverty public budget in the UK (2009-2014)](image)

Source: BPIE - Alleviating fuel poverty

Moreover, United Kingdom introduced in 2013 the “Green Deal – Pay As You Save” scheme which was in force until 2015, (an idea that was also adopted in Germany) a program that allows homeowners to enhance their residences, their heating systems and implement RES. This plan would benefit the customers with lower energy bills and would increase the energy security of the country.

The idea was the following, a property owner could use private funding, to support the initial cost of the energy efficiency measures to be implemented and the main prin-
ciple was that a bank was backed up by the government that would allow lending money with attractive interest rates.

Still, as it was mentioned earlier after 2013 the budget for energy conservation programmes was decreased in the Kingdom. The lack of the “Green Deal” was that the lending money was limited according to the expected energy savings of the measures implemented. Many properties didn’t exhibit enough savings in order to get the initial capital and pay for the improvement measures. Hence, the scheme could not work in practice.

Furthermore, in the United Kingdom, the Energy Act 2011 makes the government force regulations into the national building codes by April 2018 making it illegal to lease properties in England and Wales that do not meet the recommended minimum energy performance standards (MEPS). A minimum energy standard of an EPC rating of ‘E’ will be set from April 2018, and this means that any properties with a rating of ‘F’ or ‘G’ will not be allowed to be rented out without specific energy upgrades.

Someone can agree that this policy seems to be an essential first step to deal with energy poverty and to reach the energy targets that were set by the EU.

Hence, the “EnergieSprong UK” initiative applies; though in an early form, and it is an “energy facilitator” programme with the purpose of implementing energy efficiency measures in residences providing an extended performance warranty, a fast refurbishment, taking funds from savings in energy costs and creates attractive neighborhoods.

Lastly, the “Green Deal” scheme is expected to be relaunched after 2017 with some improvements, especially in the funding part. Some characteristics might be adopted by the German KfW efficiency house model.

5.2 Germany

The following methodology is adopted in Germany, to evaluate the impact of policies which might be able to boost the level of energy building renovation activity. The investment in energy retrofitting measures can become more attractive, after setting in motion the steps below.
1. **Evaluate the present building stock**, categorized by sector, and considering all the possible stock changes (e.g. demolition)

2. Describe the **three renovation packages** according to the different levels of improvement in the performance that a building might have.

3. **Calculate** the delivered energy demand for every package and every building component.

4. Definition of a set of various economic parameters, which **affect the cost-effectiveness** from the investor’s viewpoint (e.g. energy prices, interest rate etc.)

5. Calculate the investment costs and **outcome of the energy savings for every combination** of buildings and renovation package.

6. After acquiring the calculation from step 5, the **least costly package** should be selected.

7. Estimate the cost of energy savings as the ratio between the net value and total energy savings. If the result is positive, then the renovation measures are not cost-effective.

8. Plan the output results as Energy Saving Cost Curves to allow quick and easy visualization and comparison between various scenario results.

According to the precious steps, Germany has implemented one of the most completed financial support arrangement in Europe regarding energy efficiency investments. This scheme is managed by the **KfW development bank** and has been praised both in the country and abroad as a model that significantly helps for the financial support for upgrading the energy efficiency and energy performance of the existing building stock. One out of three retrofitting projects is backed up financially by the KfW scheme [33].

This program helps property owners and other energy consumers with energy performance improvements via financial motives in the form of grants or loans for a complete renovation to reach specific energy performance levels or for individual measures. The performance levels are merely established by the calculated performance of the property with **ranked motives for different performance levels**, and this means that the higher the level of the calculated energy performance of the building the higher will the financial assistance is (Figure 25).

More than 3.8 million dwellings have been constructed or renovated since 2006 and furthermore, many researchers and studies have shown the positive effects of these in-
vestments for the German economy and the German building sector. It has created new jobs, energy cost savings and the reduction of CO₂ emissions.

Despite the fact that there is such an efficient scheme for energy retrofitting of the building stock, in Germany, there are no differences in the renovation rate which is the same as the average European level, more or less at 1% every year. Another significant clue is that only in one out of three renovations is noticed implementation of energy retrofitting measures [4].

<table>
<thead>
<tr>
<th>KfW Efficiency House “Level”</th>
<th>% of project cost subsidized</th>
<th>Maximum Grant Amount (Euros)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency House 55</td>
<td>30%</td>
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<tr>
<td>Heating or Ventilating Package</td>
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<td>7,500</td>
</tr>
<tr>
<td>Individual Measures</td>
<td>10%</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Figure 25: Germany KfW Bank granting single family homes

Source: www.kfw.de

If the national targets for 2020 and 2050, regarding energy and GHG emissions, need to be achieved, the power retrofitting rates have to be considerably increased. Although there is a high public and political support for the energy transition there also a top clash about the level of ambition, the best rate of renovation and the level of financial help. All types of improvements and especially energy retrofitting projects need to become more and more attractive especially from the investor’s viewpoint.

