# Energy audit in buildings of significant multiplicatory and architectural value

**Kyriaki Metaxa**

SID: 3302100016

SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

*Master of Science (MSc) in Energy Systems*

OCTOBER 2011

THESSALONIKI – GREECE

# Energy audit in buildings of significant multiplicatory and architectural value


**Kyriaki Metaxa**

SID: 330210016

Supervisor: Prof. Agis M. Papadopoulos


SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

*Master of Science (MSc) in Energy Systems*

OCTOBER 2011

THESSALONIKI – GREECE

## DISCLAIMER

This dissertation is submitted in part candidacy for the degree of Master of Science in Energy Systems, from the School of Science and Technology of the International Hellenic University, Thessaloniki, Greece. The views expressed in the dissertation are those of the author entirely and no endorsement of these views is implied by the said University or its staff.

This work has not been submitted either in whole or in part, for any other degree at this or any other university.

Signed: ..............................................

Name: .......KYRIAKI METAXA.............

Date: .........21/10/2011.....................

# Abstract

The thesis revolves around the matter of energy refurbishment of existing buildings, in the face of significant environmental, economic and social benefits, which have been well documented by numerous studies. In particular, it investigates the most "suitable" strategy towards the improvement of the energy performance of a respected part of the social housing stock in Greece, which due to high levels of standardization, shares common characteristics.

The chosen methodology is a typical energy audit, which complies with the provisions of the national regulatory framework, and includes two energy renovation scenarios. The object of the audit is a representative building that belongs to the working class complex of O.E.K., located in Ampelokipoi, Thessaloniki and dating back to 1963. The results of the audit confirmed the lack of efficiency of such buildings. The suggested interventions showed the huge potential that these buildings hold for energy conservation, with a consequent positive effect on their operational cost.

Moreover, the different energy saving scenarios that were investigated, clearly demonstrate one thing. The road to increased environmental, financial and social benefits, passes through an energy renovation planning that is collective in its approach, and also integrates innovative technologies as well as renewable energy sources. Above all, it presupposes a shift in attitude and mentality on behalf of all actors; the authorities, the specialized workforce and of course the public.

Student Name

Kyriaki Metaxa

Date

21/10/2011

I would like to thank those of you, who offered to help me bridge the gaps and complete this work. I would also like to thank those who haven't done so, but instead left me be, as I believe this is another equally important creative force.

# Contents

# 1 Introduction

In a time when the issue of energy consumption of buildings constitutes a top priority, on a European as well as on a global scale, Greece has been one of the last countries to adopt the Directive on the Energy Performance of Buildings. The majority of the Greek building stock records low in terms of energy efficiency, as a number of studies demonstrate. A change is vital therefore, if Greece is to fulfill its binding environmental goals in the future. Granted that the social housing sector in Greece had already reached its boom by the time the first Greek Thermal Insulation Regulation was issued, there is a high potential for energy conservation in this area. Added to this problematic, is the immature energy renovation market in Greece. Steps have already been taken in order to promote the development of this part of the national economy. Yet, a well planned policy is essential so as to ensure that all actors collaborate, in the most efficient way, for the pursuit of a national goal.

In architect's Aris Konstantinidis own words *"… good things, beautiful things always come through a necessity. Esthetics doesn't exist for me"* [1]. The scope of this study is to determine what would be the most appropriate *"good things"* that could happen to the social building stock of the Workers' Housing Organization (O.E.K), in terms of its energy performance. More specifically, the research targets to the buildings that date before the introduction of the first Greek Thermal Insulation Regulation, in 1979. These represent a significant proportion of the social housing stock of Greece that share common characteristics, as similar working class complexes have been realized in many Greek cities, namely Athens, Thessaloniki, Irakleion, Trikala, and others. Determining the most promising and cost-effective energy renovation strategy for the social housing stock, could contribute to the national policy making. Such a development would have substantial environmental and economical benefits to offer, apart from relieving vulnerable social groups, which are at risk or already suffer from fuel poverty.

The study focuses on the working class complex that is located in Ampelokipoi, Thessaloniki, on grounds of personal interest. The complex is a representative example of the building activity of the Workers' Housing Organization, during the 50s and 60s. On top of that, it is a fine example of the efforts of distinguished Greek architects of the interwar period, to associate international architectural movements, such as Modernism, with Greek architecture, under the socioeconomical and political conditions of that time.

Over and above, these buildings trace back to the specific circumstances that led to the today form of Greek urban centers, and are also part of the local history. In the view of the author, the architectural and historical value of the complex, presents an additional opportunity for growth; following in the footsteps of other European social housing products, like for example the famous Karl-Marx-Hof in Vienna, planned by Karl Ehn. The complex is open to organized tours, and a permanent exhibition about the social democratic era of the city, can be found in the place where the bathtubs and showers were originally accommodated.

Considering the high levels of standardization that is met in the complex, one building was chosen as a representative sample. The necessary data have been collected and an energy audit has been performed, in accordance to the national legal framework. The chosen methodology is characterized by high levels of realism, in an effort to support the ambition of this study as to contribute to future developments. Two energy renovation strategies were then plotted, with the main difference between them being, the level of independence or collectiveness in the implementation of the energy saving measures. Moreover, these integrate renewable energy sources to a different extent.

Furthermore, the method of financing distinguishes between the two scenarios. The interventions of the first scenario are eligible for financing through the current incentive scheme, "Energy savings in residential buildings", of the Ministry of Environment, Energy and Climate Change. Therefore, this aspect offers the opportunity to produce constructive criticism over the scheme and its projected environmental and economic benefits.

On the contrary, the second scenario cannot rely on funding of this nature, thus an investigation of alternative funding schemes applied in relevant projects, elsewhere in Europe, seemed imperative. Judging by pilot programmes that are under development in Greece, but also in other countries, another ministerial supportive scheme, namely the "Building the Future" programme, could be applied in this case. Energy performance contracting is another possible option, especially after the issuance of Law 3855/2010, on energy services.

In order to better understand the problematic of this study, it is essential to examine the linkage between energy and the building sector. Thus, the benefits of energy conservation in buildings in relation to the environment, economy and the society are being presented in the second chapter, along with the challenges this faces. Furthermore, the primary market drivers, as well as practices from social housing refurbishments and urban regenerations programs are also included.

The third chapter intends to shed light on the efforts of European policy to emphasize and promote energy efficiency, with special interest in the energy efficiency of buildings.

Hence, it consists of an overview of the European regulatory framework; the goals, the implementation roads, as well as the different national strategies among European Member States.

To be more specific, the strategies of Germany, United Kingdom and Greece are presented, along with a short analysis of the main supportive schemes that have been launched or proclaimed.

Social housing policy is closely related to the history of a country. As a result, the variety of social housing products, and the issues that the public housing sector faces, as well as the housing market crisis, originate to a great extent from the political decisions of the past. Chapter four analyses the correlation of social housing policies with energy policies. Furthermore, a short description of the social housing sector of Germany, United Kingdom and Greece is presented.

Chapter five, refers to the case study. This begins with a general introduction on the urban development of the city of Thessaloniki, and further elaborates on the architectural, historical value of the complex under study, and the challenges it faces. The next subchapters refer to the origins of the town of Ampelokipoi and the dynamics that formed it, to the working class complex of Ampelokipoi, and finally to the representative building.

In chapters six, the methodology and the results of the energy audit are presented.

Chapter seven follows, with a description of the energy renovation scenarios, a short analysis of the interventions included in each case, funding suggestions etc. The impact of each scenario on the energy performance of the building can be found in the end of the corresponding subchapter.

Finally, in the last chapter, specific conclusions regarding the energy renovation scenarios are deduced, besides some more general. These refer to the challenges that energy refurbishment of buildings faces in Greece, as identified in this thesis. Recommendations for further study are also included.

# 2 Energy and Buildings

Building and construction sector is strongly linked to economy, health, community and environment. It is at the same time a rather wasteful one with buildings consuming a large amount of energy, contributing to the $CO_2$ emissions, generating waste and using natural resources. Since the first oil crisis in 1973 a number of building regulations setting new requirements have been successively issued, taking into account the energy use and environmental impact of buildings. As a result, buildings have become more efficient and attention has been paid on the reduction of pollutants, heating and cooling loads and new technologies have been promoted. Nowadays the demand is on sustainable structures of high efficiency and integration of efficiency and RES technologies.

The challenge to improve new constructions cannot stand as an excuse to neglect the existing, building stock. Buildings that were constructed at a time when efficiency and energy consumption were not the primary concern, stand in the way of meeting the environmental commitments made by the member states to mitigate climate change and reduce $CO_2$ emissions. Bearing in mind the low rate of new additions to the building stock, refurbishment of existing buildings has a lot to offer. Apart from the direct energy benefits there is a range of equally significant co-benefits related to employment, fuel poverty, indoor living conditions, added value to the properties, better allocation of energy efficiency funding etc [2].

Bad quality housing is more often accessed by socially vulnerable groups [3]. Social housing can therefore play a vital role in energy conservation. Its long-standing aim of “a decent home for all at a price within their means” complies with the context of the framework of European directives and international environmental goals. The fact that it is a part of the housing market that has already received state intervention facilitates the implementation of retrofitting policies. Furthermore, the large number of standard multi-apartment residential building blocks featured in central planning habitats of the past can lead to the application of similar solutions for improved energy efficiency, thus ensuring an economy of scale.

Environmental goals and energy conservation are not strong market drivers. In fact, renovations scarcely aim at the reduction of energy consumption right from the beginning. They may originate from a general poor building condition where renovation is urgent or coincide with a change in personal circumstances. Economical benefits are translated into added value for the property and the prospect of receiving increased rent is also motivation for some owners. In addition, improved comfort and the existence of incentives and regulations are important. The development of a market though presupposes the combination of certain factors; the existence of a strong legal framework, the facilitation of decision making processes in cases of home co-ownership, provision for financial incentives along with sufficient and skilled workforce [4].

A number of case studies of social housing refurbishments and urban regenerations that were realized in different countries was presented in the 2nd Conference "HOUSING EUROPE" "Retrofitting of Social Housing: Financing & Policy Options" that was held in Thessaloniki (2006). In all cases the process was initiated by the social housing organization or the local authorities, aided by a development company and had strong support and involvement of the tenants and stakeholders. The refurbishment plans included alterations, improvements and comfort enhancement works (Reunion island), energy conservation works and integration of renewable technologies (Regio Emilia, Italy), low-cost energy systems and advanced energy management (Solar Village, Greece), revitalizing the urban fabric, including buildings, exterior spaces and infrastructures (Maroussi, Greece).

Practices show that usually such projects rely on loans and subsidies by national, European and local- private or public- sources in order to overcome the obstacles of high-front cost and long payback periods for certain measures. In Estonia the reluctance of banks to borrow to housing associations and cooperatives is overcome by a subsidy offered by the municipalities that enables to keep down the loan interest [5]. An additional reason justifying state subsidies is that the improvement of existing buildings means less demand for energy assistance in the future plus increased economic activity and job creation. Another way to overcome the funding barrier is suggested by the European cooperation project FRESH. In a recent report published in January 2011, FRESH introduces the concept of Energy Performance Contracts (EPC), in which an energy service company invests in a comprehensive refurbishment and repays itself through the generated savings [6].

Despite the benefits for all encountered parties in the renovation of existing buildings (state, owners, tenants, and housing market) there is substantial potential for an increase in the number of renovating works in the future. P. Davies and M. Osmani interviewed a sample of architects operating in different regions in the UK while investigating the main obstacles and incentives for the penetration of low carbon housing refurbishment in the market. The study concluded that high capital costs for micro-generation technologies and energy efficient materials, disparity in VAT between new build and refurbishment, and the complexity of the UK existing housing stock are the most considerable low carbon housing refurbishment challenges. In contrast, the research indicated that a tax rebate, removal of the VAT disparity, increased research to produce affordable micro-generation technologies, and increased government supplied low carbon programs were identified by the participants as the key incentives to drive the LCHR agenda [7].

Economists have been examining for decades the co-relation of energy consumption to economic growth. On one hand, it is argued that energy is a vital and necessary input of production along with labor and capital. Therefore it could be considered as a factor with potential limiting effect to economic growth. On the other hand, as energy can become a growing market itself, experts claim that energy has a neutral impact on growth. Causality between energy consumption and GDP is a significant finding especially in view of the implementation of energy conservation policies aiming against climate change. A systematic study of over 100 countries showed energy to GDP causality especially for developed countries [8]. This causality was recently investigated particularly for Greece and similar results arose. However, analysis of the relationship of energy consumption to GDP in reference to the residential sector suggests interdependence. Therefore, there is room for energy efficiency policies without the threat of hindering development in this sector [9].

Energy consumption in residential buildings is affected by a number of parameters. The date of the construction is a significant one. It is safe to assume that a substantial number of the buildings in Europe were built before the first efficiency or thermal regulations were introduced in the late 70s [10,11]. This part of the building stock is uninsulated; of low energy performance thus it is related to high energy consumption. Still it is not always safe to link newer constructions to lower rates of energy consumption. The main reason being the behavior of the users combined with higher income and increased thermal comfort requirements [12]. The typology of the building; whether it is a detached house or a multifamily building, the density of the area, the occupancy profile can also influence energy consumption.

The climatic conditions of the location play a significant role in defining the energy required in order to achieve adequate heating and cooling. We should note that most of the energy consumed in the residential sector goes to space heating, followed by hot water and lastly by appliances and lighting. The effect of the climate is depicted in a comparative study on electricity demand and air temperature in Athens and London, for the period 1997-2001. Both cities shared a winter peak however a second significant peak appeared for Athens during the summer [13]. This is a result of extensive air-conditioning as an answer to high temperatures. It can be further linked to problematic design of the urban environment and buildings, user's behavior and awareness along with easier access to the electromechanical equipment in the market.

As mentioned above, the behavior patterns of the inhabitants can offset the benefit of an improved building envelope and heating systems and still lead to high energy consumption. Responsible energy behavior on behalf of the inhabitants can lower the energy demand of the residence. Increasing solar gains during winter for example, adjusting the thermostats in spaces depending on whether they are being used or not, installing low-energy lambs etc are few of the things that tenants control. Small behavior changes can bring about energy savings from 5% – 10% and in some cases up to 20% a year. According to the BewareE project of IEE, this goes along with household cost savings of up to 300 euro a year [14].

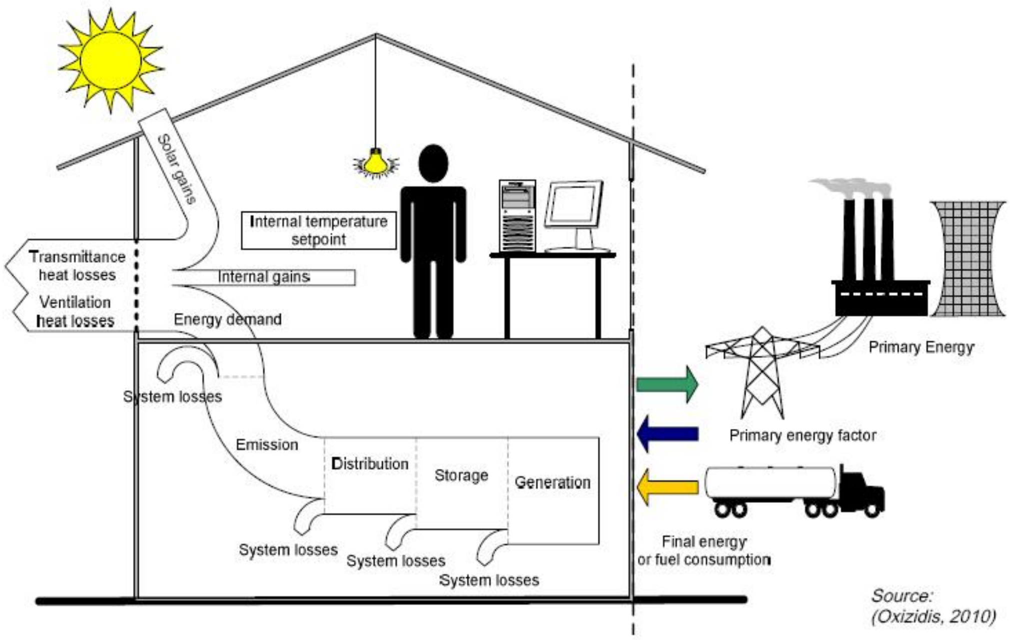



**Figure 1:** Building Energy Balance

**Source:** Anastaselos D., Introduction to Energy Efficiency and Savings, course notes (2010), 27

Research work on human behavior along with the results of a number of European programs aiming at raising awareness and stimulating responsible energy use attitudes in households suggest that the most effective way to do so is by combining written and verbal advice. Leaflets and brochures can well inform in energy problems and solutions but face-to-face contact or over the phone is more effective at encouraging behavior changes. In fact, one barrier noted in the Echo Action program is that many people are quite informed on energy issues but they are in need of specific and impartial technical assistance. Furthermore, a campaign towards changing attitudes is proved to be generally more cost-effective than other technical measures of energy conservation. Best practice examples available in the database of BewareE program demonstrate the need for collaboration among private actors, public institutional partners and inhabitants.

**Wind turbine: 44 € / ton $CO_2$**

- 1.300.000 EUR
- Life expectancy 30 years
- Saves 980 ton $CO_2$/year

**Washing machine: 570 € / ton $CO_2$**

- 200 EUR extra for the A label
- Life expectancy 7 years
- Saves 0.05 ton $CO_2$/year

**PV solar collector: 600 € / ton $CO_2$**

- 6.000 EUR
- Life expectancy 25 years
- Saves 0.4 ton $CO_2$/year

**Behavioural campaign: 30 € / ton $CO_2$**

- 30.000 EUR
- 'Life expectancy' 1 – 3 years
- Saves 360 ton $CO_2$/year

**Figure 2:** Cost-effectiveness of behavioral campaign versus technical saving energy measures
**Source:** M. Scharp, J. Kortman, A. Huber, A. Martin (2010), Developing and implementing energy awareness services Brochure, Intelligent Energy Europe Program, 11

# 3 Regulatory Framework

Ever since the first oil crisis in the 70s, the European governments have set as a priority to limit the dependency on fossil fuels, including the building sector. They have adopted policies and issued regulations to improve the efficiency of buildings, for environmental, financial and reasons of health. The rising and fuel prices, the production cost of energy and the need to make savings both in corporate and family budgets stand among the primary drivers for the implementation of such policies. Nowadays the focus is more and more on the design and construction of sustainable buildings. These are characterized not only by improved thermal qualities and efficient energy systems, but in addition, they have integrated in their design renewable technologies that can achieve zero or even positive energy balance.

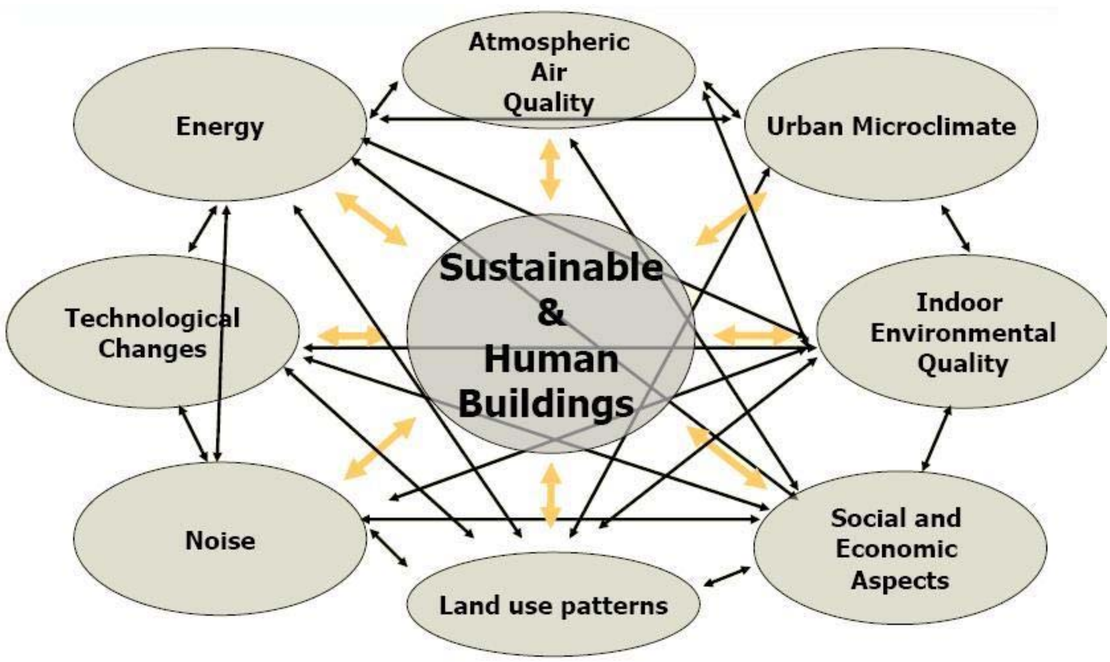



**Figure 3:** Sustainability in buildings and its correlation to society, economics, quality of life and environment, technology, spatial development

**Source:** A.M. Papadopoulos, Sustainability in the built environment Intro course notes, Sustainable Built Environment course, MSc Energy Systems, IHU, sl. 54

The buildings of the residential and tertiary sector account within the European Community for more than 40% of final energy consumption with a rising trend, which is bound to increase the energy consumption and carbon dioxide emissions attributed to these sectors. The European Parliament and the Council of the European Union issued in 2002 the Directive 2002/91/EC, as part of the Community's initiatives on security of supply (Green Paper on security of supply) and climate change (Kyoto Protocol). The directives' main objectives are the improvement of the energy performance of buildings with cost-effective measures and convergence of building standards towards those of Member States with already high levels of requirements. The 2002 Directive was designed to promote the energy performance of buildings through:

- The introduction of a framework for an integrated methodology for measuring energy performance
- The application of minimum energy performance standards in new buildings and certain renovated buildings, and regular updating of these standards
- The energy certification and advice for new and existing buildings
- The inspection and assessment of boilers and heating/cooling systems

Member States were given three years to transpose EPBD into national legislation in each Member State. For their support, the Concerted Action EPBD was launched to promote dialogue and dissemination of good practices. Additionally, Build Up is an initiative supported by the Intelligent Energy – Europe programme to provide information services for practitioners and consultants, experts in energy agencies, interest groups and national policy makers in the European Member States. Nevertheless, transposing the EPBD into national legislation and then fully implementing the Directive has been slower than was envisaged.

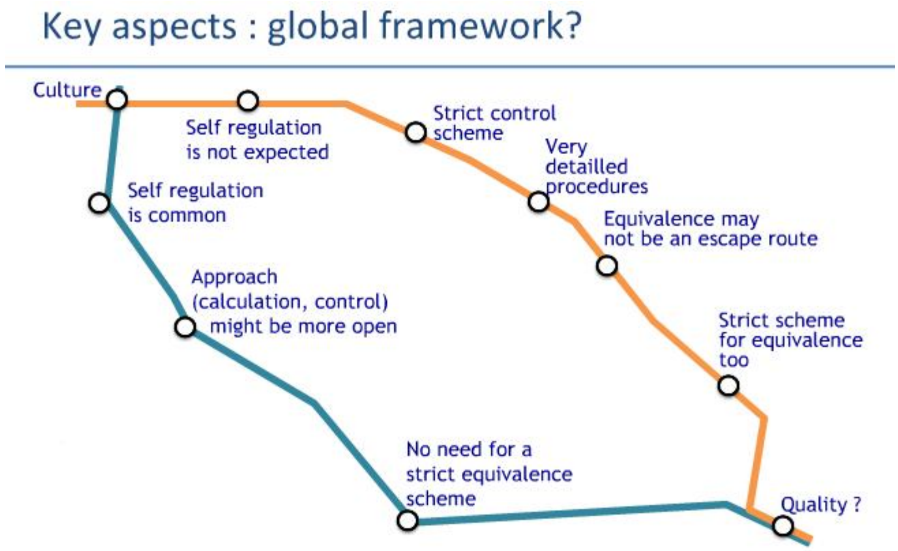



**Figure 4:** The role of cultural aspects in the national implementation of the EPBD

**Source:** Retrieved from: http://www.asiepi.eu

It is clear that culture, and more specifically the level of citizen's self regulation expected in a Member State, determines whether a strict regulatory and control scheme is preferred, compared to a more flexible approach with regard to national implementation. The various reports demonstrate a significant variation in EPBD implementation, with differences in impact, compliance and control. For instance, there is lack of a uniform method to assess the energy use in a similar way as the calculation methods differ from country to country. Additional national differences such as health regulations that influence the ventilation rates, indoor and outdoor climate conditions, building use, construction practices, cost of technologies and labor make the comparison far more complex [15].

Acknowledging the weaknesses of the 2002 Directive and the untapped energy saving potential that buildings still present, the European Parliament and the Council of the European Union approved EPBD's recast, in form of Directive 2010/31/EU. As of 31 December 2020 new buildings in the EU will have to be of a very high energy performance and consume "nearly zero” energy over the year, whilst the demand will be provided “to a very large extent” from renewable sources. Regarding the renovation of existing buildings, no exact target is set but Member States should develop strategies to stimulate that refurbishments are towards the low energy direction and inform the Commission about the relevant national plans. The Recast took provision of a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements. Furthermore, it mandated the listing of incentives on behalf of the Member States by 30 June 2011 for the transition to nearly zero energy buildings.

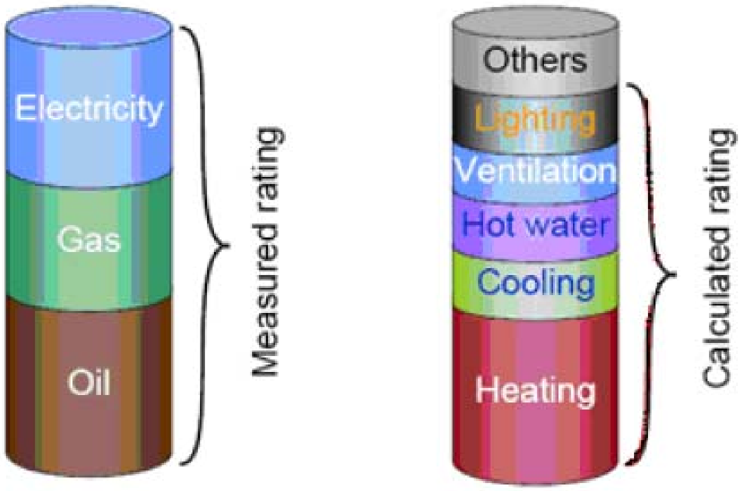



**Figure 5:** Measured versus calculated (asset) rating methodology. The calculated method has been chosen in sixteen member states, the measured procedure has been chosen by eight and three members permit both methods.

**Source:** A.M. Papadopoulos, KENAK course notes, Sustainable Built Environment course, MSc Energy Systems, IHU, sl. 25

Although Member States are bided by common goals, each has followed a different route towards their implementation, depending on the available expertise, the level of public awareness on energy efficiency, the current state and local government mechanisms, the availability of human resources, the level of development of energy saving technologies and the response of the market. The overview of three examples follows in order to demonstrate the different approaches adopted concerning the implementation of the EPBD in Germany, UK and Greece.

In Germany, a country with continuously increasing energy performance requirements over the last three decades, the Energy Saving Regulation (2007) (Energieeinsparverordnung, EnEV) further tightened the requirements, introduced the holistic calculation method of DIN

18599, and improved the Energy Performance Certificate and a regular mandatory inspection of air conditioning units. The last amendment of the Energy Saving Regulation (EnEV2009) tightened the level of requirements by 30% on average. Since the beginning of 2009, it has been compulsory nationwide to use renewable energies for heating in new buildings, according to the Renewable Energies Heat Act (Erneuerbaren-Energien-Wärmegesetz). This obligation has even been expanded to certain refurbishments of existing buildings in some federal states. After the Recast EPBD, Germany is considering standards for nearly zero energy buildings, for the implementation of an independent control system for Energy Performance Certificates, as well as for the compulsory energy performance indicator in commercial advertisements.

Three ministries share responsibility for the implementation of the EPBD in Germany; the Federal Ministry of Transport, Building and Urban Development, together with the Federal Ministry of Economics and Technology and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

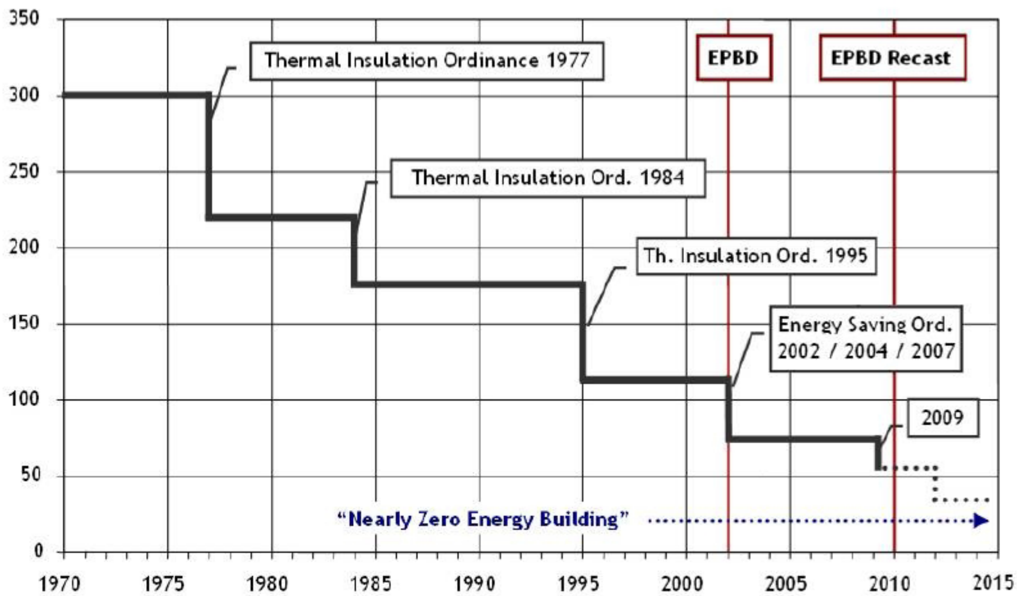



**Figure 6:** Evolution of primary heating demand in kWh/m²a with reference to the energy performance regulations in Germany

**Source:** H. P. Schettler-Köhler, S. Kunkel, Implementation of the EPBD in Germany, IEE/CA/07/333, p. 10

Energy Performance Certificates has been compulsory for new buildings and major refurbishments since 2002. These can be grouped into two categories, according to the type of the calculation method: certificates on the basis of calculated demand and certificates on the basis of metered consumption. As Germany has a long record of billing the heating and water costs based on metered consumption, these data were used in order to limit the cost of the Energy Performance Certificates. Against this background, data from a period of at least 36 continuous months must be used and the influence of the weather during the data collection period has to be considered in order to achieve comparability with data obtained by calculating demand.

The certificates are being issued by authorized individuals based on their professional qualifications. For new buildings, the assessors' requirements are defined by regional law. In any case there is no official approval certification, while individuals who issue certificates without being authorized face a penalty by fine. Such an open approach results in a wide circle of assessors with positive effect on the volume of certificates issued. Apart from employing the metered consumption data in the calculation process, the lack of a central registry for the issued certificates also restrains the costs. In contrast to other member states, in Germany there is no official software for energy certificates. Software is being developed and can be procured freely in the market. At the same time, private stakeholders have taken initiatives to guarantee the right transfer of the technical rules into the software so as to ensure the quality of the results.

Information campaigns and specialist handbooks play an essential role in the German implementation strategy. The CO2 building refurbishment programme was launched in 2007 to promote measures for saving energy and reducing $CO^2$ emissions in residential buildings. The KfW Bankengruppe (German Development Loan Bank) financed corresponding measures both at low interest rates and in the long term. The programme extends to efficient new buildings and to refurbishments of existing buildings as well. In the latter case the support is granted as an investment subsidy. The building under refurbishment has to meet the requirements for new buildings and all costs caused directly by the energy saving measures are eligible investment costs. A basic condition for granting these subsidies is that all measures are undertaken exclusively by specialized contractors as a means of boosting growth and employment.


**Figure 7:** Advertising campaign for the CO2 refurbishment programme

**Source:** H. P. Schettler-Köhler, S. Kunkel, Implementation of the EPBD in Germany, IEE/CA/07/333, p. 8

It is a quite different picture n the United Kingdom. A number of regulations and amendments were issued for the implementation of specific EPBD articles between 2006-2008 in England, Wales and North Ireland, and between 2003-2008 in Scotland. The latest developments during the last year include the Building Regulations revisions and a new regulation regarding the Approved Inspectors in England and Wales; the Building (Scotland) Amendment Regulations in Scotland. In Northern Ireland there are The Building (Amendment) Regulations, issued in 2006 and The Energy Performance of Buildings (Certificates and Inspections) Regulations two years later. In England and Wales the Departments for Communities and Local Government (CLG), for the Environment, Food and Rural Affairs (Defra) and the Department of Energy and Climate Change are responsible for the implementation of the EPBD. In Scotland, responsibility lies within the Building Standards Division and in Northern Ireland is the responsibility of the Department of Finance and Personnel (DFPNI), supported by the Department for Social Development (DSDNI).

The EPBD is implemented in UK through SI 991 and translates into labeling procedures for new and existing buildings, advising on energy efficiency improvements, certification by energy assessors and two stages of compliance checking, namely in the design and construction stage. A national calculation method has been established based on the characteristics of the building itself, its services and a standardized occupancy profile. Moreover, Display Energy Certificates (DEC) are produced in UK for public buildings with a heated surface area of more than 1000m$^2$; they are publicly displayed and updated annually. This includes a list of upgrading recommendations that needs to be updated on a 7year basis. The building's performance is compared to a hypothetical building with performance equal to one typical of its type (the benchmark). On the other hand, in Scotland there are no DECs and a regular Energy Performance Certificate is displayed in public buildings.

A new building in England and Wales must comply with five criteria. To begin with, its calculated $CO^2$ emission rate must be below a target emission rate. Secondly, specific design limits are given for the building's fabric performance as well as for the building's systems. Thirdly, solar gains have to be limited in order to reduce the cooling load. Furthermore, information on the optimum building operation must be provided. More important, the performance of the building as built must be consistent with the performance intended in the design stage. Similar criteria have been set in Northern Ireland. Following a similar approach, the revised energy standards in the building regulations of Scotland aim at a 23-28% fewer emissions for non-domestic buildings and 18-25% fewer emissions for domestic buildings. In addition, design and construction methods which improve the emission rate and make greater use of Low and Zero Carbon Technologies are encouraged.

Correspondingly, minimum energy efficiency standards exist for renovation work, alterations, and new installations in existing buildings. These apply to newly constructed thermal elements as well as to existing ones that become part of the building's thermal envelope due to alterations or changes in the use of a space. Moreover, for specific major improvement works in large buildings that would most probably increase their energy intensity, further requirements to make the existing building more energy efficient exist. These are known as consequential improvements and should be implemented provided it is technically, functionally and economically feasible.

All Energy Assessors in the UK need to be members of an Accreditation Scheme or a professional body that has the approval of the Government. These bodies are responsible for ensuring the qualifications of the assessors and the quality of the assessments and any certificates or reports produced. In England and Wales, the Community and Local Government Department has arranged for independent quality audits to be carried out for each Accreditation Scheme. In some cases, this has resulted in assessors being suspended or their accreditation removed. In all of the UK, the EPCs are maintained in a registry while the same happens for the DECs in England and Wales. The national calculation method is carried out either by approved simulation software or by a simplified tool that has been developed by BRE, based on a set of CEN standards, the SBEM - Simplified Building Energy Model. It is accompanied by a basic user interface - iSBEM.

In order to exploit the whole energy saving potential in buildings a number of complementary initiatives has been launched so far. For instance, the Warm Front scheme [16] relates to households that are in, or at risk of, fuel poverty, and are living in poor quality houses. In the period 2001-2011 over 2.3 million homes have benefited by the Government Warm Front Grants. The scheme continues to offer new or replacement gas heating systems, oil or alternative technology systems in properties with no access to gas and a full range of insulation measures. In 2011 though, the Government has revised the scope of the Warm Front scheme which is now targeted at households on certain income related benefits and living in properties that have a Standard Assessment Procedure (SAP) rating of 55 or below.

The Green Deal [17], to take effect from autumn 2012, is the Government's initiative to support the implementation of energy efficiency measures in households and businesses without needing to pay for work upfront. Quality-assured work will be carried out through accredited retailers and repaid through the subsequent savings on energy bills. In cases where the expected savings cannot repay the costs, but there are strong policy reasons to promote energy efficiency measures, extra support will be ensured via the Energy Company Obligation mechanism. The Government will also work with energy suppliers to deliver energy efficient measures to help provide extra support for low income and vulnerable households and those who live in homes which are particularly difficult to improve.

Another supporting scheme is the Renewable Heat Incentive [18], by which the Government intends to switch from fossil fuels to more clean and sustainable green sources which will reduce the environmental impact of the UK building’s heat requirements besides securing UK’s energy supply. The scheme will be introduced in two phases. In the first phase, long-term tariff support will be targeted at in the non-domestic sectors, namely the industrial, business and public sector. In parallel, there will be support for households through the Renewable Heat Premium Payment. The second phase of the RHI scheme will include more technologies as well as support for households. This transition will be timed to align with the Green Deal.

A third approach worth mentioning is the one of Greece. In Greece there was no specific regulation concerning the energy performance and certification of buildings until the introduction of EPBD. The previously existing Greek Thermal Insulation Regulation, introduced in 1979, prescribed limits for U-values for the building elements, the building’s facades and the building on the whole, in order to restrict heat transfer through the building’s envelope. Moreover, the Technical Guidelines of the Technical Chamber of Greece (TOTEE) [19] focused on the installation and operation of boilers and cooling systems in buildings, on the calculation of the heating and cooling loads and on ventilation and thermal comfort. The transposition Law 3661/2008“Measures for the reduction of the energy use in buildings” was passed through parliament in 2008 and a number of necessary implementation regulations were introduced, in form of Ministerial decisions, like the "Regulation of Energy Performance of Buildings" KENAK (Ministerial decision D6/B/5825 National Gazette 407/9th of April 2010) and of new Technical Guidelines. Also that year, a Presidential Decree that defined the qualifications and training of energy auditors was published (Presidential Decree 100/NG177/6th of October 2010).

The new regulation defines the methodology for the calculation of the energy consumption of new and renovated buildings, sets the minimum energy performance requirements and prescribes the issue of an energy performance certificate, the inspection of boilers and air-conditioning systems and the implementation of a national body of energy inspectors according to Directive 2002/91/EC. An Energy Efficiency Study is mandatory for new buildings and fully-refurbished existing ones, of more than 50 $m^2$ surface. The study documents that the building complies with the requested energy consumption limit and is being ranked at least as energy class B. Buildings undergoing major refurbishment must also achieve class B. Moreover, the building under consideration must be compared to the Reference Building. This is defined as having the same geometry, orientation, use and operational characteristics as the building in question. However, it differs as it has a set of predefined thermal properties for the building fabric, and a set of characteristics for the heating and cooling installations, hot water production and lighting (in the case of the tertiary sector).

An Energy Performance Certificate with a validity of ten years, must be issued for every new construction, every existing building that undergoes major refurbishment and for every building that is being sold or rented. The calculation methodology is the monthly methodology of EN13790, and a set of national parameters have been defined where necessary. The methodology covers heating, cooling, ventilation and hot water for all buildings, plus lighting for commercial buildings. The EPCs report displays apart from the building's rank, its energy need, consumption and $CO^2$ emissions. A software tool was developed for the calculation with funding from the Technical Chamber of Greece. Other software that is offered by private companies can be used, as long as it verified by the Ministry of Environment, Energy and Climate Change.

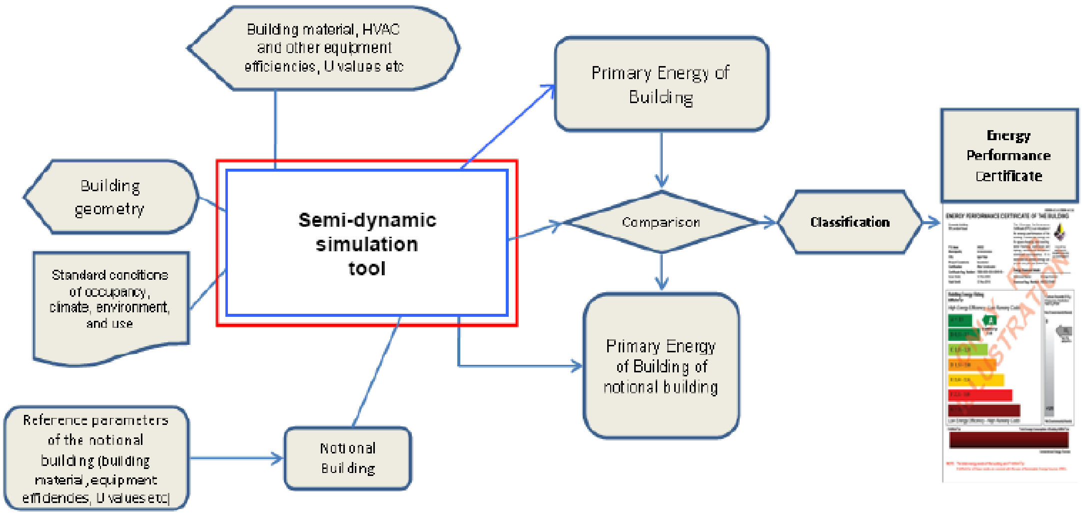



**Figure 8:** Diagram of the calculation methodology followed in the issuance of EPCs in Greece.
**Source:** A.M. Papadopoulos, KENAK course notes, Sustainable Built Environment course, MSc Energy Systems, IHU, sl. 12

The Certificates are being issued by the Energy Auditors, who are members of a public entity formed for this purpose. For a period of one year carrying out energy audits is undertaken by provisional energy assessors who are listed in the official registry of auditors established by the Ministry of Energy, Environment and Climate Change. These must be qualified engineers with ten years of documented experience in relevant subjects. In 2011, the procedure for certifying regular energy auditors is scheduled to be initiated. These will be engineers with a minimum of three years of professional experience and after the mandatory attendance of a 60 hours basic training program plus another 60 hours for HVAC systems, which will be certified by written exams, organized and supervised by the Hellenic Technical Chamber. Depending on the engineers' academic background, the auditors will be classified into two groups. Class A experts will be allowed to perform inspections and issue EPCs for buildings with heating and/or A/C installations up to 100 kW, while there will be no restrictions for class B experts.