Moreover, the property owner can receive extra funding for supporting the construction supervision by an expert and for other services and technologies as well. KfW can further offer complete loan offerings. Additionally, in Germany, the Federal Office for
Economic Affairs and Export Control provides grants for the installation of heating systems with RES, solar thermal energy, heat pumps and a boost on heating systems.

Furthermore, in April 2017 the “EnergieSprong” programme also started in Germany. After examining the results in The Netherlands, the Ministry of Energy in Germany has allocated a budget to fund a team that will develop the market for the upcoming three years. The German energy agency “data” is in charge of the management. The Ministry of Energy believes that this scheme will bring many results in retrofitting the building stock and come closer to achieving 2020 and 2030 energy-related targets.

5.3 Ireland

A Member State that has suffered a lot from the economic crisis is, Ireland. In 2012, almost 1.32 million people were at risk of poverty and 20% of the households were estimated to suffer from energy poverty. This is why the Irish government initiated the “National Fuel Scheme”, the “Households Benefit Package” and the “Better Energy Warmer Homes Scheme” [29].

The “Better Energy Warmer Homes Scheme” is a part of the wider “Better Energy Programme”. It is considered by the Department of Communications, Energy and Natural Resources as the “primary mechanism by which low-income households are protected and represents the ideal mechanism through which efficiency based supports are channeled”. The “Better Energy Warmer Houses Scheme” provides advice and funds for implementing energy efficient measures for low-income households and targets explicitly energy poor and vulnerable people. From 2000 to 2013 95,000 dwellings were financed including measures like attic insulation, dynamic lighting etc. In 2010, the Irish actions achieved a 25GWh reduction, and many beneficiaries got away from energy poverty. However, the funds allocated for this programme in 2012 were substantially reduced in 2014 [29].

Moreover, low-income people have access to the “National Fuel Scheme” that supports the eligible citizens with 20euros/week for 26 weeks to cover their heating needs, and since 2012 410,000 people received this aid. To continue with, for the “Household Benefits” package almost €284 million was spent per year for energy subsidies. By noticing Figure 26, it is assumed that the scheme which supports energy efficiency measures takes the lowest share of the fund’s allocation of the energy poverty budget. Never-
theless, the “Irish Warmer Homes Scheme” and the general “Better Homes Scheme” is one of the most successful policies that took place in Europe.

![Figure 26: Ireland, budget allocation for supporting policies (2004 – 2014)](image)

Source: BPIE - Alleviating fuel poverty

According to an article published in June 2017 by the Sustainable Energy Authority of Ireland (SEAI), deep retrofitting of the existing Irish building stock is one of the most significant energy efficiency challenges of the country and also a considerable chance for enhancing economy and employment.

Thus, the “Deep Retrofit Pilot Programme” was launched in 2017. It was created by SEAI to tackle the energy efficiency challenges in Ireland and upgrade the existing building stock. The initial scope of the programme is the residential sector. A basis on the “Warmer Homes Scheme” exists regarding the eligibility criteria. It is a pilot programme with a higher goal of large-scale energy retrofitting projects. The programme includes a great update on buildings towards zero energy requirements. SEAI will provide 50% funding of the total capital costs and project management costs and a further funding up to 95% energy-poor households.
5.4 The Netherlands

Many successful all-inclusive renovation programs and models include a kind of “energy renovation facilitator” that serves as project coordinator to accumulate engineering and architecture firms, renovation contractors and of course financial aid.

One of the most recognized and complete in-depth energy retrofit initiatives which include such a facilitator duty is the “EnergieSprong” model or “Stroomversnelling” which is the Dutch EnergieSprong (Dutch for “energy leap”). EnergieSprong is a private initiative that wants to deliver desirable, comfortable and affordable homes for everyone and life. The programme provides refurbishments:

a. With a guaranteed (30 years) performance by introducing a new financing concept.

b. With government collaboration to improve the regulatory framework for efficient solutions.

c. With fast renovations which hold for less than 2 weeks.

A modern and holistic retrofitting process and funding approach which began as a part of the Dutch government-funded innovation program for social housing. “EnergieSprong” provides whole integrated retrofitting packages with lasting performance security that makes the solution commercially fundable and expandable [10].

According to energiesprong.eu the refurbishment of this programme comes with a 30-year warranty, the project funds come from the money that would typically spend to pay the energy utility bills and maintenance costs. The end goal for the owners or the tenants is to get an enhanced and more comfortable residence with no additional monthly expenses.

By 2016, 1,170 residences in The Netherlands had been a part of the program with an important percentage of which to be already upgraded. The national objective is to upgrade 111,000 properties to nearly zero energy performance in the years to come.