Similarly to other member states, the Greek government has taken initiatives so as to achieve certain efficiency improvements. For instance, the former Ministry of Development had launched the "Change Climate" incentive program[20] that subsidized the replacement and recycling of old, inefficient air-conditioners. The programme started in June 2009 and ended four months later. This action was co-funded by the European Regional Development Fund (ERDF) and National Resources. Each consumer could withdraw up to two A/C units and replace them with new, more efficient ones. Participants were eligible for a subsidy of 35% of the retail selling price of the new device, with a maximum grant of 500€. The subsidy was being received in the store to eliminate bureaucracy and inconvenience for the public. The selling stores have been responsible for the withdrawal of the old devices and were provided with the necessary documentation from the recycling company. By presenting the aforementioned documents, the stores received the subsidy that had been offered to the consumers.

As part of an effort to meet the national energy and environmental targets, the Ministry of Environment, Energy and Climate Change has put into effect the “Energy savings in residential buildings” program[21] in January 2011. This co-funded program addresses owners, whose buildings are classified as low efficiency houses and were constructed before 1980. The program offers grants and loans under favorable conditions in order to carry out certain interventions (retrospective thermal insulation, replacement of windows, replacement of the boiler, installation of solar collectors for domestic hot water) and improve the energy performance of the buildings by at least 30%. After verifying that they satisfy the eligibility criteria, the participants have to check their financial credibility in collaboration with a bank that also participates in the programme. A first energy audit follows, so as to determine the performance of the property and the appropriate interventions needed. Afterwards, the participants submit their application and documents to a participating bank for approval. As soon as they receive approval, they can implement the suggested renovation measures and verify the results by means of a second energy audit.

The “Building the Future” programme [22] is scheduled to begin in October 2010 and has a horizon of nine years. It aims at restructuring the building materials market so as to ensure that any energy building efficiency improvement achieved by 2020 will be accompanied by a reduction in energy consumption of buildings in all sectors. It will be implemented in stages and it is foreseen to cover energy works of over 25 million Euros in the first three years. In its essence, the programme is a partnership between the public sector, the building industry and the public. The actions of the programme extend in three levels:

- Implementation of measures that integrate advanced as well as mature technology throughout the building stock, aiming at the reduction of the energy consumption and the improvement of the quality of existing buildings.
- Demonstration of products and technologies of high energy and environmental performance in projects so as to facilitate their penetration to the market and promote related energy policies e.g. zero energy buildings.

- Coordinated actions in the field of the industrial and academic research with the scope to design certified energy related products in order to place them in the domestic and international market.

The public sector will be responsible for implementing voluntary agreements with the private sector so as to ensure significant discounts to citizens- at least 20%- on products and services. In addition, it will have to organize the market so that transparent information regarding the certification and technical characteristics of each product could be easily accessible.

Summarizing, it is clear that energy efficiency is in the heart of the Europe 2020 Strategy for sustainable and inclusive growth [23]. Although significant steps have been made towards this objective, recent Commission estimates based on the implementation of the energy efficiency measures until December 2009, indicate that the EU is more likely to achieve only half of the 20% objective. This is the reason why, the Commission has developed a new Energy Efficiency Plan, published in March 2011. The plan suggests that the public sector should take a more active role in building's adaptation to the new, more ambitious goals, by increasing the refurbishment rate of public properties under specific provisions provided by the Commission. Furthermore, the energy performance contracting is foreseen as an important tool in accelerating the energy improvement of the existing building stock. This has been successfully implemented in Denmark, France and Germany providing a record of good practices as well as obstacles that have to be overcome [24].

Other issues of concern involve the promotion of district heating with the aim to deal with the heat consumption in buildings and the need to produce properly trained human resources that will be able to respond to the future energy efficient building solutions. The focus is also set on the reluctance of owners and tenants to finance energy saving measures in sight of sharing the benefits. This issue has been addressed in several member states by the development of a legal framework which defines the amount to which the investors are entitled while at the same time it secures the tenants' rights. Finally, the low level of public awareness and accreditation of Energy Service Companies (ESCOs), along with the need for innovative financing schemes, have a deterrent effect in the development of their activities in the market.

On top of the Europe 2020 Strategy the EU has already set the strategic goal for 2050; that is the development of a low carbon economy. This can be related not only to the 20% efficiency target by 2020 but also to keeping the temperature rise due to climate change below 2°C, by achieving by 2050a reduction of the greenhouse gas emissions of 80-95% compared to 1990. Some Member States have already undertaken steps in this direction, by setting emission reduction objectives for 2050. In a detailed sectoral analysis of the Commission the residential sector is in the third rank as far as the magnitude of reductions needed by 2030 and 2050 is concerned. Different set of assumptions about the technological innovation and fossil fuels prices were examined in order to produce the following matrix.

| GHG reductions compared to 1990 | 2005 | 2030 | 2050 |
|---|---|---|---|
| Total | -7% | -40 to -44% | -79 to -82% |
| Sectors | | | |
| Power ($CO_2$) | -7% | -54 to -68% | -93 to -99% |
| Industry ($CO_2$) | -20% | -34 to -40% | -83 to -87% |
| Transport (incl. CO2 aviation, excl. maritime) | +30% | +20 to -9% | -54 to -67% |
| Residential and services ($CO_2$) | -12% | -37 to -53% | -88 to-91% |
| Agriculture (non-$CO_2$) | -20% | -36 to -37% | -42 to -49% |
| Other non-$CO_2$ emissions | -30% | -72 to -73% | -70 to -78% |

**Table 1:** Sectoral reductions

**Source:** European Commission, A Roadmap for moving to a competitive low carbon economy in 2050, 2011, p. 7. Retrieved from: http://ec.europa.eu

Electricity holds a central role in the low carbon economy, given that it can replace to a good extent the use of fossil fuels in transport and heating. After all, the recent recast Directive on Energy Performance of Buildings points to the direction of nearly-zero buildings after 2021. This is translated into the integration of renewable technologies in the design, apart from stricter energy performance standards.  The additional costs required can be recovered through the fuel savings achieved. However, finding a proper and effective financing mechanism for the refurbishment of existing buildings remains a quite challenging Issue. In this direction, some member states make use of structural funds whilst others launch financing schemes such as favorable interest rates, to leverage private investments in the most efficient building solutions. Shifting to low carbon energy sources also entails consumer protection from volatile fossil fuel prices, health benefits, and job creation.

Regardless of the complexity that is always involved in delivering a legal framework which has to be implemented in all EU member states, a strong regulatory framework as well as supporting mechanisms have already been in place and are under constant revision that results in further improvement and new targets. Nevertheless, one has to keep in mind that climate change is a global problem which cannot be solved by EU alone and international progress must be strongly pursued in the future.

# 4 Social Housing

Social housing has developed in various times and forms across Europe. However, social housing is characterized by a common mission to provide households with housing they can afford, thus answering a failure of the free market. It can also serve for complementary missions such as social integration of deprived populations. The current economic, financial and social crisis was triggered by a mortgage credit crisis and the collapse of the housing bubble (in the USA), has not affected the housing markets of member states in the same way as they are radically different. Yet, in all but a handful of countries, the cost of housing has risen rapidly and now represents a considerable share of the household budget for Europe's low-income families.


**Figure 9:** Households with dependent children experiencing housing cost overburden, Eurostat, 2009 (% of total population). Housing cost overburden is defined as occurring when the total housing costs represent more than 40% of disposable income.

**Source:** Retrieved from: http://www.relationshipsfoundation.org

Cities and consequently housing has changed to a great extent through the past hundred years. In the 19th century Europe has witnessed profound social and technological changes. Over and above, during the following periods of both the World War I and WW II, European capitals were vastly devastated and in need of mass reconstruction. Thus, social housing has become one of the major instruments for public authorities in the enforcement of a housing policy. At the same time, it provided architecture and urban science with a fine opportunity to manifest new ideas and practices regarding among other city growth, modern living, affordable housing, construction.

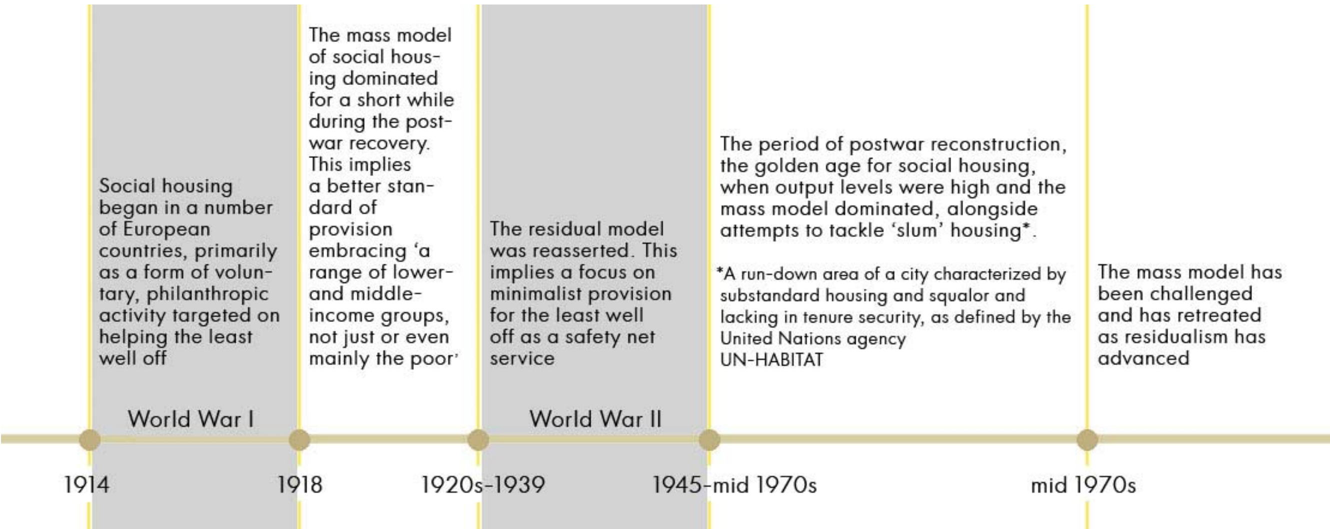
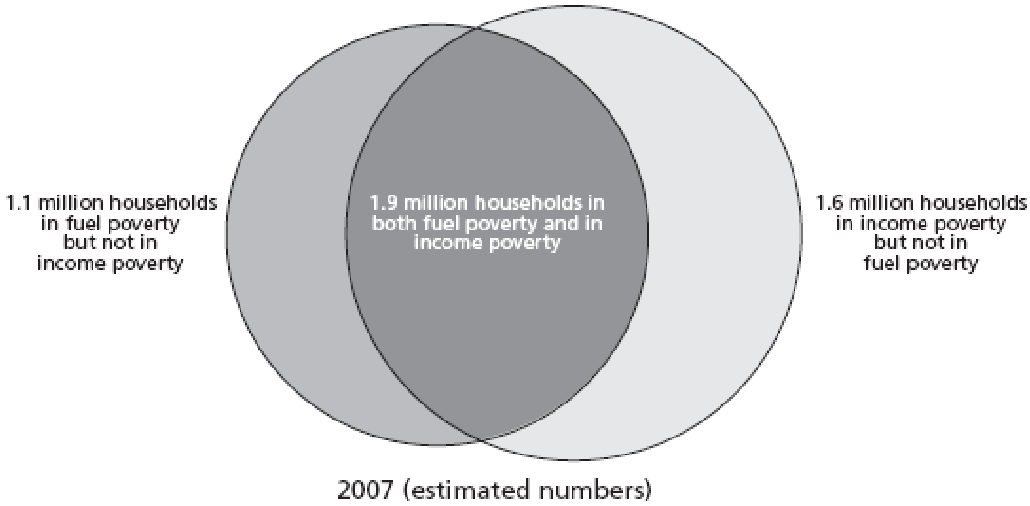



**Figure 10:** The phases of development of social housing according to social scientist Michael Harloe (*The People’s Home? Social Rented Housing in Europe and America*, 1995)
**Source:** author

Over the last decades different policies revolving around social housing have been implemented in European countries. For that reason there is no single definition of social housing in Europe primarily due to difficulties in determining co-operatives that manage the stock, time-limited subsidies and the role of private stakeholders. Social housing expressed as a percentage of the total housing stock in 2007 ranged from 35% in the Netherlands to single digit numbers like 4% in Hungary. This was a consequence of a decreasing trend in new public housing schemes in combination with mass privatization and cases of demolition. A comparative analysis in Austria, Denmark, England, France, Germany, Hungary, Ireland, the Netherlands and Sweden has revealed that no matter the origins of social housing, the pressure it faces is somewhat similar and the attention is now on partnership, along with the constant pursue of mixed-communities with concerns about segregation and vulnerable households [25].

Besides social concerns, the growing demand over energy efficiency in buildings cannot but affect the social housing stock. For example, the objective of lifting 20 million people out of poverty and reducing energy consumption by 20% of the Europe 2020 Strategy is particularly relevant here. Energy prices, household income and housing quality contribute equally to fuel poverty. According to Boardman's definition provided in 1991, a household is said to be in fuel poverty if it would need to spend 10% of its income in order to maintain adequate energy services [26]. This is the expenditure approach towards fuel poverty definition. The consensual approach on the other hand is based on the concept of a series of elements that are connected with energy use and building fabric. These are generally regarded as being necessary and households that lack one or more of these necessities are regarded as being fuel-poor [27].




Note: A household is deemed to be in income poverty if its disposable income, before deducting housing costs, is less than 60 per cent of median household income; all incomes are adjusted (equivalized) to take account of differences in household size and composition.

Source: Palmer et al (2008, p15)

**Figure 11**: Relationship between fuel poverty and income poverty, England (2007), p. 32

**Source**: B. Boardman (2010)

It is worth mentioning that fuel poverty is not synonym of income poverty although linked concepts. Future fuel poor are most likely to come from households that are in income poverty but not in fuel poverty primarily because they live in inefficient houses [28]. An increase in energy prices, like the one noted in many European countries can impose a great burden on many households that could experience financial shortages in other areas of life, a possible cut off of energy supply, health risks. Fuel poverty can be described as a circular process. Firstly, poor people can afford only cheap, poor quality housing. Due to the inefficiency of the houses, the energy costs are high. Hence, a big share of their low income goes to energy services. As energy prices rise so does the proportion of income spent on them. Trapped in this circle the initially poor most likely shift to fuel poor and fail to save money in order to improve their housing conditions.

Higher concentration of fuel poor households is noted in the southern European countries; Portugal with 56%, Spain with 38%, Greece with 36%, and Italy with 16%. French, Belgium, UK and Ireland follow with rates around 8-9% while Germany, Denmark, Netherlands and others are in the range of 4-5% [29]. Many studies have established a correlation between the income of each household and the quality of space it occupies. Reports regarding problems of housing deficiency come more frequently by those at risk of poverty than those with higher income levels [30]. Moreover, Santamouris et al. in a data collecting survey from a number of households located in Athens in 2004 concluded that the higher the income the higher the percentage of buildings with insulation and double glazing [31].

The major barrier against refurbishment of existing building stock in general as well as of social houses has been identified to be the financial resources required [32,33]. The Financing energy Refurbishment for Social Housing project of IEE reports 35 million homes across Europe, housing 120 million people and accounting for some 18% of green house gas emissions [34]. The project demonstrates the application of energy performance contracting in social housing comprehensive refurbishments to social housing operators from France, UK, Italy and Bulgaria, thus producing real examples and disseminating practices.

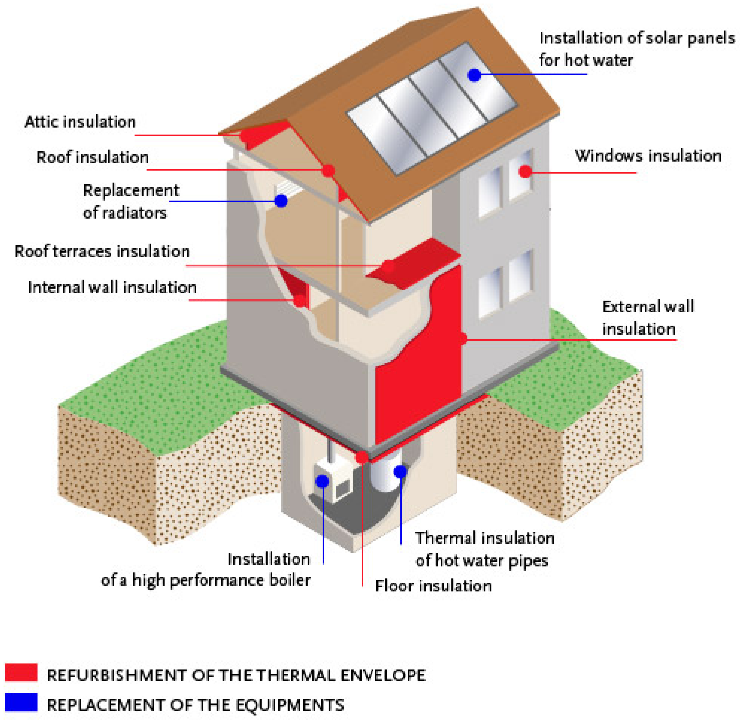



**Figure 12:** Example of a comprehensive refurbishment

**Source:** Retrieved from: http://www.fresh-project.eu/project/

The urgency of the matter of fuel poverty in Europe is denoted by the addition of references and directions in the directives of the third energy liberalization package prompting member-states to secure the rights of the energy vulnerable customers and to ensure their support. In sight of the benefits of energy performance contracting with respect to energy improvement works and the scarcity of state funding, the most efficient way to improve the existing social houses seems to be through the private players. In other words setting the context within which energy retrofit becomes financially lucrative and so as to develop such a market.

Following, is a short overview of the social housing sector and the challenges that the development of an energy renovation market faces in Germany, the UK and finally Greece.

## 4.1 The case of Germany

After World War II, the shortage of housing was resolved in Germany by government incentives to stimulate production in the rented sector. The emphasis was on fiscal subsidies to stimulate private building activities. This led mainly to the construction of private rented dwellings. Even at present time, the construction firms are required to operate the housing as 'social', in other words, to enforce income limits, rent ceilings etc - for a certain period. The length of this lock-in period has ranged from 40 years or so in the 1970s and 1980s to 12-20 years now. After its expiry, the owners of the dwellings are free to rent or sell the dwellings at market prices. In practice, however, many of the developers are municipally-owned companies that continue to operate the units as de facto social housing.

The social building stock in Germany consists of a variety of products illustrating the goals of the German housing policy after the World War II. In the 1950s the focus was more on the production of suitable dwellings for a wide range of social groups, thus attention was paid on the size, equipment, rent level and maintenance cost. Nowadays, the production of rented housing and owner-occupied housing are both still regulated. Since the late 1980s special emphasis has been placed on specific groups rather than general policies, with a focus on providing for the aged, single parents and larger families. The Law on the Reform of Housing Regulations in 2001 marked this shift from socio-spatial policy to individual care. Nonetheless, as new urban problems have emerged - including regional economic disparities, demographic changes, urban polarization and over a million vacant homes - a debate has started about the need for and the appropriate forms of social housing in the reformed welfare state.

German history has left its mark on public housing as well. The division of the country has led to two different development axes; the mass housing provision in Eastern Germany and that of the Western part. By the time the Wall was demolished, the East German housing stock consisted of the "working class palaces" built in the 50s, a number of high quality constructions of the International Modern movement in the 1960s and the 1970s massive industrial production of pre-fabricated buildings. In the latter the urban dimension was to great extent neglected and strong feelings of dissatisfaction appeared, particularly as a quality housing market emerged after unification in 1990. Consequently, many areas of municipal buildings from the GDR period have increasingly been abandoned by better- off social groups. Older and poorer residents remain, and young transitory groups with limited financial resources move in.

On the contrary, social housing in the Federal Republic consisted of highly subsidized rented and cooperative flats in urban blocks. Social rented housing was originally built in areas of war damage and it was later used for urban renewal purposes. An amount of owner-occupied housing could be found in peripheral developments. Municipal and cooperative housing companies were the basic players in social housing market until the 1980s when the federal states' programmes opened up to the private sector. Private investors, who often belonged to the wealthier German middle classes, received generous tax relief in return for co-financing the construction of social housing. With the exception of a quality slump during the mass-production period of the 1970s, social housing was targeted to lower middle classes and key workers. As it was always a leader in architectural and urban design social dwellings were never stigmatized as lower-class homes.


**Fig 13:** Different social housing products: (1) the Weissenhof settlement in Stuttgart built by Modernists for exhibition, in 1927, (2) the Siemensstadt estate built in 1929 in Berlin, classic Modern example, (3) the Weberwiese High Rise in former East Berlin, built in 1951 by Hermann Henselmann, (4) the Heckert prefabricated buildings in Chemnitz, built in the 70s, in the Socialist Realism style.

**Sources:** (1) http://barbaralamprecht.com, (2) http://housingestates.wordpress.com,

(3) http://en.wikipedia.org, (4) http://www.thelocal.de/

Social housing is currently undergoing a shrinking trend. Despite the strong involvement of the market that resulted in high quality constructions its role as an instrument of urban and social policy has weaken. In parallel, phenomena of gentrification have led to negligence on behalf of the municipalities over the lower-quality dwellings that seem unprofitable [35]. As a result, vulnerable groups of the society are trapped in a shrinking public housing sector of low quality located in areas that gradually obtain a bad reputation. Fortunately, high ecological standards have been pursuit by providers ever since the mid-1980s. Nowadays energy retrofitting is rather widespread in Germany on grounds of high environmental awareness of the society and a well developed energy renovation market. It is highly possible for the German government to achieve the goals it has set to reduce the primary energy requirement of buildings by 80% by 2050 and increase the thermal retrofit rate from 0,8% to 2% annually. Supposing that the retrofit rate is increased as intended, in order to meet the 80% goal, these retrofits have to be deep [36] and this seems achievable considering the well established national renovation market.


| ENERGY RELATED INDICATORS | Initial situation | After refurbishment | Reduction |
|---|---|---|---|
| Energy performance | 289.7 kWh/m²a | 39 kWh/m²a | 87 % |
| Energy consumption | 196,392 kWh/a | | |
| $CO_2$-emission | | | 58 kg/m²a |
| Heating system | gas central heating system | gas central heating system (condensing boiler) | |
| DHW-system | hot water warmed up by heating system | „solar energy centre" with solar plants | |
| Monitoring system | yes, quality assurance is accomplished by collections of data over a period of 2 years after refurbishment | | |

**Fig 14:** Good practice example of the **"**Retrofitting of Social Housing" program. The social houses were built in 1955 in Steffensweg, Bremen-Walle and they were refurbished in 2005.

**Source:** Retrieved from: http://www.rosh-project.eu

## 4.2 The case of the UK

Another country with a long history of social housing is the United Kingdom. As a result of shifts in the national housing policy a diversified social housing stock has been produced through the years. This ranges from slum development projects to high quality houses, though maintenance plays a key role in the today's quality of the stock. Originally, social housing was offered by charitable non-profit organizations that addressed the problems of particular social groups. In 1890, the UK Parliament offered the possibility to local authorities to develop housing for work-class tenants. It was not until the late 70s that this pattern was changed, with the introduction of non-profit organizations, known as housing associations that are regulated by government and non-government bodies. Nowadays, social housing is rental housing for low-income households, with rents regulated by public authorities and is considered by CECODHAS as targeted and residual [37].

The mass flow of workers due to the emerging factories has made a significant impact on the life of individuals as well as the urban environment on the whole. In the years of the industrial revolution high levels of homelessness were noted in the big city centers. Back-to-back housing was built for the workers and it seemed under the social pressure of those times as a reasonable answer on grounds of its high-density. However, as three of the four walls were common with the adjacent buildings, there was poor light not to mention poor ventilation. Granted that in the 19th century the medical opinion supported that disease was spread through inhaling bad air, it comes as no surprise that the 1909 Housing Act banned this type of constructions [38]. Gradually, council housing of high quality has been developed in major cities of Britain.

The invention of the railways and later the car gave birth to the concept of the Garden cities. The theory of Sir Ebenezer Howard in the late 19$^{th}$ century was referring to self-contained communities surrounded by zones of greenery, which contained carefully balanced areas of residences, industry, and agriculture. It gained popularity and financial support that resulted in the realization of two such communities and it was later adopted in the New Towns Act, when the UK government pursued the development of new cities in order to address the lack of housing after the World War II.

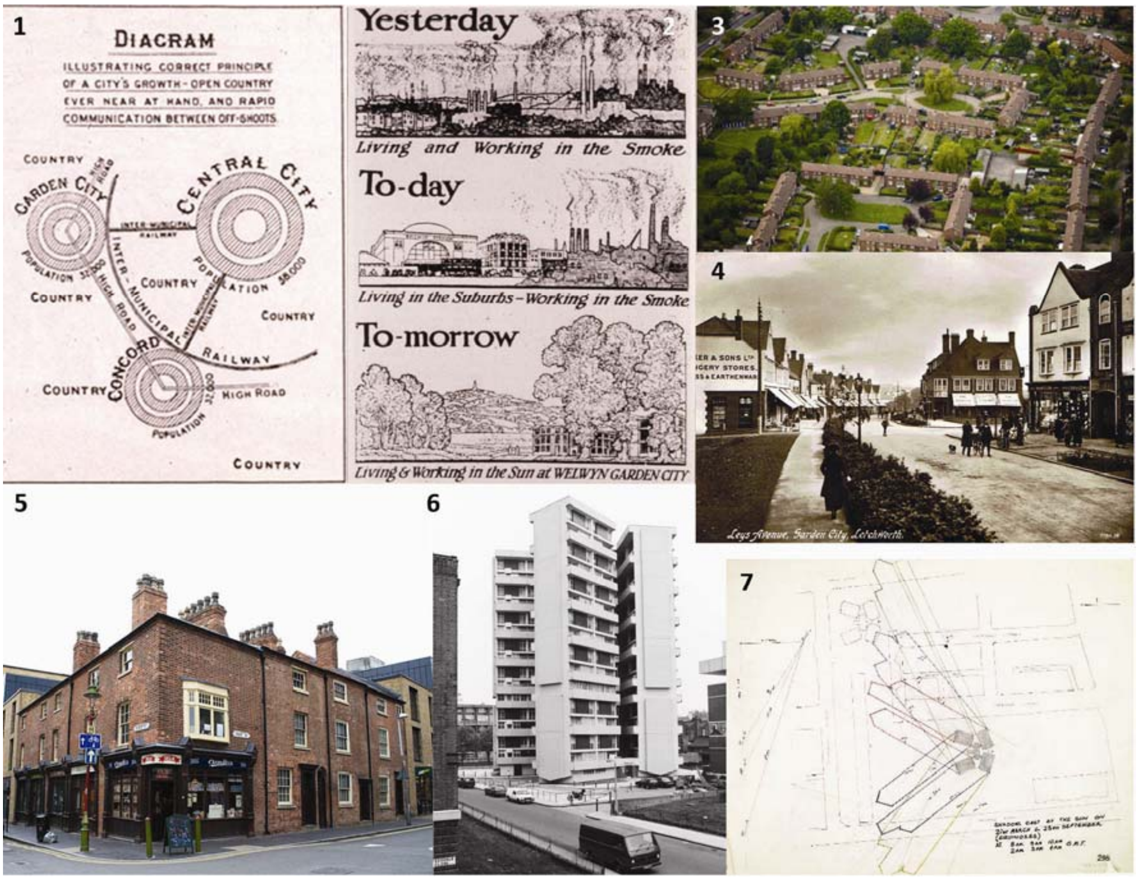



**Fig. 15:** A variety of social housing and influences of urban theories and architectural styles.

(1) diagram of a city's growth according to the Garden Cities theory of Sir Ebenezer Howard, (2) brochure propagandizing living in Welwyn garden city, (3) Welwyn garden city aerial, (4) postcard of Letchworth, the pioneering garden city, (5) "back-to-back" low quality houses, (6) Keeling council house, designed by brutalist architect Denys Lasdun, it was the first post-war council house to be listed, (7) plan showing the shading of Keeling house at different times of the day.

**Sources:** (1) http://www.library.cornell.edu, (2) and (3) http://ocw.mit.edu,

(4) http://lgc.amolad.net/, (5) http://en.wikipedia.org,

(6) and (7) http://www.keelinghouse.co.uk/

In the periods preceding World War I as well as II the focus was on producing new council housing of high quality –"homes fit for heroes" as it was proclaimed. The road to that passed through slum clearances and new development programs. On the one hand there were millions of council flats with indoor plumbing and central heating in semi-detached dwellings with gardens, and on the other hand high-rise buildings. The latter were designed by architects like Peter and Alison Smithson, Denys Lasdun and others, the majority of whom have distanced themselves from the Modern movement and sought a sense of belonging and community in their projects.

The expansion of public housing during the 60s meant continuous slum clearance in combination with new block of flats, some of which was of dubious quality design and construction. In addition there was higher concentration of low-income and non-white families that led to increasing stigmatization and marginalization in parts of the public housing. Despite records of overcrowdedness, an increase of the multi-earner households in council tenure that coincided with a declining private rented sector, has led to a common view of council housing as a positive experience. Indeed, there was social and economic diversity in the council sector during the 60s and 70s that justified the voices calling for differentiation in rents or additional charges for multiple earners. According to Malpass, a strong desire for home-ownership among council tenants is documented in a variety of studies [39].


"It's up to you, Alf—but we feel that you'd help the cause more if you walked"

**Fig. 16:** The Jaguar-driving council tenant about to join the campaign against rent increases, by Cookson in 1969

**Source:** Malpass P. (2010), Housing, markets and policy, Taylor & Francis, US, 43

The shrinkage of the welfare state by the Thatcher government entailed significant changes in UK's social housing. To begin with, financial support was withdrawn from local authorities and grants were channeled to housing associations for the construction of new homes. As a result, many councils have transferred their housing stock to housing associations. Lastly, the best public housing occupied by the best-off council tenants was disposed through the so called "right to buy" scheme. At the same time modest growth in privately developed social housing was exhibited in UK. With the simultaneous reduction of general subsidy for public housing production, local authority housing production in the UK declined from over 100,000 units a year during most of the 1970s to fewer than 30,000 a year by the mid-1980s and essentially zero by 1993 [40].

The “right to buy” policy has received a range of criticism. It was viewed as a tool leading to a classless housing system, as a vote-buying exercise, as a short way for companies to make profits out of portfolios of ex-local authority housing, as socially unjust and so on. What most critics agree though is the failure of the policy to produce new stock which in return has determined the characteristics of the housing stock and contributed to the housing crisis of last years [41].Private, mix-tenure development programs and neighborhood regenerations are key elements of the recent UK housing policy that attempt to address these physical, ownership, financial and social issues that the public housing sector faces. The primary critique received for such projects is that the number of council flats produced is less than before and there is no replacement elsewhere. Finally, eco-towns are a government-sponsored programme of new towns to be built with the involvement of private players that will include social housing units and are intended to achieve exemplary standards of sustainability.

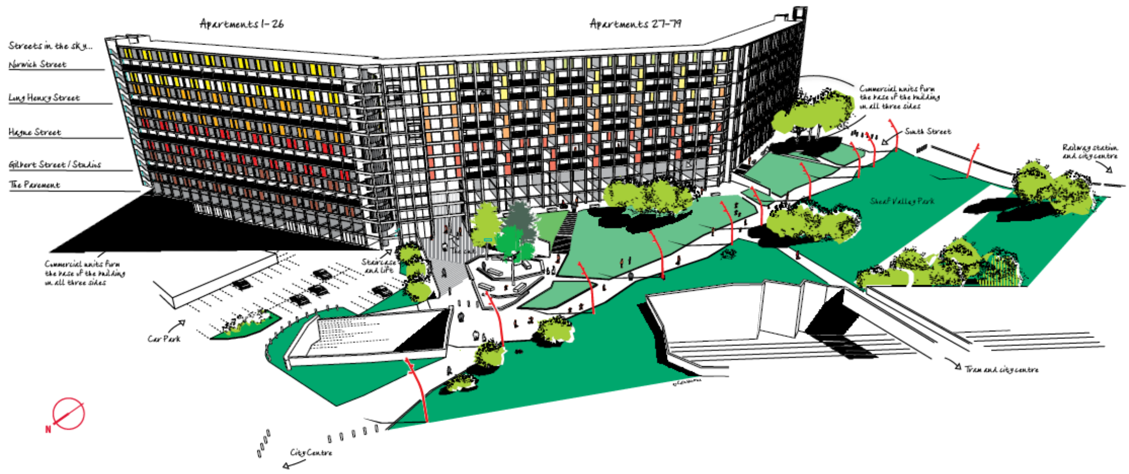



**Fig. 17:** The well received regeneration project of the largest listed building in Europe, the Park Hill, opened in 1961, in Sheffield. The renovation has won the approval of the original architects, Ivor Smith and Jack Lynn who envisioned “streets in the skies”.

**Source:** http://www.urbansplash.co.uk

In addition, there are a number of initiatives to improve the existing social stock. The fact that two-thirds of local authority and three quarters of housing association dwellings met the Decent Homes standard in 2004 shows that higher efficiency standards exists in this sector [42]. Nevertheless, tenants in social housing are significantly poorer and to a greater percent out of work than those in the private sector which explains why they are in greater risk of fuel poverty. The Decent Homes program is regarded as successful and Government is now considering introducing the Green Deal with the aim to boost energy renovation works by means of a Pay-As-You-Save mechanism. An interactive mechanism (Energy Company Obligation) is suggested as a subsidy for the vulnerable households. Although this proposition is appealing it could lead to even greater outcomes if it included further financial incentives such as council tax rebates, stamp duty refunds, and reduced VAT on refurbishments [43].

## 4.3 The case of Greece

Compared to Germany or the UK, the public housing sector in Greece is rather limited. No public rental sector exists in Greece and there is only one body in charge of social housing, the Workers' Housing Organization (O.E.K). It was founded in 1954 and aims to provide homes for workers and employees, in the form of homeownership tenure, who by means of insurance contribute to its financing. It applies various forms of housing assistance in addition to constructing new settlements. OEK's construction activity has declined significantly in recent years. In 2004 51% of the agency's activity was construction of new houses, while in 2007 only 24% went to construction. Now, the agency's main activity is to provide subsidies for housing loans, serving as an intermediary between borrowers and banks. Banks claim that although expected by Law, very few borrowers pay these subsidies back to OEK [44].

Looking back on the country's history, the Catastrophe of Minor Asia [45] in 1922 is viewed by many as a milestone of the utmost national importance, in terms of history, politics, demographics, that touched all areas of development of the country, including the field of urban developments. Such was the impact of the evacuated or relocated population, due to the compulsory exchange of populations following the Treaty of Lausanne, that the term "Greek refugees", although a collective term, is primarily attached to this population. Over a million and a half Greeks fled rural Greece as well as the urban centers, Athens and Thessaloniki. In the beginning, the refugees settled in makeshift settlements, in tents, huts, and in abandoned villages, under appalling living conditions.

Numerous suburbs, towns and villages were established as an answer to the demanding housing needs of the additional population of Greece. This goal was initially undertaken by the Ministry of Social Welfare & perception and the Rehabilitation Commission for Refugees. The Commission was established by the League of Nations as a necessary condition for obtaining a loan. Overall the planning of the refugee settlements was not associated directly or even indirectly, to the design of cities. The proclaimed program for the reconstruction of Eastern Macedonia, which has been influenced by the urban theories that had already been applied in Europe, has come to an abrupt end. Instead, the range of actors involved (Commission for Refugees Rehabilitation Services, Welfare, the prefectures, police authorities etc) led to an independent action. In addition, the layout of the settlements was quite simplistic; it was formed by the strict repetition of a single, basic rectangular land-property. Empty squares were used in order to project the location of future public spaces and functions; a church, a school, a square. This pattern inherited problems in relation to the future development of the settlements. In addition, the distance from the existing cities created discontinuity problems and inability to adapt to the existing urban fabric.

Profound changes happened in all aspects of life in Greece, during the Interwar period. To begin with, the addition of the Greek refugees to the population boosted the rural population, while some emigrated abroad, and the more affluent part gradually contributed to the growth of the industry by setting up factories near refugee settlements and drawing workforce from there. Furthermore, the technological advances that were noted in Europe, affected the urban environment of the Greek cities; there is electrification and asphalt laying of streets for the first time, central heating systems, elevators and extensive use of concrete in residences. At the same time, robust personalities of the newly established School of Architecture, in Athens, affect the aesthetics and the development of the city. In addition, the messages of the political, social and architectural movements that flourished in Europe during the 30s, did not go unnoticed (new town plans, 4o C.I.A.M. held in Athens, in 1933 etc) and have found their Greek interpretation, by the time reactionary regimes emerged and World War II commenced.

Unfortunately, the large scale destruction caused by the World War II, and the three years of civil war that followed, delayed the implementation of any plan of organized public housing. Slum clearance programs began in the early 50s. In fact, in five years duration, from 1952-57, half of the slum sheds have been demolished and approximately 9.000 people have received better accommodation, with other 26.000 pending [46]. Yet, a lack of affordable housing still existed, and informal settlements appeared near the cities. According to a United Nations-Habitat report [47], the “first generation of informal settlements” refers to an estimated 380.000 informal houses that were built around Athens and Thessaloniki, between 1945 and 1966. At that time, the private housing sector was boosted by a series of economical and legal measures and ever since the role of the state as a provider of housing has significantly shrunk.

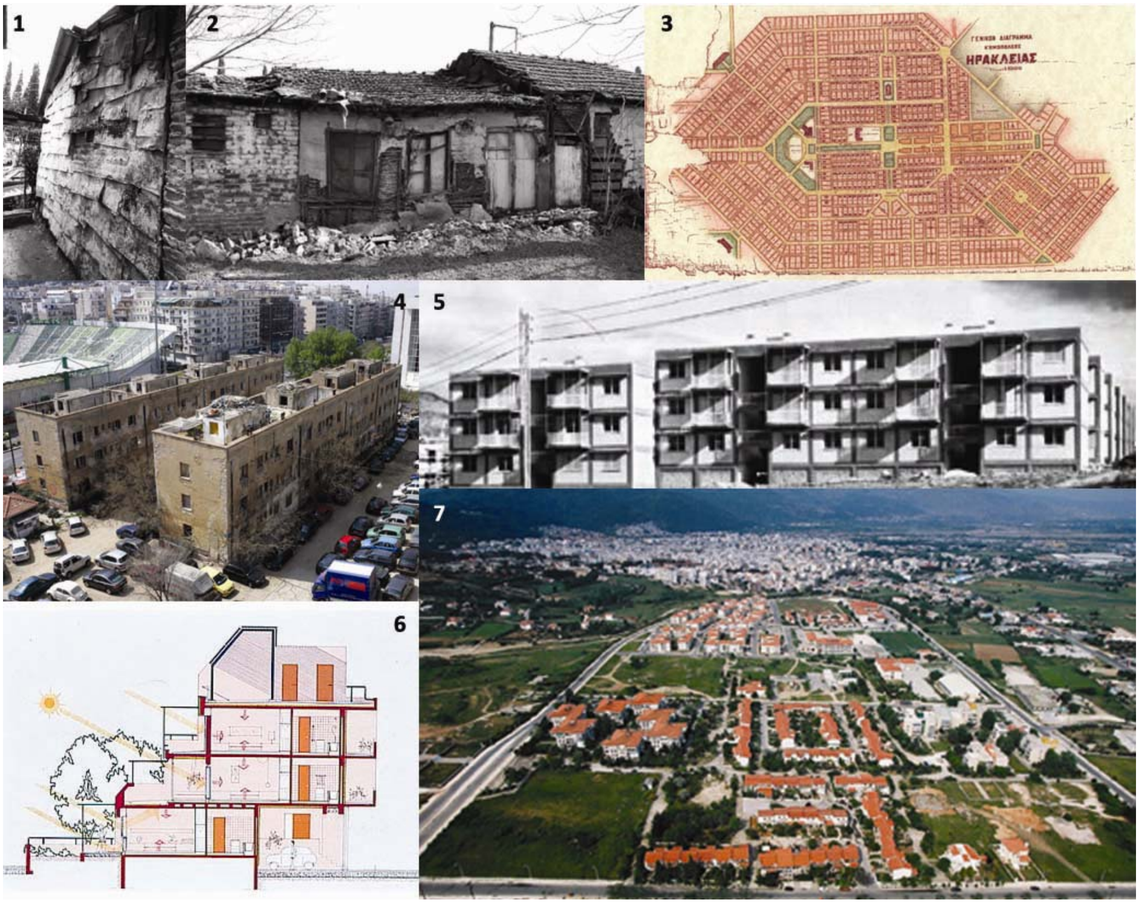


**Fig. 18:** Examples of social housing in Greece: (1) and (2) Armenian refugee sheds, still standing in Ampelokipoi, Thessaloniki. They were build by the refugees on land provided by the state - same building techniques were used by Greek refugees, (3) Irakleias' town plan, in Serres, designed as a garden city in the 30s, (4) the listed complex of block of flats in Alexandras' avenue, designed by Laskaris and Kyriakos, in 1933, for Greek refugees, a fine example of the Bauhaus movement, (5) working class complex in Nea Philadelpheia, Athens, designed by Konstantinidis and constructed by O.E.K. in 1957, (6) cross-section of a solar house in "Solar Village 3", O.E.K.'s experimental project, designed by Tombazis and constructed in Lykovrysi, Attica, in 1978, (7) the new settlement build by EKTENEPOL in the rural area near the city of Xanthi, in the 90s. It was not a genuine social housing program, still in its demise, O.E.K. bought pieces of land for the erection of social residences. It is now considered a dormitory town.