It is beyond any doubt that the more complete targets and directives approach are revealed in Europe, the path will lead the EU countries and their energy strategies to more holistic policy packages that also include funding and financing [34].
5.4.1 EnergieSprong

EnergieSprong is a radical approach regarding deep house retrofitting, new built standard and funding. Its birth occurred in the Netherlands in 2011 and started as a public-funded innovation programme and has established new standards in the market. EnergieSprong is an international programme now and its purpose is extending this approach to other markets as well. It attracted two major European funds from the Horizon 2020 project and an Interreg North-West Europe project.

Furthermore, for the implementation in each market, it uses the social housing sector, looking to be extended at a later stage to the private residence market. The team aggregates mass demand for high quality retrofits in a market and develops the correct financing and regulatory conditions by collaborating with each government differently.

Now, Stroomversnelling is the Dutch EnergieSprong network which coordinates the collaboration between all involving stakeholders to achieve implementation and application of energy efficiency measures. Its network is composed by contractors, component suppliers, housing providers, local governments, TSOs and other parties. The main goals are to reduce the cost of deep renovation projects, make it popular to the building owners and occupants and increase the acceptance and growth of such projects [34].
6 METHODOLOGY

6.1 Targets – Energy Codes – EPCs - Financing

According to IPEEC (International Partnership for Energy Efficiency Corporation) and the study “International Review of Regulatory Policies”, there are many regulatory policy instruments implemented in the EU as guidance for energy performance enhancement in the existing building stock. A number of policy elements and tools exist globally, addressing building stock energy retrofitting. Some of them seem to be successful and some are not. The building energy codes alone will not result efficiently in building renovations and without other schemes, policies and programmes they will not result at all, especially when deep energy savings are in need.

Alternatively, energy codes can be a part of a more holistic policy programme and become the solution in order for advanced energy savings to be delivered.

Thus, best practices occur in many member states both in development of complete energy policy targets and also in the implementation of specific building performance regulations resulting in more efficient existing buildings both in national and even better at a regional level.

According to IPEEC, the policies that seem to hand over the most significant activity in energy retrofitting of the existing buildings are the following:

1. Complete targets for improvement. These targets should be supported by fundamental policies and initiatives. This includes legislative framework, financing and informational promotions proposed to all kind of stakeholders. By these targets the long-term ambitions can be set at a high level and the energy performance requirements will be constantly upgraded.

2. Acknowledgement of energy performance. Authorities tied to a purpose. This purpose is to improve the energy performance of the poor performed building stock. There is a high potential of improvements although the political challenges at the stage of implementing and enforcing the policies.

3. Connect financing schemes to deep savings. Simply, by giving categorized incentives. A scheme that promotes “the deeper the renovation the higher the reward” could greatly impact the markets.
4. *Create roles for “renovation facilitators”* in order to guide the various policies and the stakeholder groups needed. These roles seem to be very useful when implementing deep renovations.[35]

These four policies are going to be further analyzed in the following sub-chapters.

### 6.1.1 Set up the renovation targets

Firstly, the set up of renovation rates plays a significant role for the reduction of building energy consumption. Those targets should set the goal for the reduction of building energy consumption over a period of time, using a group of buildings or a specific sector (i.e. public buildings). Thereafter, these targets become the principle for implementing more policies (e.g. for a higher number of buildings) which will help meet the initial target. In some EU countries, policies have organized requiring a particular percentage of buildings to be retrofitted in terms of energy performance annually [35].

**Figure 27: The steps towards creating the correct policies**

*Source: IPEEC*

Furthermore, actions by the European Commission, to create a movement for significant retrofitting, are decided in article 4 of the Energy Efficiency Directive. The article states that “*the Member States shall establish a long-term strategy for mobilizing investment to renovate the national stock of residential and commercial buildings, both public and private*”. Moreover, some requirements, established in the Directive, combine to support the renovation process:

a. Energy saving obligations
b. Renovation strategies

c. Dedicated financing mechanisms

The long-term strategies of the EU countries for mobilizing investment in the renovation of their national building stock must contain policies and measures to encourage cost-effective primary energy retrofitting in buildings. At the same time, with the lure to encourage investments in deep renovation, the EPBD provides a definition for significant renovation, and the Member States must set minimum energy performance requirements for buildings that are subjected to significant renovation with a purpose to achieve cost-optimal levels. All necessary measures must be ensured in a national level, for these minimum energy requirements to be achieved.

While most targets are established for a specific sector or sub-sector of the building stock, France uses a new and original policy approach: retrofitting commercial buildings is mandatory and individual buildings are required to present a “plan for renovation”. Plan for renovation means that they are required to develop plans for a significant discount in their energy consumption by at least a quarter of their 2010 performance level, and those plans must be implemented within a specified time period (in 2017). France further investigates mandatory retrofitting for private residential buildings whose primary energy consumption exceeds 330kWh/m² (EPC ratings of F or G) before 2025 [35].