**Sources:** (1) and (2) Ο προσφυγικός συνοικισμός των Αμπελοκήπων, Τετράδια Ιστορίας 5, έκδοση του Κέντρου Ιστορίας Αμπελοκήπων Θεσσαλονίκης, Μάρτιος 2010,

(3) and (7) http://www.greekscapes.gr, (4), (5), (6) http://www.culture2000.tee.gr,

During the fifty five years of operation of the Workers' Housing Organization, much has changed in terms of building regulations with the introduction of the Thermal Building Regulation, in 1979 to be a strong reference point. Ever since, O.E.K. has demonstrated a desire to incorporate energy and the environment in its housing plans. For instance, the "Solar Village 3" was an ambitious experiment that aimed at the application of the bioclimatic design for the creation of high quality environment in social residencies, and the upgrading of the social housing standards in general. The impact of environmental design is clear, both on the master plan of the settlement and on the design of the 453 solar houses. The latter incorporate passive, as well as energetic solar systems for the heating and domestic hot water needs of the residents. Relatively recently, the organization collaborated with the Aristotle University of Thessaloniki, and received consultation over the energy improvement of the basic types of buildings of a settlement as well as of the settlement on the whole [48].

It is obvious that a percentage of social housing, which was build before 1979, is lacking in energy efficiency. Moreover, the exemplary example of "Solar Village 3" also faces problems in maintenance and misuse from the owners' part. Despite the slow development of the energy renovation market in Greece, pilots for the improvement of inefficient working class buildings of O.E.K. have been, or are being currently, developed. The first is an initiative of the municipality of Tauros, Attica and is referring to the energy renovation of two building types. This was embraced by the Center for Renewable Energy Sources and Saving (CRES), and it was funded through the Thermie A European program. The second is the "Green Pilot Urban Neighborhood" of the Ministry of Energy and Climatic change, which is managed by the Center for Renewable Energy Sources and Saving, in collaboration with the municipality of Agia Varvara, Attica. The program aims to set an example by upgrading four blocks of flats to zero-energy buildings, by implementing innovative solutions to the building fabric and to the heating and cooling systems. A significant part of the works is being realized within the context of voluntary agreements, on behalf of a number of Greek industries and companies.

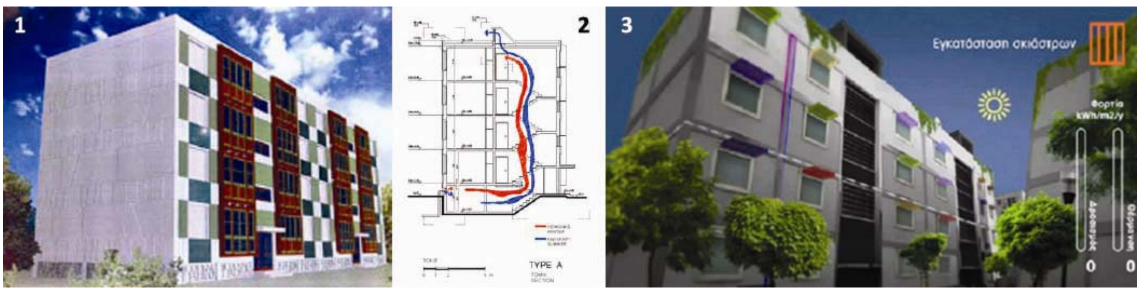



**Fig 19**: Energy renovation of buildings of O.E.K.: (1) and (2) in Tauros, (3) in Agia Varvara

**Sources:** (1) and (2) http://www.cres.gr, (3) http://www.buildnet.gr

# 5 Case study

This study focuses on the energy performance of a specific building complex located in the western Thessaloniki, and in particular in Ampelokipoi. A short overview of the urban development of Thessaloniki as well as Ampelokipoi follows, in addition to a presentation of the building complex under consideration.

## 5.1 The city of Thessaloniki

After the catastrophic fire of 1917, Thessaloniki became the center of innovative urban developments. Only a year later the International New Planning Committee with Ernest Hébrard in the presidency delivered the new town planning. Overall in the process of replanning Thessaloniki strong state intervention is observed. From the commissioning of the planning, the establishment of land values, the role of the private sector up to the urban development principles and tools that were chosen. The whole process exceeded practices regarding spatial development that were used until then. The project was an opportunity to promote the theories of the new born discipline of urban planning and fully exploit the *tabula rasa* terrain left by the fire. Even though it was not fully implemented it managed to change the national and religious terms under which space was occupied at the time and produce a more modern, European city.

In the new design, Thessaloniki is organized around its administrative and financial centre. A network of roads is designed in order to facilitate economic transactions as well as to promote the city's monuments. Other infrastructures are included in the plans along with urban gardens and entertainment areas. A major concern of the design team was the provision for the city's future growth. The attraction of new population was considered desirable and the suggested space for new residential areas, some of which would have been public housing projects, opened to the east. In the northern area of Thessaloniki, a large number of refugees and fire-inflicted families had already settled, thus commencing the extension of the city towards that direction. Refugee settlements have been observed to the west as well; in fact the remains of such still stand in the regional municipality of Ampleokipoi. In the area stretching from Vardari to Dendropotamos, is where the industrial centre of the city was located according to the new design [49].

Despite the fact that the Aristotelous axis is the only part of the Ernest Hébrard's design that was eventually realized, the future spatial arrangement of the city uses is in some cases not far from the initial planning. The industrial center of the city is currently in the west, in the area of Sindos. A substantial concentration of factories, roughly forty, was operating in the area of Ampelokipoi up to the Second World War. In addition, social houses can be found in the east, in the area of Foinikas, although it is rather difficult to verify a strong linkage between this complex built in the 60s'and Ernest Hébrard's initial intentions half a century ago.

The social houses in Ampelokipoi as well as those in Foinika mentioned above, were constructed sometime in the 60s' by the Workers' Housing Organization (O.E.K.). For the complex in Ampelokipoi on which this study shall focus, the date of construction can be more exact, around 1963. At that time, shrinkage was observed in the primary sector along with an increase in the secondary sector followed by the tertiary. As a result, a big part of the rural population moved to the two urban centers, Athens and Thessaloniki, whose population increased significantly. Thus, intense housing needs demanded urgent response. During this period O.E.K. had realized a number of social housing complexes in both cities that share similar characteristics.


**Fig. 20:** Working class apartment blocks in N. Philadelpheia, Athens(1), in Foinikas, Thessaloniki (2) and in Ampelokipoi, Thessaloniki (3)
**Sources:** (1) www.architects.gr, (2) and (3) author

It is quite difficult to verify the designer behind each O.E.K. project, as it was the result of collective work by a team of architects, who worked in ministries, agencies etc, under the guidance of a project director. The complex under study [50] however, resembles a lot another one, built in N. Philadelpheia, in 1957. This is documented to have been designed by Aris Konstantinidis, who held the position of head architect and project director of O.E.K. from 1955 to 1957. While studying in the Polytechnic School of Munich he got familiarized with the ideas of the modern movement. He was against the blind mimesis of foreign architectural styles and struggled to bridge contemporary architecture with his Greek origins, aiming in establishing Modern Greek architecture. He is the first architect to introduce effectively and in large-scale public works the principle of standardization in architectural composition as well as structure. Characteristic architectural elements of his work such as rationalization of the floor-plans, functionality of spaces, integration of natural environment and highlighting the special character of each material used in the construction can be identified in the public housing programs of that period and in particular in the apartment blocks situated in Ampelokipoi.

"In the working class blocks everyone knew each other. Not only the people living in your own building but that of the neighboring as well. I used to play daily with two girls my age who lived nearby. We used to pick up the advertising brochures and play "offices". Each one would have her own office which was situated in the entrance of her building. My brother, on the other hand, would hang around with his classmates that lived in the closest buildings. There were more children living in those blocks and they used to play hide and seek in the evening and even organize exchanging bazaars.

One might say that through a child's eyes everything seems like a fairy tale. In every story though there is a "villain" to spice things up a little bit. In our block there was a man who loved to listen to urban folk music (laika) really loud regardless of the time. In summer, he would sit in his balcony, which was about two meters away from our living room, turn on his stereo and sing. Finally, my brother decided to exploit his recent knowledge of the guitar, and break this "tradition". At the peak of his frustration and in the absence of our parents of course, he opened wide the balcony doors, set the amplifier outside, facing the neighbor's balcony and played the most hardcore rock song he knew!"
Source: author

Konstantinidis viewed architecture as a social function and space as a "life vessel". Indeed, he succeeded in creating space that could host life and allow a number of day-life activities to occur and people to interact. People's lives blended together and common struggles and joys were easily shared among the individuals contributing to their sense of self-identity and their place in a greater community. Locals recollect the vivid atmosphere in the basements of some buildings in Ampelokipoi where the concept of multifunction or recreation room was introduced for the first time in Greek residences. The relationship of trust built over the years among the first and second generation of beneficiaries, who continue living in the apartment blocks, is still present and in fact proved to be quite helpful in this research as interviewing the residents was part of it.

The objective of the short overview is to emphasize on the reasons justifying the focus of this study on the working class complexes of O.E.K. in general and more specifically on those located in Ampelokipoi. Their architectural value tends to be ignored by the majority of the society as well as by members of the engineering community [51]. Unfortunately the huge housing pressure, due to the catastrophe in Minor Asia in 1922 that drove a high number of refugees to Greece as well as the strong immigration flow noted in the 50s and 60s, caused a sudden boom in construction that did not allow for a mature incorporation of the modern movement in Greek architecture. The lack of ornament and the standardization met in the apartment blocks, or else "*polykatoikies"*, produced by the system of "*antiparohi*" [52] increased the confusion over modern architecture. Although, in the beginning, moving to a modern apartment of a "*polykatoikia"* was considered a sign of social and financial elevation gradually, these spaces were criticized as "ugly boxes" and drifted under this label the few exceptional examples of high value architecture realized in Greece.

The working class apartment blocks in Ampelokipoi are undoubtedly part of the local history. At the same time they are a living trace of the socio economical and political forces that boosted the urbanization process throughout Greece. The level of awareness regarding the relation of space, historic memory and identification of individuals, communities even society on the whole is rather low in Greece. History is not only accumulated in books but leaves its trace on walls, streets, squares as well. By paying attention to these and preserving its collective heritage, a society maintains a connection with its past and in the end enjoys a series of benefits. Apart from raising self-awareness historic preservation can be translate into job creation, increase of land-value, development of heritage tourism, contribution to school-curriculum by incorporating visits to historic places in the teaching process etc.

Above all the people living in the apartment blocks realized by O.E.K. in Ampelokipoi and elsewhere regardless of their acknowledging of the architectural or historical value of their properties, face the fact that these buildings perform poorly in terms of energy. They date approximately a decade before the introduction of the first Thermal Insulation Regulation (1979) and as result they are uninsulated. Their current energy performance along with suggested energy conservation scenarios are to be presented in later chapters of the study. In order to further clarify the value of an investigation regarding the energy renovation of such public residencies it is considered helpful to present the existing political, economical and social conditions as well as the challenges that adaptation of buildings and in particular social houses face beforehand.

Poor building envelope quality and outdated energy systems can be easily incorporated in a story based on memories of how day life unfolded in a working class neighborhood roughly two decades ago. Nevertheless this narration fits fairly well to today situation as noted in so many reports and supported by numerous statistical data. An on-site audit, interviews with the inhabitants and the results of an energy audit performed within the context of Energy Efficiency course all agree that it matches quite well with the living conditions of slightly half the apartments of the sample-building in the working class complex of Ampelokipoi. The buildings of this complex embody the principles of architectural modernism that was applied in the 60s in Greece. In parallel they are a living trace of local history. At the same time they undoubtedly hold a huge potential for energy conservation.

Two retrofitting scenarios will be investigated in this study. Firstly, a scenario of soft interventions yet effective in the improvement of the energy performance of the building will be examined. The energy saving measures included in this scenario could be implemented via the current “Energy Efficiency at Household Buildings” and “Building the future” programs thus the applicability of these initiatives would be also investigated. Secondly, a scenario of deep renovation with the final objective to explore the prospect of full non-dependency on fossil fuels combined with integration of RES and other measures will be analyzed. In both cases the current official software of TEE-KENAK will be used in order to calculate the annual energy demand, the primary and final energy consumption of the buildings, the $CO_2$ emissions. The financial savings that follow the energy savings will be examined in the economic feasibility study.

The contribution of this study revolves obviously around the evident increased energy efficiency of the building with the subsequent improvement of the living conditions of the users and the reduction in the cost for heating and cooling. This outcome can be easily multiplied as a result of a common design followed in all working class complexes built at that time by OEK. Additional desiring result would be to present constructive criticism on the prevailing state funding schemes in reference to energy efficiency related projects and produce suggestion and guidelines for successful implementation of such projects.

## 5.2 The city of Ampelokipoi

*Ampelokipoi* (Vine gardens) is a regional municipality of Thessaloniki with a history of over 70 years. Its name is attributed to the vast vine gardens that covered the area in the past. Archeological findings show that this area was used as a cemetery during the roman and early Christian period and has also witnessed a high concentration of carving stone and marble workshops. The first community center was the settlement of *Eptalofou* that was formed gradually from 1913 until 1925 and was especially occupied by refugee families after 1922. In the past it was common for a settlement to be organized around a religion center thus, it was not long before the refugees from Minor Asia commenced the construction of the *Zoodochou Pigi* Church in 1928. Other districts were added to the initial core, the *Teneke* settlement, the

*Ampelokipoi* settlement, the *Armenian-refugee* and the *Kaistrio Pedio* district. It is easily noticeable the great number of factories that were used to operate in the area up until the Second World War. An effort to clarify their position within the boundaries of today's municipality is depicted in the following picture.

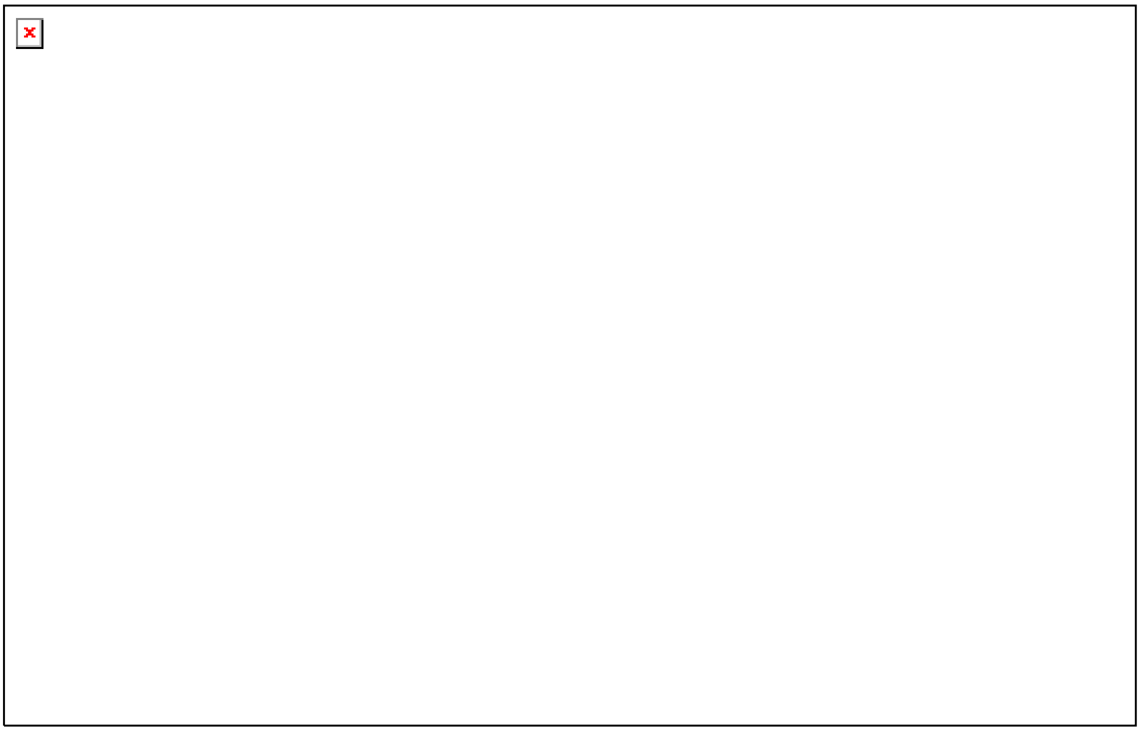


**Figure 21:** Historical and topographical map of Ampelokipoi, up until the World War II
**Source:** author, part of the permanent exhibition of the Center for the History of Ampelokipoi in Thessaloniki (Κ.Ι.Α.Θ.)

In the recent years Ampelokipoi has reached a population of roughly 70.000 inhabitants while under the recent legislation of "Kallikratis' Law" 3852/2010 for the administrative reform it was united with the neighboring municipality of Menemeni. There was no specific provision regarding the urban development of neither of the municipalities of the western urban complex of Thessaloniki. At the same time the area is in close proximity to the industrial area of the city, which is located in Sindos. As a result, the urban and natural environment of this region is under intense strain.

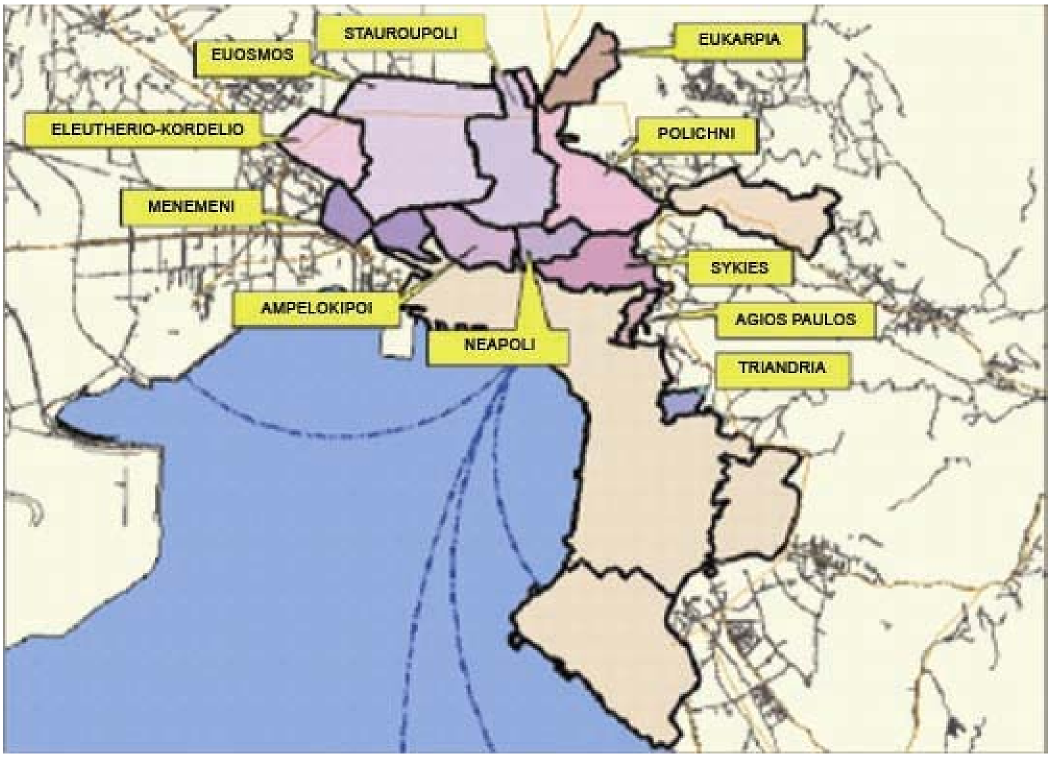



**Figure 22:** The urban complex of western Thessaloniki
**Source:** Θ. Τσιτσώνη (2006), 4

The city of Ampelokipoi has a surface of 1,8 million $m^2$ and stand out as the most densely populated municipality in the complex. According to the census of the NSS in 2001 the population density in Ampelokipoi was 23.858 inhabitants per $km^2$ while in Evosmos it came up to 5.523 inhabitants per $km^2$.

Konstantinos Krikelis, president of the Center for the History of Ampelokipoi in Thessaloniki and active journalist, comments on the unanimity of the city council in the 80s over the need to adopt certain measures in order to boost local economical development, increase the city council revenues and satisfy the urging housing demand of the workers that were anticipated to settle in Ampelokipoi [53]. At that time the building factor was 70% and the legislation allowed three-storey buildings. Taking into consideration the almost flat terrain of the area, the small size of the land-ownerships that could deter land-owners enrichment and the width of the roads that were viewed as sufficient enough, the city council embraced the idea of five storey buildings.

In this questionable direction the city was preparing itself in order to welcome some thousands of new citizens. The route chosen though lacked in provision for the level of quality of life offered to the community. This is evident considering the low rate of green space per capita that amounts to 1,36 $m^2$. Bearing in mind the proximity to the industrial area it becomes all the more clear the inability of the existing greenery to offset the environmental and health risks involved. Moreover, most of the realized parks are small in size and their design does not comply with basic principles that could lead to the creation of modern, functional spaces able to host leisure activities, enhance people interacting and create specific ecological conditions. Accurate assessment of the needed space of a specific population for recreation is not realistic since it is not quantifiable, but qualitative and psychological. However, 8-10 $m^2$ per capita is considered as an acceptable standard internationally. Indicative numbers used in the design of suburban green spaces in other countries is shown in the following matrix [54].

| COUNTRY | GREEN SPACE ($m^2$/capita) |
|---|---|
| USA | 60 |
| UK | 30-40 |
| Netherlands | 45-50 |
| Paris | 25 |

**Table 2:** Indicative numbers used in the design of suburban green spaces in other countries
**Source:** Θ. Τσιτσώνη (2006), 12

## 5.3 The working class complex in Ampelokipoi

The complex was a social housing programme of the Workers' Housing Organization (O.E.K.) in the 60s. It aimed at providing decent homes to a number of beneficiaries. With the completion of the construction works O.E.K. performed a "lottery" that indicated the owners of the apartments. The complex stretches in a roughly 40.000 $m^2$ area in the periphery of the municipality. It is surrounded by the "Alexander the Great" military camp and the following streets: Plastira-Geugelis-Papaflessa-Davaki-Fillipoupoleos-John Kennedy-Venizelou. The buildings are spread over five blocks of different surface and shape that share in common a large percentage of open space where gardens were implemented and properly equipped so as to facilitate people's interacting.

**Figure 23:** The apartment blocks in Davaki str. The picture was taken in the 60s.
**Source:** Φωτογραφίζοντας τους Αμπελόκηπους, Δήμος Αμπελοκήπων, 2005, p. 47

In total thirty apartment buildings were constructed upon the architectural designs of architect Aris Konstantinidis, one of the most important Greek architects who beyond any doubt has left his mark in the history of modern Greek architecture. A mix of different types of buildings whose structure follows a specific construction grid is noticed in the complex. Although standardization and rationalization can be identified in their floor plans, in the composition of the master plan, the shape, size, dynamics of the open space left among the buildings is a high priority. Thus the buildings are arranged in such a way that allow for smaller open areas, parks and squares that work as neighborhood centers. Furthermore, this arrangement of square and rectangular buildings that are characterized by a common architectural language not only emphasizes the existence of a distinct community but also attempts to address the issue of institutionalization.

No matter how elegantly the buildings were arranged and how carefully the open space was designed, still it is clear that the energy performance of the buildings was not of high concern in the architect's agenda. As mentioned earlier such housing programmes came as an answer to intense housing demands due to internal immigration and urbanization. Moreover, the environmental impact of a building was not a challenge for architects of the time. In fact awareness regarding energy efficiency was low considering that the first Thermal Insulation Regulation was not introduced until twenty years later. Therefore, it is not surprising that the whole complex is set with a 40° deviation from the north. Moreover, no central thermal heating system was installed and certainly no insulation.

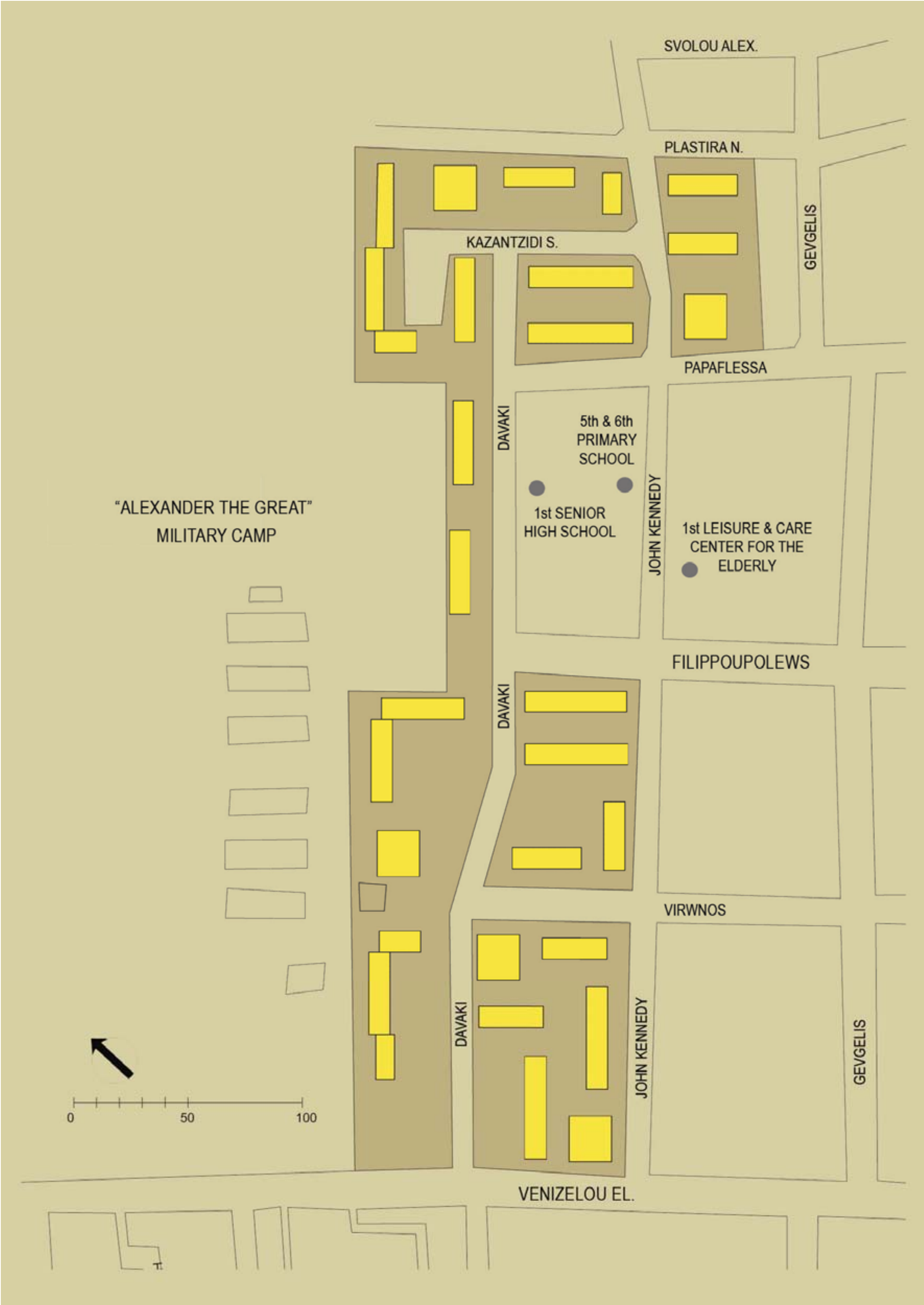



**Figure 24:** The working class complex master plan

**Source:** author

The architect might had a qualitative view of the environmental impact that open spaces have in an area it is more likely though to have focused on their effect on the inhabitants' social life. Still a comparison of the coverage ratio between a block of the working class complex and its neighboring that has been the outcome of private housing development generated by the "antiparochi" system points out the benefits of treating a block as a unit instead of breaking it down to smaller land-ownerships. To begin with, in the first case we note a significantly greater percentage of open space. On a qualitative level, this space has the properties of public space whereas in the second block it seems to be literary the left over after the construction. From public green parks and pedestrian passages to more private gardens the un-built surface of the first block presents a strong functional role. Contrary to the neighboring block, where the ground-floor of many of the multifamily buildings is organized as a pilotis that serves as a parking lot, each land-ownership is distinct by series of banisters and the green areas are lacking. It is worth mentioning that as cars became more affordable, many of them appear parked in front of the working class buildings.

**BLOCK 1**

**Total surface: 9564 m2**

**Built surface: 2099 m2 (0,21%)**

**Open space: 7465 m2 (0,79%)**

**BLOCK 2**

**Total surface: 9262 m2**

**Built surface: 4841 m2 (0,52%)**

**Open space: 4421 m2 (0,48%)**

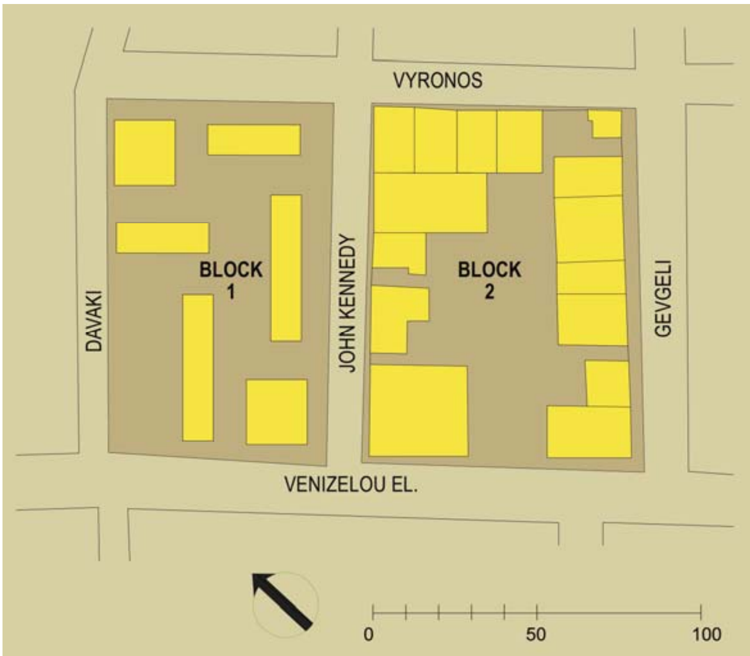



**Figure 24:** Difference in the coverage ratio between a public housing block (Block 1) and its neighboring that was the result of private housing market development (Block 2)
**Source:** author

The majority of the thirty buildings of the complex are of rectangular shape of different length and only five are square. Their structure however is identical. The bear-holding elements are made out of concrete while the external walls are double-brick constructions without insulation. The separating walls are single-brick. In total the buildings are $4^{1/2}$ storey high. In some units a basement with rock walls can be found whereas in others only a half floor rock base is noted. A standard floor plan is being repeated in the rest of the four floors. Square and small rectangular buildings have one entrance and at least two apartments per floor. Two entrances are observed in rectangular units of greater length for safety reasons as they have to provide safe exit to four households per floor. The staircase is the only vertical means of circulation from the basement to the roof. Every pair of households shares a storage room which is situated on the roof and in some cases in the basement.

The initial architectural synthesis of each apartment's floor plan could be characterized rather compact. No waste of space can be observed thus each 68m$^2$ apartment included a living room, separate kitchen with adjacent storage room, a bathroom and two bedrooms. Also each apartment had two balconies, the bigger in the front façade with access from the living room and a smaller one next to the kitchen. As time passed, families grew and new household needs came to surface. In order to meet them the owners of the apartments made certain alterations with the most common one to increase the size of the kitchen by reducing the attached balcony (e.g. apartment no 3). In some apartments this change combined with the complete removal of the storage space resulted in creating a third room (e.g. apartment no 2). Finally, another alteration often met particularly in the ground floor apartments is to include the balcony space to the kitchen (e.g. apartment no 4).

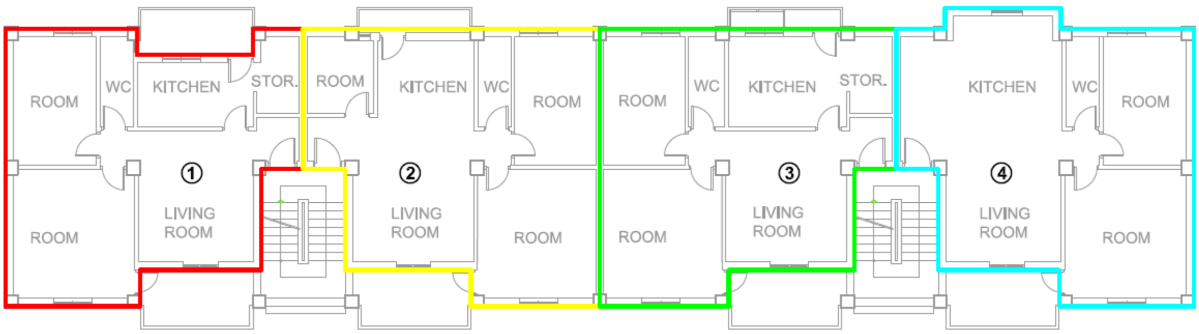



**Figure 25:** The initial floor plan of a typical apartment (No 1) and the most commonly found interventions (No 2,3,4) integrated in a floor plan.
**Source:** author

Changes have occurred in the openings with many owners adopting PVC or aluminum-frame windows and doors more often with single glazing. There is a number of owners though that has not shifted from the original wooden-frame, single glazing openings. In addition with the aim to modernize their properties many residents abandoned the original stoves and have adopted individual oil or natural gas furnaces instead. Apart from heating purposes these systems cover the household's hot water demand. They are installed on the roof, sometimes in the storage room and in the basement. Many apartments are now equipped with air-condition units and others use solar systems for their domestic hot water needs. It is clear that in buildings of such high level of standardization, with residents having very similar occupancy profiles independent energy systems is a choice that goes against the very principle of economy that characterizes the overall housing project.

## 5.4 Representative working class apartment block

For the purpose of this study examining a representative building was considered adequate in order to obtain the necessary information to plot the most efficient energy savings strategy.

The chosen building has a length of 37,40 m, and a width of 8,80 m that is common for all rectangular-shape units. Alike all of the complex buildings its maximum height is 15m. It has a NW-SE orientation and is fully exposed. It has four typical floors, two separate entrances and no basement. All the auxiliary spaces are situated on the roof which is to a great extent used by the residents. Sitting spaces under pergolas, small gardens, parties even a self-made gym are some of the ways in which the residents occupy the roof.

This housing unit consists of sixteen apartments (four per floor) of roughly the same surface. Slight variations can be explained by the alterations that have been implemented over the years by the owners. However, even in the property documents the apartments do not appear to be of the same size. These small differences can be attributed to the size of the chimneys which lessens from floor to floor until it reaches its minimum acceptable dimensions on the roof. With the exception of one apartment that is a rental, the rest are occupied by their initial owners, their descendants or they have become property of others. At the same time two vacancies are noted.


**Figure 26:** Aerial of the building complex. Marked in color is the representative building under study.
**Source:** Retrieved from Googlearth

As far as alterations in the floor plan is concerned, more particularly the disposition of the external walls, only two apartments retain their initial outline. Internal modifications within the apartments are not of interest since this study deals with the energy performance of the building depending on its envelope and energy systems. Furthermore, in seven apartments out of the total the original wooden-frame, single-glazing openings are met. In case where a replacement had occurred, the most often met choice was that of PVC- framed windows and doors. Since it was not possible to identify the exact type of opening for each apartment it is safe to assume that in lack of other information the existing opening is of PVC frame, without thermal bridge and of single glazing.

An astonishing 50% of the households still warm their home with stoves. The majority of the remaining properties have shifted to individual natural oil furnaces, except one that relies on an oil furnace. Those are either situated on the roof or in a storage room. During the cooling period, almost half of the households operate at least one room-air conditioner. Five out of the eight apartments that have not upgraded their heating system have not installed a split unit either, while one of them makes use of two units. Finally, nine households out of the total use an electric heater to cover their domestic water demand. The majority of which are those that have not installed a furnace. On the other hand those with installed natural gas furnaces, exploit this system for the domestic hot water demand as well. Only three families have installed a solar collector for this purpose. It is worth mentioning the different views among the residents in terms of the solar collectors. A resident living in an apartment with natural gas furnace and solar collector stated that her family almost never uses the latter for heating the water. Contrary to another owner who also has a natural gas furnace, used to operate a solar collector in the past and she is now considering of installing a new one for the second time.

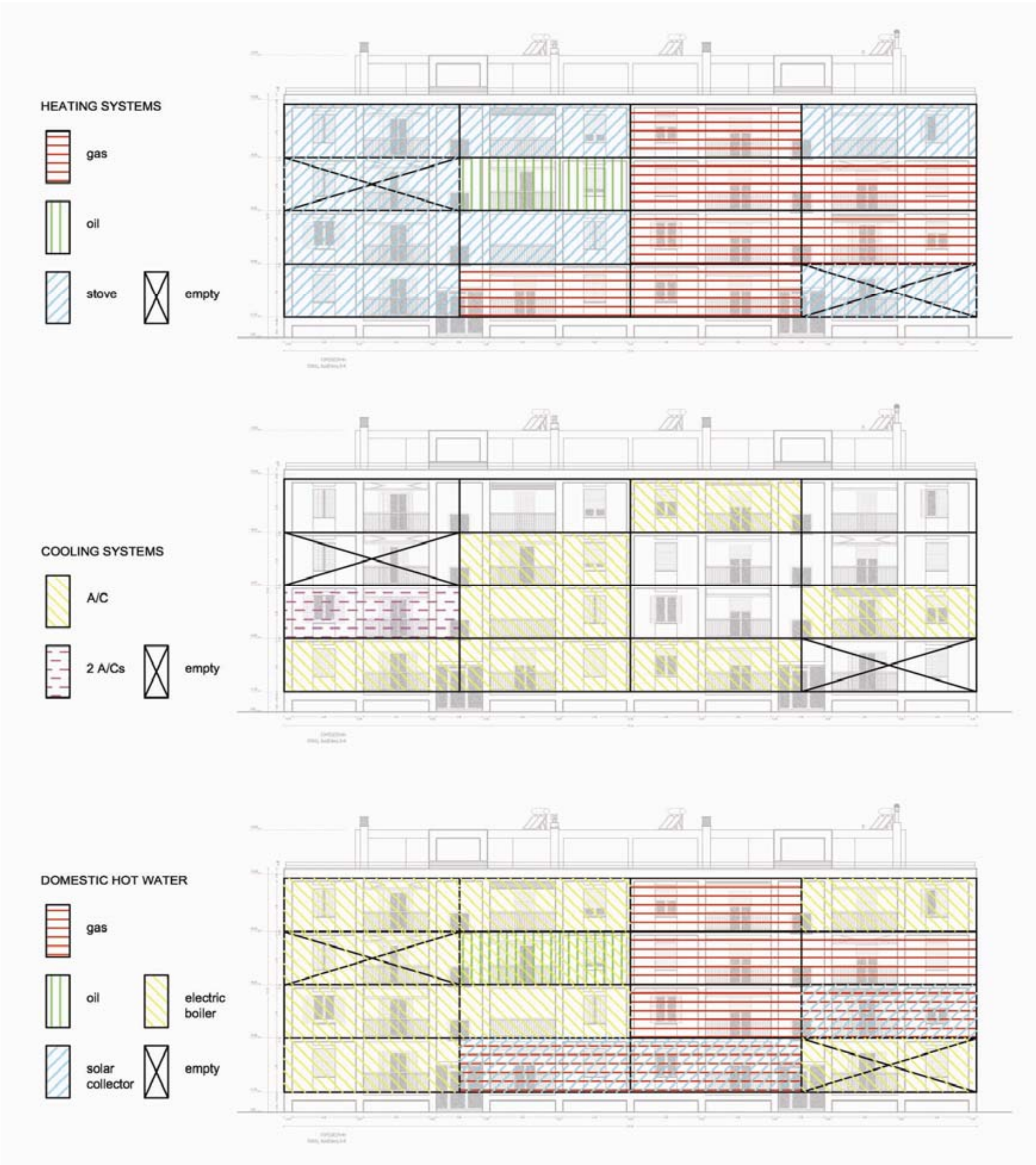



**Figure 27:** The current energy systems found in the building. From top to bottom: Heating systems, cooling systems, domestic hot water systems

**Source:** author

# 6 Energy Audit

An "energy audit" is defined as *“a systematic procedure to obtain adequate knowledge of the existing energy consumption profile of a building or group of buildings, of an industrial operation and/or installation or of a private or public service, identify and quantify cost-effective energy savings opportunities, and report the findings”* [55]. In this direction, the representative building was subject to an energy audit according to the “Regulation of Energy Performance of Buildings” KENAK (Ministerial decision D6/B/5825 National Gazette 407/9th of April 2010) and the Technical Guidelines issued by the Technical Chamber of Greece.