6.1.2 Energy codes for retrofit

The majority of the building codes were developed to affect the energy efficiency and the energy performance of the new buildings. Nevertheless, there are many cases where the building codes also apply for the retrofitting of the existing building stock. The EU countries differ in the scope of their building codes, and this is mainly due to the many differences between the building stock classification for each country (size, typology and others).

Most of the building codes though are using specific rules regarding specific building elements (e.g. U-value) and performance approaches, which demonstrate that the building meets the requirements at least as it was designed. The current use of the building, its depletion and the user’s behaviour play a significant role in the building stock performance.
Moreover, in Sweden, there is a new trend of energy regulation, which is known as “outcome-based” codes. In this model, the conformity is determined by measuring of all the energy being used by the existing building and the elements that consume energy and are associated with the building site. The building is measured on a full operation, and a “Target Energy Use Intensity” (EUI) is established. The building must present a calculated EUI less or equal to the energy target set by the regulation.

Additionally, another essential regulatory mechanism that has much impact on the energy performance of the stock is implementing and improving the building equipment "minimum energy performance standards" (MEPS). Standards regarding equipment that consume energy have to be replaced at the end of their useful life. Still, MEPS do not affect the same like the walls, roofs and windows do [35].

6.1.3 Mandatory Energy Performance Certificates
Mandate transparency in building energy performance is a global trend. In EU, EPCs allow all the stakeholders to have better information on energy performance.

Europe’s EPBD requires by all Member States and through their building codes as mentioned in the previous chapter to have policies for issuing and displaying Energy Performance Certificates (EPCs) when a building is constructed, sold or rented. Furthermore for buildings occupied by public Authorities over 250m2 which are frequently visited by the public. EPCs are issued for the consumers to understand the performance of the buildings and most importantly to provide information on potential improvements.

An important policy that will and should be implemented in national energy policy schemes is to prohibit any sale or lease to those residencies and buildings that present energy performance rating under a specific threshold. Consequently, data can be taken regarding the rating from EPCs.

The abovementioned policy can be found in UK’s “The Energy Act” scheme which commits the government to make it illegal to lease properties which do not meet the MEPS. As from April 2018 all rented properties will be expected to meet a minimum level of EPC rating of E. By this policy all dwellings characterized by an EPC rating of F or G will have to be mandatory refurbished.
6.1.4 Financing motivation

Energy policies should include not only the minimum energy performance requirements through energy codes but also incorporate financing and inducement schemes so that property owners can recognize energy-saving opportunities and improve the financial return on performance improvement investments [35].

German KfW Bank has implemented one of the most successful programmes of this policy instrument. As mentioned in previous chapters, this scheme helps property owners and any other kind of energy consumers with energy performance improvements via financial incentives, which are provided as grants or loans. These funds are given for either complete energy renovation to achieve a stated performance level or for individual measures.

Furthermore, homeowners can also receive financial aid for getting support from a construction supervisor. Continuously, the Federal Office of Economic Affairs and Export Control in Germany gives grants for the installation of heating systems with RES, solar thermal energy, heat pumps and improvement of the heating systems.

The German scheme is a complete program that incorporates both private investing and public funding to achieve targets.

6.2 Implementing Energy Codes - Policies

In Europe, national governments are very influenced by the requirements they get from the Union. Directives like the EPBD and the EED make the role of the EU very important and accelerate the implementation of various building regulations and policies in a national level.

Professional and academic societies along with international collaborations like International Energy Agency also have a part in the establishment and implementation of policies.

Furthermore, it is important to mention that despite the fact that energy building codes are adopted in a national level, their implementation take place at a local level. Local building authorities present inadequate resources for supervision and imposition of the standards and directives that are introduced. Thus, they are often understaffed.
After interviewing experts at local levels, IPEEC concluded that energy codes are most of the time in the group of the lowest priorities.

Moreover, energy codes alone are not enough to deliver significant energy savings. Their application is limited to the existing rate of renovation of the building stock annually (1%), and their compliance is a problem with no incentives given.

Consequently, a complete package of comprehensive policies is needed and along with energy codes will overcome the different issues to improving the building performance. A particular IPEEC BEET project, “Building Energy Efficiency” concluded that if the national and regional governments want to realize and secure a more energy efficient building sector, it is imperative to “establish ambitious, concrete and effective policies and programmes”. A comprehensive approach is required regarding design, development and implementation. For that reason, to speed up the transformation of the market and collect every possible efficiency benefits with almost no cost, the following should be attempted according to the national circumstances:

- Regulations and legislation
- Incentives
- Labels
- Voluntary schemes

The existence of international best practices (KfW Bank, Germany, EnergieSprong), have demonstrated that holistic policies which include regulation, financing (private and public), information and other plans have presented the most significant positive effects. It is also a fact that implementing those policies at a subnational level might give more ambitious results [35].
6.3 The steps forward - Recommendations