The formal software developed by the Technical Chamber of Greece was used in order to calculate the energy demand and consumption of the building, the $CO_2$ emissions and also its ranking. Basic data required refer to the building identity, the general characteristics of the building envelope, windows and doors, the installation and level of insulation of the heating and domestic hot water systems, the air-conditioning system and the shading from neighboring buildings or installed devices. These were selected by means of onsite investigation and interviewing the residents whenever this was possible. Furthermore, parameters such as the region and climatic conditions of the area where the building is located and the operation hours were already incorporated in the software.

Although the building accommodates exclusively residencies and a general common occupancy profile can be assumed for the whole of the building, six thermal zones were identified. This is due to the differences in the energy systems that have been installed in every apartment. In reference to the technical characteristics of the systems safe assumptions were made in cases where there was no access or this was denied.

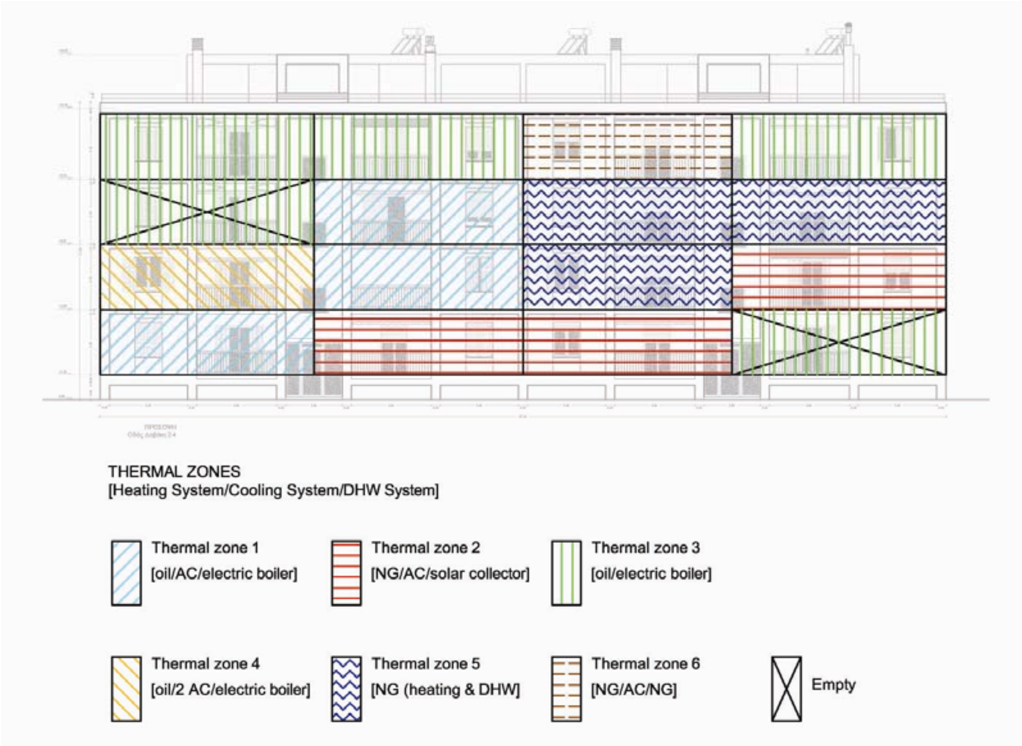
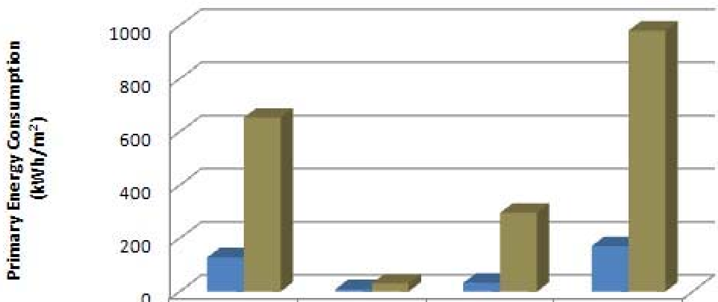



**Figure 28:** The thermal zones noted in the building

**Source:** author

Comparing the total primary energy consumption of the building to that of the reference, it is of no surprise that the building is ranked in the last energy performance category, category G. As it is now, the building consumes almost four and a half more energy than it demands for heating, cooling and DHW. The energy sources used are primarily fossil fuels (55,5% natural gas, 31,4% oil, 12,6% electricity which in Greece is produced mainly from lignite). Only 0,5% comes from RES. As a result the building's operation is responsible for 248,6 kg/m$^2$ of $CO_2$ emissions.




| | Heating | Cooling | DHW | TOTAL |
|---|---|---|---|---|
| Reference Building | 128,8 | 9,2 | 32,8 | 170,9 |
| Baseline Building | 654,4 | 30,6 | 295,8 | 980,7 |

**Figure 29:** The primary energy consumption per end use and on the total

**Source:** author

# 7 Energy renovation scenarios

Energy renovation strategies fall under the scope of this study due to the age of the building complex and secondly the low integration of state of the art energy efficiency technology. Two different energy savings scenarios were investigated with regard to the base building. There is a distinct approach expressed with each scenario in terms of decision making that defines the whole process up to the end-product. The first one is a package of soft interventions that can be realized independently by each household whereas the second goes on to a deep renovation that can be achieved only by means of a collective approach from scratch. A main parameter that affected the structure of the scenarios was the ambition to enable the criticism revolving around the current ministerial energy efficiency initiative “Savings at home” and further on to pin point the challenges that a more aggressive energy retrofit policy would have to face in Greece.

Without doubt energy retrofit in social housing presents a number of benefits. Nevertheless the jump from theory to practice faces many challenges. In recent years a series of European programs have come to identify them and suggest solutions for developing energy retrofit projects in low-income housing (FRESH, AFTER, FINSH, INOFIN) [56]. In Greece the limited applicability of full scale energy retrofitting in the housing sector in general is due to several reasons such as the ownership status, the unavailability of many financing options, and the relatively low energy awareness of the public. Multi-storey, multi-family residential building is a common building typology in Greek cities where the rate of homeownership exceeds 86% [57]. Therefore the procedure that is to be followed in the certification of a whole building is of great importance.

In addition, matters of co-ownership have to be clarified in sight of the implementation of energy renovation programmes such the ongoing “Energy Efficiency at Household buildings” programme. The types of residencies which are eligible for subsidy through the program are: a detached house , a block of flats (for the part which concerns all building apartments), or an independent apartment on condition that they meet certain criteria. The basic steps for participating are:

- Preparation: Credit ability check/ First energy audit/ Identification of interventions/ Collection of documents and offers
- Application Submission: Application submission to the participating bank/ Evaluation/ Approval

- Implementation of Interventions: Loan agreement/ Implementation of interventions/ Second energy audit/ Loan disbursement

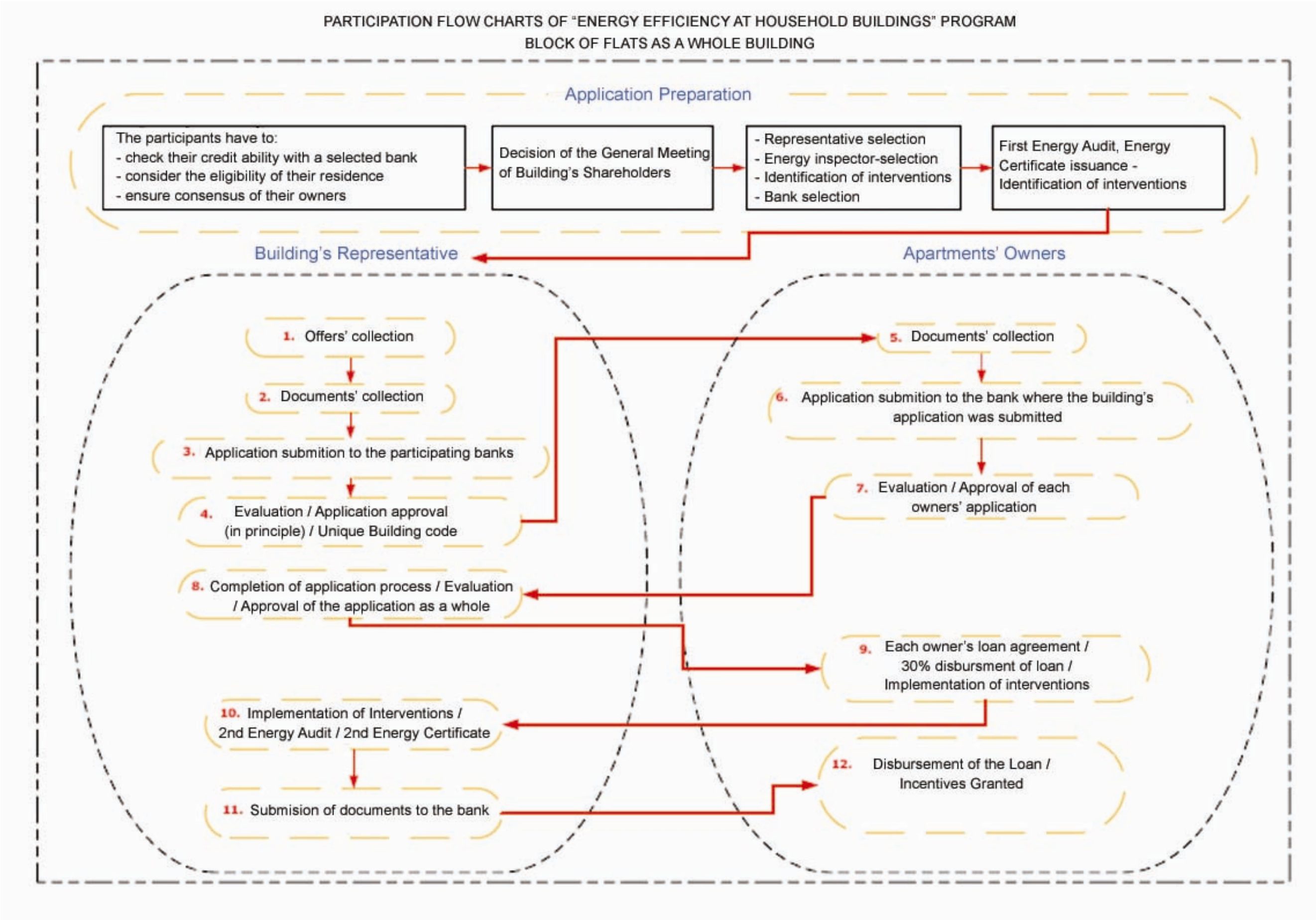



**Fig. 30:** Participation flow chart of the program for a block of flats as a whole building

**Source:** Retrieved from: http://exoikonomisi.ypeka.gr

This rough presentation of the implementation steps of the program could be characterized rather comprehensive with reference to a detached house or an apartment. Nevertheless additional presuppositions must be satisfied in the case of a block of flats. To begin with, the co-owners of the building must unanimously decide to participate in the program. The owners of each apartment declare to apply for entry to the program, regardless of whether they satisfy the eligibility criteria. Failing to receive approval, does not influence the implementation of the interventions since the owners commit to self-finance them. As logical as this may seem considering that certain energy saving measures can not be as effective if they are not applied to the whole of the building (e.g. external insulation), it hinders the participation of the building as a unit for financial reasons. In the long run it is translated into lower levels of energy conservation achieved by the programme.

| Type of residence | Total number* | Percentage |
|---|---|---|
| **Block of flats** | 33 | 1.2 % |
| **Detached house** | 946 | 34.7 % |
| **Apartment (part of a block application)** | 85 | 3.1 % |
| **Independent apartment** | 1662 | 61 % |

*based on the approved applications by 9/9/2011

**Table 3:** Approved applications by type of residence for entering the "Energy Efficiency at Household buildings" programme

**Source:** Application's approval for the "Energy Efficiency at Household buildings" programme, 9/9/2011.Retrieved from: http://www.tempme.gr/

The most recent decision of the National Fund for Entrepreneurship and Development (ETEAN) on the approval of entry to the program concerned primarily independent apartments. Such a development confirms the existence of significant obstacles that prevent owners from applying collectively. Granted that the most common path of access to the programme is by independent participation, the Ministry of Environment, Energy and Climate Change has suspended any limitations in the eligibility of independent apartments.

With reference to the energy renovation scenarios that follow, any alteration in the building was decided after careful consideration and with great respect to its architectural identity. The key-factors for adopting a measure were:

- Its contribution to the improvement of the building's energy performance and indoor quality
- Financial parameters such as the cost, payback period and the generated savings
- The level of acceptance on behalf of the residents and the easy maintenance

Finally, every energy measure suggested must meet the specifications of the Greek energy regulation for buildings (Law 3661/2008).

"They've got insulation to die for!"

## 7.1 Scenario 01: Rational use of energy

This scenario aims at refining the existing situation by improving the thermal properties of the building fabric in combination with an upgrade of the heating, cooling and domestic hot water systems. More specifically the energy savings measures suggested are:

- External insulation of the walls
- Insulation of the roof
- Window replacement
- Upgrading of the heating and DHW systems

The first three measures aim at reducing the heat losses from the building envelope, with the corresponding effect on the energy demand of the building; that is the energy that has to be generated by the electromechanical systems in order to maintain a comfortable indoor environment. Lastly, upgrading the energy systems minimizes the losses due to outdated equipment, miscalculation of the required size, improper maintenance etc.

As inputs for the economic analysis of this scenario the maximum indicative costs according to the eligible expenses of the "Energy Efficiency at Household buildings" programme were used [58]. In the case of measures that are not included in the programme, like the installation of a distribution or transmission system for heating purposes, reasonable costs were used after consultation with experienced engineers.

- <u>External insulation of the walls</u>

Properly insulated buildings are protected against adverse weather conditions. Such constructions are not inflicted by vast differences in temperatures between the internal and external surface and provide thermal comfort and high quality of living to the residents. Furthermore, the energy consumption for heating and cooling is reduced. In fact, the ratio of energy consumption and the corresponding cost for the purposes of heating and cooling of buildings with and without insulation is one to three [59]. Compared to the commonly followed method of applying cavity insulation for the walls and external insulation for the load-bearing elements, this technique minimizes the thermal bridges. As a result, a constant indoor temperature can be maintained for a longer period after switching off the heating and cooling systems.

The insulation material chosen was expanded polystyrene of 8cm thickness, applied externally on the brick walls and load-bearing elements, certified by a CE mark.

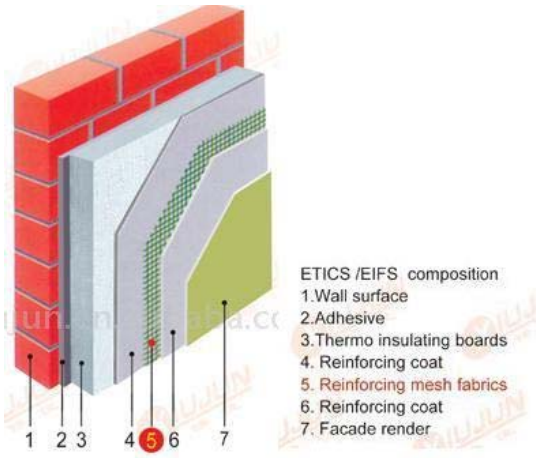



**Figure 31:** The External Thermal Insulation Composite System's composition

**Source:** Anastaselos D., Efficiency and Savings course notes, Energy Saving Measures, p. 2

- Insulation of the roof

In general, roughly 15-20% of the heat of a house is lost through an unprotected roof. The inverted roof technique is suggested for the protection of the roof. This refers to covering the roof surface with insulation tiles that are composed by special blocks of high-standard white cement with affixed layers of extruded polystyrene (XPS).

**Figure 32:** Insulation tiles applied by the inverted roof technique

**Source:** Retrieved from: http://www.kelyfos.eu

- Window replacement

Window replacement can significantly reduce the heat loses in the winter as well as the solar gains that occur through the openings in the summer. The window is composed of the frame and glazing which has its own U-value. U-value is a measure of the rate of heat flow through a window. The lower the U-value the lower the heat flow is. The overall U-factor of a window assembly includes the effect of the glazing, the frame and any e-coating or spacer.

U-FACTOR (Btu/hr-ft²-°F)

| GLAZING TYPE | Wood or Vinyl Frame (with insulated spacer) | Alum. Frame with thermal break (with conventional spacer) | Aluminum Frame without thermal break (with conventional spacer) |
|---|---|---|---|
| Single glass | ----- | 1.07 | 1.30 |
| Double glass, 1/2-inch air space | 0.48 | 0.62 | 0.81 |
| Double glass, e = 0.20*, 1/2-inch air space | 0.39 | 0.52 | 0.70 |
| Double glass, e = 0.10*, 1/2-inch air space | 0.37 | 0.49 | 0.67 |
| Double glass, e = 0.10*, 1/2-inch argon space | 0.34 | 0.46 | 0.64 |
| Triple glass, e = 0.10 on two panes*, 1/2-inch argon spaces | 0.23 | 0.36 | 0.53 |
| Quadruple glass, e = 0.10 on two panes*, 1/4-inch krypton spaces | 0.22 | ----- | ----- |

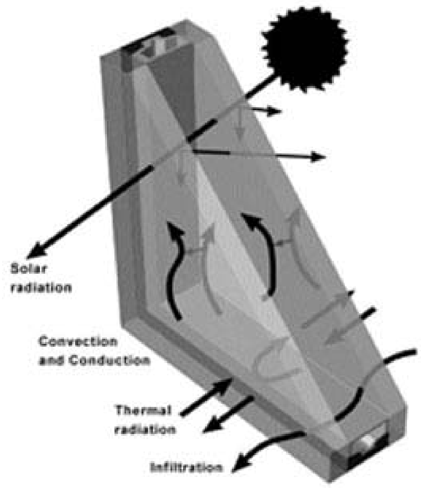



**Figure 33:** Representative window U-Factors for 3x5 foot windows provided by ASHRAE and the energy flows through windows

**Source:** Retrieved from: http://www.efficientwindows.org

For the purpose of this study the old openings are to be replaced with new double glazed, of low emissivity and with a thermal break. For the calculations, the maximum acceptable U value for climatic zone C was used according to T.O.T.E.E. 20701-1/2010 [60].

- <u>Upgrading of the heating and DHW systems</u>

The proper design and operation of these systems can be translated into significant savings. Having applied the previous measures the heating and cooling loads have been successfully reduced. Bearing this in mind, rightsizing the systems is appropriate. In addition to reducing energy consumption and costs, heating upgrades will reduce noise, equipment footprint and optimize operation.

Upgrading of the heating system applies to households that use outdated systems such as oil stoves for heating and an oil boiler. These are replaced by independent natural gas boilers whose power has been calculated according to the procedure described in the T.O.T.E.E. 20701-1/2010 [61]. For the apartments previously operating an oil stove, there is a need to install a distribution and transmission system. Their efficiency is calculated in accordance with the corresponding provisions of T.O.T.E.E. 20701-1/2010 [62].

During the heating period the aforementioned systems cover the demand for hot water of each residence. Solar energy is a favorable solution for a Mediterranean country like Greece, in order to meet the domestic hot water demand during the cooling period. Therefore, solar thermosiphonic systems are suggested for all apartments. Each system is certified and includes among others a flat-plate solar collector with a total surface of $3m^2$, installed facing south, at a tilt angle β=45°C. Its solar coefficient is taken from table 5.8 of T.O.T.E.E. 20701-1/2010 and is equal to α= 0,33. There is adequate free space on the roof for properly installation of the collectors so as to avoid losses from shading one another.

The energy conservation achieved by this set of soft interventions amounts to 80% and lifts four classes the building, from category G to C. Breaking down the energy conserved in each end use, 83% is achieved in heating; 20% in cooling and another 80% in DHW. By adopting the measures presented above, the building consumes roughly five times less fuel on the total. More specifically, no oil is used anymore; 42% less natural gas; 85% less electricity and approximately six times more solar energy. The overall $CO_2$ footprint of the building is reduced by 82%. From an economic point of view, the total cost of this investment is roughly 174.000 Euros. The annual operational cost of the building is rapidly reduced by 81% and amounts almost one thousand Euros less than that of the reference building. Finally, the simple payback period for this investment is 2,5 years.

## 7.2 Scenario 02: Deep energy renovation

Supplementary to the previous scenario, the first priority set is to take the necessary steps in order to reduce fabric energy losses. This is achieved again by applying external insulation on walls and roof and also by replacing the openings with more efficient ones. The second priority is to increase the use of renewable energy sources in meeting building energy demand. The third and final priority is to otherwise ensure a more efficient use of fossil fuels. To sum up, the following are included in this scenario:

- External insulation of the walls, roof and window replacement
- Installation of central heating system exploiting solar energy
- Installation of solar collectors for the domestic hot water of the apartments

More analytically:

- <u>External insulation of the walls, roof and window replacement</u>

The analysis as well as the final technical characteristics of the insulating materials used and the new openings that were presented in the first scenario apply also in this one.