The following Figure 29, Figure 30, Figure 31, Figure 32, past, current and future policies are demonstrated among UK, Germany, The Netherlands and Ireland. There is also a grade-column next to each plan, which represents their effectiveness. The grading system is simple and is constituted by plus and minus score as explained in Figure 28. Starting from (-) serving policies rejected by the author; reaching the top of (+++) which will be used in the next chapter of the Greek case study as a policy recommendation.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Rejected Policy</td>
</tr>
<tr>
<td>+</td>
<td>Policy with some positive elements / Not suggested</td>
</tr>
<tr>
<td>++</td>
<td>Suggested Policy</td>
</tr>
<tr>
<td>+++</td>
<td>Best Practice Policy</td>
</tr>
</tbody>
</table>

Figure 28: Grading system
<table>
<thead>
<tr>
<th>Existing or Past Policy</th>
<th>Grade</th>
<th>Future Policy</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of budget to income support programmes and decrease of budget for energy efficiency programmes</td>
<td>-</td>
<td>“EnergieSprong UK” Private energy coordinator, with private funding through energy savings. Warranty of energy performance</td>
<td>+++</td>
</tr>
<tr>
<td>“Green Deal” 2010 Implementing energy efficiency measures with private funding backed by government to support initial cost. But the funding was limited and according to the expected energy savings</td>
<td>+</td>
<td>Green Deal is expected to be improved in 2018 and provide better funding solutions to homeowners</td>
<td>+</td>
</tr>
<tr>
<td>“Energy Act” After 2018 it will be considered illegal to lease or sell a property with an EPC class label of “G” or “F”</td>
<td></td>
<td></td>
<td>++</td>
</tr>
</tbody>
</table>

Figure 29: UK policies
### Germany

<table>
<thead>
<tr>
<th>Existing or Past Policy</th>
<th>Grade</th>
<th>Future Policy</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>KfW development bank supported by Government. Gives financial motivation and provides grants or loans with attractive rates.</td>
<td>++</td>
<td>“EnergieSprong DE” Started April 2017. Private energy coordinator, with private funding through energy savings. Warranty of energy performance</td>
<td>+++</td>
</tr>
<tr>
<td>General Federal Office for Economic Affairs Export Control gives grants for RES and boost of heating systems</td>
<td>++</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 30: German policies**

### Ireland

<table>
<thead>
<tr>
<th>Existing or Past Policy</th>
<th>Grade</th>
<th>Future Policy</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Better Energy Warmer Homes” – Better Energy Programme giving advices and funds for energy eff. measures considering low income, energy poor and vulnerable population</td>
<td>++</td>
<td>“Deep Retrofit Pilot Programme” initiated by SEAI. Providing funding to projects that demonstrate a holistic strategy for significant improvement of residential energy performance. Special care will be given to energy poor households</td>
<td>++</td>
</tr>
<tr>
<td>“National Fuel Scheme” &amp; “Household Benefits” Giving subsidies for fuels and money to cover heating costs</td>
<td>+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 31: Irish Policies**
### The Netherlands

<table>
<thead>
<tr>
<th>Existing or Past Policy</th>
<th>Grade</th>
<th>Future Policy</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>“EnergieSprong NL”</td>
<td></td>
<td></td>
<td>+++</td>
</tr>
<tr>
<td>• Private initiation started in The Netherlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Adopted by other countries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Setting new standards for super efficient retrofitting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A complete process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Collaborate with governments to improve regulations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Funded by money normally spend on energy bills and maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Guaranteed performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 30 years warranty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Renovation lasts less than 2 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Elimination of initial costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Key point of the programme is that it acts as an “energy facilitator” or “energy coordinator” among the stakeholders of an energy renovation project.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 32: The Netherlands policies**
In the above figures (Figure 29, Figure 30, Figure 31, Figure 32) the policies and schemes from countries that were examined in this thesis are illustrated. Taking into account the nature of these policies, the following steps are proposed for implementing energy efficiency measures for the revitalization of the existing building stock in Europe:

1. **Target the correct building stock.** Retrofitting every existing dwelling at once is not essential. In the case of a homogeneous typology, there will be limited issues with implementing new regulations and room for more attractive prospective investments. Thus, if a single building typology is studied, then it will be easier to promote it to same building types as best practice. *The importance of building stock classification is obvious.*

2. **Introduce “energy facilitator” teams,** like “EnergieSprong” which *give incentives* and *energy performance guarantees* to the stakeholders by eliminating initial renovation cost and *funding it with money that will be earned by reduced energy bills.* These teams have the back up from the government and the collaboration in order to optimize the existing regulation and energy building codes. They present an advanced network of companies and parties that concern the deep retrofit sector.