- Installation of central heating system exploiting solar energy

Solar collectors may be used instead of a boiler or in a complementary way for heating purposes. Ensuring that the generation system will operate properly even in cases of limited sunshine, the installation of a supplementary fossil fueled boiler is recommended. Additional controls and storage capacity is required. Such a system could be combined with a refrigeration unit designed to produce cool water for space cooling purposes. Through a network of pipes the hot or chilled water is then distributed to the emission system of every space. With regard to that a very promising choice that matches the low temperature heating system described above, are fan coils. The main reason is that they can operate with water temperature far lower than the standard radiators. They have the added benefit that they can be used for cooling in the summer, provided that the system is designed for such purpose as well.

In the second energy renovation scenario a natural gas boiler is suggested in order to meet the heating demand of the building as this was calculated to be after the application of external insulation and the replacement of the openings. Part of this demand, more precisely 20% of it, is to be covered by solar collectors installed on the roof at an azimuth angle of 180° and a slope angle of 45°. If this scenario was actually to be realized, a study investigating the load-bearing ability of the building should have proceeded. For the purpose of this study, it is assumed that the suggested installation poses no risk to the safety of the residents and to the proper operation of the building. The collectors are suggested to be installed on a pergola which is basically an extension of the roof of the storage spaces. In this way the collectors are being lifted 2,5 meters from the level that some residents occupy without hindering the use of the space for other purposes. The meteorological data of Thessaloniki [63] were also taken into account in order to calculate the required solar collector surface. This equals to 70,45 $m^2$, however roughly double is needed, 144 $m^2$ to be precise, so as to avoid shading.

The necessary data regarding the energy systems installed in the building were all either calculated as specified in the T.O.T.E.E. 20701-1/2010 or taken by the relevant tables of the guideline.

- Installation of solar collectors for the domestic hot water of the apartments

Solar water heating systems use solar collectors to collect heat from the sun and use it to warm water which is stored in a hot water tank. A conventional boiler is also used to provide additional heat to the warm water or in cases when solar energy is unavailable. Different types of systems exist (e.g. open or closed loop). However exploiting solar energy for the domestic hot water demand of a residence presents substantial financial benefits along with a reduction of the residence's carbon footprint regardless of the type of system.

Similar thermosiphonic systems like those suggested in the first scenario are included in this one.

The deep energy renovation scenario results in 94% less primary energy consumption and leads to the building's ranking in class A. A reduction in the order of 96% is noted particularly for heating; the same amount of energy is being conserved with reference to the DHW whereas the energy consumed for cooling is the same as in the previous scenario. By exploiting almost 15 times more solar energy the building now consumes 93% less natural gas. On the whole the building now consumes 90% less fuel and emits 93% less $CO_2$ emissions. The economic analysis showed that the total cost of this investment is roughly 156.000 Euros. The annual operational cost of the building is particularly low, only 3.600 Euros, in other words it is reduced by 96% and is almost 4,5 times lower than that of the reference building. Finally, the simple payback period for this investment is 1,9 years.

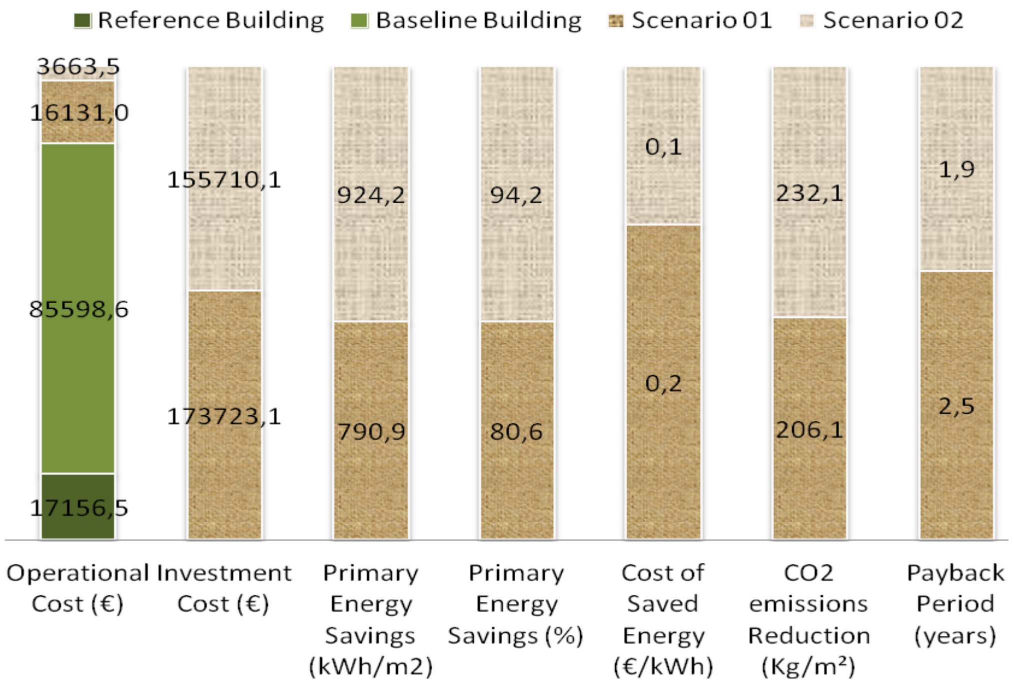



**Figure 34:** Graph summarizing the results of the energy audit and the energy renovation scenarios

**Source:** author

# 8 Conclusions

Up to this point the energy conservation potential in the social blocks of flats, located in Ampelokipoi, has been quantified. The methodology used in this procedure is in full compliance with the national Law3661/2008. Valuable specific conclusions can de deduced by comparing the two energy renovation strategies that were investigated in the study. To begin with, the soft interventions' scenario includes some of the most mainstream energy saving measures and by definition causes less inconvenience on the residents. It is also easier to finance in sight of the ongoing "Energy Efficiency at Household buildings" ministerial supporting scheme. However, all indicators show that it falls behind in comparison to the second scenario in terms of primary energy consumption, fuel consumption, $CO_2$ emissions, operational and investment cost and finally in the payback period.

On the other hand, the second energy conservation plan includes interventions that are rather rare in residential buildings. For instance, shifting from a completely independent heating system to a central one with autonomy is not common in renovations despite the fact that this is the prevailing model of the heating system of a new construction. Furthermore, using solar energy for space heating is something relatively new for the Greek residential sector although solar thermo symphonic systems are widely used. The study indicates however that such a collective approach in the refurbishment of social housing offers greater environmental, financial and social benefits. At the same time it presupposes a change in mentality.

It is common knowledge that the built environment is related to a number of sciences, social structures, to quality of life etc. Social housing along with planning has been after all a valuable policy-tool in addressing social exclusion and poverty. At the same time and under the weight of the binding environmental goals that Greece has set as a European Member State, the development of an energy renovation market is crucial. Unlike Germany, the conditions required in order to motivate the private players are rather immature in Greece.

Over the last years Greece has harmonized its national regulations with a series of European directives with reference to energy market liberalization, penetration of RES, energy efficiency, energy services (Law 3661/2008, Law 3855/2010 etc). Therefore, the necessary legal framework for the development of an energy market in general and an energy renovation market in particular exists.

Nevertheless, refurbishment of buildings is hindered by the typology of buildings, the majority of which are multi-storey, multi-family buildings in combination with the structure of the housing market.  In particular, the high rate of homeownership -around 86%- is a challenge for the decision making process in Greece. It is worth mentioning that Germany with a rather stable [64] home-ownership rate since 1945 –around 40%- has adjusted its home-ownership law in 2007 in order to facilitate energy refurbishments. Other countries like France and Spain has followed Germany's example.

An equally important factor for the development of such market is the need for financial incentives. This seems to be the first obstacle that energy renovation has to overcome not only in Greece but in other member states as well. Determining the most appropriate tools for the refurbishment of bad quality housing is a significant step in forming efficient and cost-effective supportive mechanisms. The overall environmental and economical gains of launching a supportive programme need to be clarified beforehand as this shall define the funding mechanisms, the participation process, the eligible buildings and renovations works etc.

As far as financial incentives in Greece is concerned, a number of "green programs" have been launched or are being prepared on behalf of the Ministry of Energy and Climate Change with the collaboration of the Center of Renewable Sources [65].The ongoing "Energy Efficiency in Household Buildings" program has hypothetically financed the first energy renovation scenario. Up to now, the program is characterized by high levels of independent participation and the minimum desired renovation goal is to lift the property one ranking place. It is highly likely that in the end the program would result in a number of low-depth renovation works that could contribute to a degree to raising public awareness but not so much to the national environmental goals.

Finally, an equally important factor for the development of the Greek energy renovation market is the existence of skilled workforce. Steps have been made in this direction; still the level of development is rather low. Aiming at supporting the market as well as informing consumers and investors the Center of Renewable Sources has developed the Greek Professional Energy List, in 2007. With regard to energy certification, the procedure for issuing the permanent energy assessors permits is still pending. Granted the high rate of unemployment in Greece and the governmental proclamations towards "green development", a training program for the unemployed in positions relevant to sustainable environmental management otherwise called "green jobs" has been launched this month by the Greek Manpower Employment Organization.

The objective of this study is to produce knowledge with reference to energy conservation in social housing and the challenges involved that could affect a future national retrofitting policy. Focusing on O.E.K.'s social housing complexes of the 60s due to their high level of standardization involves a wide range of benefits reported in this study that could affect a large part of the population besides the overburdened vulnerable households. A further study with the aim of making a record and analysis of such complexes found around Greece is recommended.

# References and Bibliography


[1] Κ. Θέμελης (2000), Ο λόγος του αρχιμάστορα: Μια συνομιλία με τον Άρη Κωνσταντινίδη, Ίνδικτος. Retrieved from: http://gerontakos.blogspot.com/2007/09/blog-post_4003.html

[2] CASH- Cities Action for Sustainable Housing, Baseline study, 2010, 8. Retrieved from http://www.urbact.eu

[3] M. Santamouris, K. Kapsis, D. Korres, I. Livada, C. Pavlou, M.N. Assimakopoulos (2007), On the relation between the energy and social characteristics of the residential sector, Energy and Buildings 39, 893–905

[4] A. Huber, I. Mayer, V. Beillan, A. Goater, R. Trotignon, E. Battaglini (2011), Refurbishing residential buildings: A socio-economic analysis of retrofitting projects in five European countries, 5,10

[5] Proceedings of the 2nd Conference “HOUSING EUROPE” “Retrofitting of Social Housing: Financing & Policy Options”, Thessaloniki 2006, presentations of session 3, sl. 36. Retrieved from http://www.cres.gr/conference/proceedings.htm

[6] Milin C., Bullier A. (2011), FRESH-Energy retrofitting of social housing through Energy Performance Contracts. Retrieved from http://www.fresh-project.eu/tools/2/

[7] P. Davies, M. Osmani (2011), Low carbon housing refurbishment challenges and incentives: Architects’ perspectives, *Building and Environment 46*, 1691-1698

[8] J. Chontanawat, L. C. Hunt, R. Pierse (2008), Does energy consumption cause economic growth?: Evidence from a systematic study of over 100 countries, *Journal of Policy Modeling 30*, 210,218

[9] S.Z. Tsani (2009), Energy consumption and economic growth: A causality analysis for Greece, *Energy Economics 32*, 588-589

[10] I. Theodoridou, A. M. Papadopoulos, M.Hegger (2010), Statistical analysis of the Greek residential building stock, *Energy and buildings 43,* 2422

[11] Evaluation fuel poverty in Belgium, Spain, France, Italy and the United Kingdom, EPEE project WP2 - Deliverable 6, 14,26,33

[12] I. Theodoridou, A. M. Papadopoulos, M.Hegger (2010), Statistical analysis of the Greek residential building stock, *Energy and buildings 43,* 2426

[13] B.E. Psiloglou, C. Giannakopoulos, S. Majithia, M. Petrakis (2009), Factors affecting electricity demand in Athens, Greece and London, UK: A comparative assessment, *Energy 34,* 1862

[14] M. Scharp, J. Kortman, A. Huber, A. Martin (2010), Developing and implementing energy awareness services Brochure, Intelligent Energy Europe Program, 2

[15] IEE SAVE ASIEPI Project-Compilation of Summary Reports (2010), 10

[16] Information retrieved from: www.warmfront.co.uk

[17] Information retrieved from:
http://www.decc.gov.uk/en/content/cms/tackling/green_deal/green_deal.aspx

[18] Information retrieved from:
http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx

[19] Technical Codes 2421/86 for the installation of boilers for the heating of buildings, 2423/86 for the installation of cooling systems in buildings and 2425/86 for the calculation of cooling loads in buildings of the Technical Chamber of Greece (TOTEE)
Papadopoulou K., Papaglastra M., Santamouris M. (2009), Greece: Impact, compliance and control of legislation, IEE SAVE ASIEPI Project , 1

[20] Information retrieved from: http://www.allazoklima.gr/

[21] Information retrieved from: http://exoikonomisi.ypeka.gr/

[22] Information retrieved from: http://www.cres.gr/kape/XTIZONTAS_TO_MELLON.pdf

[23] Inclusive growth is referring both to the outcome as well as the process of growth. It is based on the argument that societies based on equality tend to perform better in terms of development. It also encompasses equity, protection in market and employment transitions which are seen as essentials for achieving sustainable growth and substantial poverty reduction.
United Nations Development Programme - International Policy Centre for Inclusive Growth, Information retrieved from: http://www.ipc-undp.org/Home.do?active=0

[24] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions- Energy Efficiency Plan 2011 (2011), 5
Retrieved from: http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm

[25] C. Whitehead, K. Scanlon (2007), Social housing in Europe, London School of Economics, London, 5-7

[26] B. Boardman, Fixing fuel poverty (2010), Earthscan, London, 22

[27] I. Househam, Policies and initiatives to combat fuel poverty (2010), Eco Ltd / UNDP, 4

[28] B. Boardman, Fixing fuel poverty (2010), Earthscan, London, 32

[29] I. Househam, Policies and initiatives to combat fuel poverty (2010), Eco Ltd / UNDP, 5

[30] O. Lelkes, Z. Eszter (2009) Quality of Housing and the Link to Income. Research Note Nr. 2. Prepared for the European Commission, Directorate-General “Employment, Social Affairs and Equal Opportunities”, 39

[31] M. Santamouris, K. Kapsis, D. Korres, I. Livada, C. Pavlou, M.N. Assimakopoulos (2007), On the relation between the energy and social characteristics of the residential sector, Energy and Buildings 39, 897

[32] Hutchinson A. (2011), Towards a European agenda for social housing, Discussion paper of the Commission for Economic and Social Policy, 3

[33] Milin C., Bullier A. (2011), Energy retrofitting of social housing through energy performance contracts, Intelligent Energy Europe project-Financing energy Refurbishment for Social Housing, 6

[34] S Bullier A. (2010), Survey on social housing in Europe, Intelligent Energy Europe project-Financing energy Refurbishment for Social Housing, 4

[35] C. Whitehead, K. Scanlon (2007), Social housing in Europe, London School of Economics, London, 90-104

[36]K. Neuhoff, H.n Amecke, K. Stelmakh, A. Rosenberg, A. Novikova (2011), Meeting Energy Concept Targets for Residential Retrofits in Germany, Climate Policy Initiative, 3

[37] Bullier A. (2010), Survey on social housing in Europe, IEE "Financing energy Refurbishment for Social Housing" program, 5

[38] Sheeran G. (1986), Back-to-back houses in Bradford. Retrieved from: http://www.bradfordhistorical.org.uk/antiquary/third/vol02/houses.html

[39] Malpass P. (2010), Housing, markets and policy, Taylor & Francis, US, 44

[40] Stone M. (2003), Social Housing in the UK and US: Evolution, Issues and Prospects, Atlantic Fellow in Public Policy, 11

[41] McVeigh T., 30 years on, the right to buy revolution that still divides Britain's housing estates, The Observer, Sunday 6 December 2009

[42] J. Hillls (2007), Ends and means: The future roles of social housing in England, ESRC, England, 65

[43] Government Green Deal must offer financial incentives. Retrieved from http://www.greatbritishrefurb.co.uk/news/government-green-deal-must-offer-financial-incentives

[44] Potsiou A. C. (2010), Informal Urban Development in Europe - Experiences from Albania and Greece, United Nations Human Settlements Programme (UN-HABITAT), 23

[45] The Catastrophe of Minor Asia signaled the end of the Greco–Turkish War of 1919–1922. This was a series of military events occurring during the partitioning of the Ottoman Empire after World War I. The Greek campaign was launched because the western Allies, had promised Greece territorial gains at the expense of the Ottoman Empire. These were reflected in "The Great Idea". It ended with Greece giving up all territory gained during the war, returning to its pre-war borders, and engaging in a population exchange with the newly established state of Turkey under provisions in the Treaty of Lausanne. Information retrieved from: www.wikepedia.org

[46] Pentzopoulos D. (1962), The Balkan exchange of minorities and its impact on Greece, Mouton, Paris, 226-227

[47] Potsiou A. C. (2010), Informal Urban Development in Europe - Experiences from Albania and Greece, United Nations Human Settlements Programme (UN-HABITAT), 19

[48] Ενεργειακή βελτιστοποίηση των βασικών τύπων κτιρίων του Ο.Ε.Κ. τόσο μεμονωμένα όσο και σε επίπεδο οικισμού, Ερευνητικό πρόγραμμα Οργανισμού Εργατικής Κατοικίας- Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης, 1996

[49] Α. Καραδήμα Γερολύμπου, Η ανοικοδόμηση της Θεσαλονίκης μετά την πυρκαγιά του 1917 (1985-86), Δήμος Θεσσαλονίκης,, Θεσσαλονίκη, 86,97,123

[50] The group of architects that signed the master plan of the complex in Ampelokipoi, back in 1963, consists of: Varveris G., Skiadaresis G., Kapellou A., Aravantinos A., Misentzis F.

[51] This becomes evident in the views of engineers over the preservation or demolition of the refugee apartment blocks in Alexandras avenue, Athens as expressed in a relative forum e.g. http://www.michanikos.gr/showthread.php?t=6234

[52] "Antiparohi" was introduced in the 60s as a new system of construction. Its importance lies in the substantial reduction of the initial financial capital that implies the non payment for the purchase of land. To be more specific, the landowner and the contractor would come to an agreement within which the owner provided the land in exchange for a percentage of ownership on the construction product. "Antiparohi" was the key to postwar reconstruction of buildings in Athens and other major urban centers with all the disadvantages that have been attributed to it from time to time.

[53] Κ. Κρικέλης (2011), Πώς χτίστηκαν τερατωδώς οι Αμπελόκηποι;, *Κάτοικος Αμπελοκήπων, Αρ. Φύλλου 074*, 3.

[54] Θ. Τσιτσώνη, Δ. Βλαχάκη, Σ. Σανιδά (2006), Καταγραφή και αξιολόγηση του αστικού πράσινου στους δήμους Ελευθερίου-Κορδελιού, Αμπελοκήπων και Ευόσμου του Πολεοδομικού Συγκροτήματος Θεσσαλονίκης, Επιστημονική επετηρίδα του Τμήματος Δ.Φ.Π. προς τιμή του Ομ. Καθηγητού Ν. Αθανασιάδη.

[55] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC

[56] More information in the Intelligent Energy Europe website: http://www.eaci-projects.eu/iee/page/Page.jsp

[57] Athanasaki M.I., Papadopoulos A.M. (2010), Legal issues when implementing energy renovation measures in multi-family buildings, 3rd International Conference on Passive and Low Energy Cooling for the Built Environment (PALENC 2010), Rhodos

[58] Information retrieved from: http://exoikonomisi.ypeka.gr/

[59] Information retrieved from: http://www.cres.gr/energy-saving/enimerosi_thermomonosi.htm

[60] Technical Guideline of the Technical Chamber of Greece T.O.T.E.E. 20701-1/2010, 43

[61] Technical Guideline of the Technical Chamber of Greece T.O.T.E.E. 20701-1/2010, 87

[62] Technical Guideline of the Technical Chamber of Greece T.O.T.E.E. 20701-1/2010, 101,104

[63] Tsilingiridis G., Martinopoulos G., Kyriakis N. (2004), Life cycle environmental impact of a thermo symphonic domestic solar hot water system in comparison with electrical and gas water heating, Renewable Energy 29, 1283

[64] Toussaint J., Tegeder G., Elsinga M., Helbrecht I. (2007), Security and Insecurity of Home Ownership: Germany and the Netherlands, European Journal of Housing Policy Vol. 7, No. 2, 178

[65] Δεμερτζής Α., 9 Πράσινα προγράμματα στην μάχη της οικονομίας, Ισοτιμία, Σάββατο 10 Σεπτεμβρίου 2011