3. **Give tax incentives to private companies** like REITs, ESCOs etc. to invest in urban building stock retrofitting and revitalization. Promote and inform the consumers about Third Party Financing and national programs that deliver enhancement of energy performance of the existing buildings. The private sector should take over 50% of the deep renovation funding in the EU according to the Commission guidelines. Furthermore bank loans may be excluded. An ESCO is preferable to take loans. Examples of commercial bank schemes (KfW Bank in Germany) should be taken into consideration as well.

4. **Implement a common definition of the term Energy (Fuel) Poverty for all EU member states.** For participating in investment schemes (Third Party Fi-
nancing programs), Energy Poverty criteria should be taken account initially, along with income and building performance. Energy-poor and vulnerable population should also take the first places in line for grants and loans, thus receiving higher funding is logical (e.g. Ireland).

5. **Energy Performance Certificates** is the most important instrument for building stock labeling. For the private sector to proceed to funding in higher rates, EPCs need to become more accurate, absolute and strict. They need to be more complete. EPCs should be extended and become comparable with other international certifications like LEEB or BREAM. This way could also be much more effective for the private sector to participate.

6. **Legislative measures should be implemented nationally or regionally.** For example, in case of renting or selling a property, EPCs are required in all Europe. The following could be applied: For the three first classes just information and recommendations should be adequate, and for the low performance classes the property should not be permitted to be sold or rent without implementing energy efficiency measures and without completing deep renovation (e.g. UK Energy Act).

7. An alternative could be a **threshold of energy consumption** (e.g. France). Every property above that threshold should be obligated to proceed to deep renovation and at the same time funding should be granted. Mandatory “plans for renovation” which calculate the energy performance along with the EPCs is a good solution. The property owner should apply a strategy for retrofitting the property in a predetermined period (e.g. France).

8. **National and public investment in energy retrofitting measures is the case.** Subsidies like allowances for heating should become supplementary. Funding the energy efficiency measures is the way forward. Energy prices should be regulated and decreased. Energy utility companies have a significant role on this.
Figure 33: Flow Diagram for the suggested steps of the thesis
7 Case Study - Greece

Greece, in the middle of a harsh economic crisis, presents the most significant poverty rates increase among the 28 representatives of the EU. Furthermore, in 2012, it was estimated that almost 30% of the total population was unable to keep their household warm enough regarding thermal comfort conditions [29]. A recent study (Panas E., 2012) illustrates that 62.4% spend more than 10% of their whole income for heating and at the same time 78.6% of the Greeks admitted that they are using less heating than they need because they cannot afford it.

According to the Greek Ministry of Environment Energy and Climate Change, the building sector in Greece is the highest consumer of energy in the country and responsible for about 36% of the total energy consumption. It is remarkable that during 2000-2005 an increase of 24% was noticed in the building consumption which is one to highest rise in Europe. Buildings in Greece are old and consume a lot of energy. Thus, modern technology is not incorporated in them due to the lack of a relevant legislation. Furthermore, the occupant’s behavior highly reflects the energy performance and lack of information have lead to this situation. Another fact that should mention is that energy efficiency measures in Greece apply both for winter and summer due to the country’s climatic conditions. The Greek government doesn’t seem to have a plan regarding energy conservation measures for the building stock.

The Greek government tried to tackle the situation by delivering a high budget for oil subsidies for the period 2012-2014. This allowance was provided to almost 580,000 beneficiaries for 2014, and at the same period, a smaller amount of money was allocated to “Energy Efficiency in Household Buildings”, which is the leading program for implementing energy efficiency upgrade in building stocks and households. This program is also known in Greece as “Exikonomisi kat ikon” and the funding was distributed to 40,000 payees, a significantly low number if someone considers that in Greece there are 3,700,000 buildings with deficient energy performance, constructed before the first implementation of the Insulation Regulation in 1979.
The “Energy Efficiency in Household Buildings” program gives incentives to landlords and building owners who meet particular income criteria. These criteria vary, and the highest incentives are given to people that present a family income less than 20,000 or individual income less than 12,000. In such cases, the beneficiaries receive an interest-free loan (30%) and a grant for up to 70% of the last budget estimation. The main problem is that banks’ corporation is involved and for the citizens to proceed with the application, they need to have their creditworthiness checked. As a consequence people that present a low-income are not considered trustworthy by the banks and excluded from the program. The Energy Performance Certificates are highly incorporated in the programme since the eligible residency was evaluated before and after the process. Still, instead of using this program to help fight energy poverty, Greece uses oil allowances as the main instrument, which should be supplementary [29].

The Energy Performance Certificate in Greece is valid for ten years and applies to all buildings with a surface area of more than 50m², either newly constructed or existing undergoing a renovation, all public buildings and building that are sold or leased. Energy rating in buildings is an important instrument since it informs the consumer and gives suggestions on how to improve the energy performance so that the consumer will be able to compare and evaluate the residence energy consumption and the choices for improving the performance.
Moreover, in Figure 35 is presented the reasons for issuing EPCs in Greece. The main characteristic of this figure is that at the first and second stage of efficiency measure scheme present a reduction. This means that half of the applications weren’t able to proceed to their participation in the “Energy Efficiency in Household Buildings” program.

![Figure 35: Reasons for issuing Energy Performance Certificates in Greece](source: www.ypeka.gr – Energy Performance of Buildings Certificates, Statistical Analysis for 2015)

According to this dissertation, the Greek government should give motives such as attractive tax rates to private companies (REITs, ESCOs) and incorporate Third Party Financing mechanisms in their schemes. An ESCO, for example, can deliver energy efficiency, enhancement and can accept the financial risk by either cover or help to finance the initial retrofit cost. This upfront cost can be refinanced through the energy savings that will be achieved. Public authorities can also receive assistance for upgrading buildings by grouping them into leveled projects under energy performance contracts. For this to work, ESCOs need access to financial resources and guarantees from the Greek government.

It is suggested though, the “energy facilitator” scheme to be followed by the Greek government as well. It is the most effective programme analyzed in this thesis. Since there an important lack of information and incentives to the Greek citizens, a coordination team (e.g. EnergieSprong GR) could take over the “Energy Efficiency in Household Buildings” or collaborate and enhance it. The benefits in such a case are plenty for the Greek citizens and Greek Government. As mentioned in chapters five and six, this
plan gives guarantees regarding energy performance of the building and energy saving. At the same time, the programme is funded by the money that the customer would pay in energy bills, and this is translated as an elimination of the initial funding. Managing and educating all involved parties (engineers, architects, technicians, building owners, financial institutions etc.) can deliver fast projects within ten days. Furthermore, the energy facilitator programme would be in continuous collaboration with the Greek government enhancing in this way the building energy codes and the regulatory framework.
8 CONCLUSIONS

The purpose of this chapter is to summarize the thesis study, describe the literature review, the methodology which was followed and report the results.

It is a fact that people in general spent most of their time inside their households. Indoors thermal comfort is an important part of our everyday life. Moreover, according to many studies, buildings are responsible for the highest share of the EU final energy consumption, and they represent the largest potential for energy savings. However by implementing energy saving measures in new legislation and through retrofitting the existing building stock, the sector is potentially a green energy champion.

The 2020 climate and energy package was introduced in 2007 setting some targets with a final goal of reducing by 85-90% the CO$_2$ emissions. European Commission is confident enough that this process will lead to the 4$^{th}$ industrial revolution.

Furthermore, enhancing energy performance of the building stock will deliver significant economic results and will contribute in a great scale towards achieving the EU 2020 and 2050 targets. Generally, European society as a whole will benefit by implementing energy saving measures before the climate benefits come in surface.

A critical issue is funding the energy efficiency measures. In order to overcome this obstacle, funding form national schemes and through private investment (REITs, ESCOs) as well is a must. Another important factor is that revitalization of the building stock will certainly lead to decrease energy poverty rates. Moreover, giving incentives like investment guarantees to the property owners will apparently boost building retrofitting.

Examining the existing building stock and classify according to the typologies is very important. In this way someone can emphasize to energy consumption and performance of the stock and understand which measures can be implemented in each class. Adding some further criteria like energy poverty and vulnerable population, a clearer priority can be given to buildings and people that exhibit higher need for retrofitting.

Moreover in other studies, it is illustrated that aged buildings have a higher potential for energy saving and should take priority or that after thorough audits the priority should be placed to dwelling that their consumption is equal or exceeds 150kWh/m$^2$year.
To continue with, BPIE is a European not-for-profit organisation that supports all these actions by introducing a collection of projects and surveys, with a final purpose to make policymakers and stakeholders agree on particular and practical strategies. The surveys of BPIE examine characteristics of the building stock such as typology, age, size, ownership profile, tenure status, energy performance and location. Hence, BPIE surveys become an important partner of this dissertation taking many data regarding the building typologies in EU, energy performance of the building stock, and methodologies regarding the decrease of fuel poverty, improving energy efficiency.

Continuously, it is important to study and compare some particular EU countries which present different elements regarding their building typology and climate condition. Still, the countries selected have many similarities as well. Data for studying the countries was extracted by the TABULA project. A classification exists and the classes for each country are separated mostly regarding their climate zones, building age and elements. Other studies help as well for this examination. The most important conclusion of this examination is that in all countries the stock that needs immediate renovation is the buildings built before the implementation of the first energy related regulations introduced (1960-1980).

This dissertation further examines the legislative, economic and social background of the subject which is studied. In terms of legislation, incorporating the Energy Performance Certificates in National level was very important. It is believed that properties which are certified to have low energy demand can achieve high sale prices or rents. Still, EPCs are not fully mandatory in Europe and they should be stricter and come closer to other international certificates like BREAM and LEED.

Furthermore another positive outcome coming from EPCs is the informational attitude they have, since information given to the property owners may contribute to boost major renovation projects. Thus, data is gathered and information is collected on the characteristics and components of the stock. One significant clue is that only 3% of the building stock in the European Union entitles the “A” label.

From the economic aspect, the models of REITs and ESCOs are analyzed along with their potential collaboration with Energy Performance Certificates. Private investors need to be convinced by the EPCs and as many times is mentioned in this thesis a stricter form of EPCs should be implemented in the future.
Furthermore, economic schemes are presented. Customers can use their own funds to finance ESCOs which provide guarantees, ESCOs can use their own capital of Third Party Financing may occur. In the last case of TPF there are two models. In the first an ESCO that is more reliable can borrow the money, and get payment from the client after delivering services. In the second, the customer is borrowed the money after having the support and the agreement of an energy savings guarantee of an ESCO. This deal exhibits to the bank that the fund the customer borrows creates a positive cash flow.

Moreover, some investment barriers are analyzed and examined like changing energy prices, inadequate decision making and market failures. Difficulties also appear due to the diversions of the building sector in terms of building ownership and use, housing arrangement, type of refurbishment and the period.

Lastly, equal significance presents the social aspect. An important problem is to gain the confidence of the decision makers (building owners, property investors and facility managers) and assure them for the cost-effectiveness of energy renovation. Technical problems are really low after the high development in the building sector and the essential barriers are economical and informational.

The tenant-landlord complication takes place when there are obstacles and differences between the two sides on agreeing upon a parallel strategy for the energy refurbishment of the dwelling. The tenant wants to pay lower energy expenses and the landlord does not want to invest further.

In the social aspect, energy poverty and vulnerable population also play an important role. A strong standard definition is missing in the EU regarding energy poverty since vulnerability and energy poverty share similar directions like low income and the poor quality of the existing building stock, energy poor people are likely to face other aspects of vulnerability as well, like housing status, individual circumstances, market conditions and social context. Energy poverty is also well connected with human health, older adults and children.

As an extension, low indoor temperatures are determined by low energy efficiency of the building design or the heating systems, low household income and high fuel prices. Various studies have illustrated and examined the connection between fuel poverty and health impacts. Solutions on how to reduce energy poverty and the benefits they might bring are also presented in the sub-chapter. Help from the private sector is essential since public money is not enough.
Additionally, studying the various policies and examining the best practices from particular EU countries helps this thesis to create some suggestions for policymakers. Schemes from UK, Germany, Ireland and The Netherlands were analyzed in a sub-chapter and they are further evaluated. The strongest parts of them along with an IPEEC study were used and resulted to the 8 steps suggested at chapter 6.

More specifically, the IPEEC study claims that the way forward is to:

- Set up targets and strategies for improvement of the energy saving measures
- Develop energy codes that affect energy performance of the building stock and enhance energy conservation measures
- Make EPCs stricter and mandatory all over EU and prohibit any sale or lease to those residencies and buildings that present energy performance rating under a specific threshold and finally
- Give financing motivation to all stakeholders by incorporate private investment schemes.

Having in mind the strong part of the best practices examined and the steps mentioned in the previous paragraph, this thesis makes some suggestions on how a Member State should proceed in order to implement the correct policies and energy conservation measures. Suggestion such as:

- targeting the right building stock and not all dwelling at once
- give incentives and guarantee for return of investment to all stakeholders and especially the property owners
- put the private sector in the game by providing attractive tax regulation
- decrease of energy subsidies by the governments and instead this money should be given as grants or funds for implementing energy efficiency measures
- taking account energy poverty criteria as well
- upgrade EPCs and make them stricter and give thresholds of energy consumption for residences
- regulation of energy prices
Lastly, the “energy facilitators” are teams that coordinate all the parties that are involved in a major renovation and retrofit projects. They are responsible for collaborating with governments for introducing correct legislation framework, funding for the initial investment of a project and getting they funds back from energy bills that normally the client would pay. This scheme is suggested for the case study of Greece, a country that suffers a lot from the economic crisis. It would be beneficial and would bring many results regarding the enhancement of the building stock, and will strengthen of the regulatory framework.

Retrofitting every existing dwelling at once is not essential. If a volume of a homogeneous typology is gathered, then there will be limited issues with implementing new regulations and will be more attractive for prospective investments. If one building typology is studied, then it will be easier to sell it to same building types as best practice. The importance of building stock classification is apparent for energy conservation. Relating our knowledge to characteristics of the existing buildings, comparing the classification among different countries could lead to creating new, solid energy codes and by using the suggested policies the correct energy conservation measures for the building stock sector will be implemented.
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