




EUROPE'S BUILDINGS UNDER THE MICROSCOPE

A country-by-country review of the energy performance of buildings










BPIE

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FOREWORD

Buildings are at the pivotal centre of our lives. The characteristics of a building, its design, its look and feel, and its technical standards not only influence our productivity, our well-being, our moods and our interactions with others, they also define how much energy is consumed in and by a building, and how much heating, ventilation and cooling energy is needed to create a pleasant environment.

We know that buildings cause a significant amount of greenhouse gas emissions, mainly CO_2, altering our planet's climate. By renovating buildings to high standards of efficiency we can demonstrate that ambitious climate change mitigation actions and improvements in living quality can go hand in hand. The European building stock with its unique mix of historical and modern architecture provides both significant opportunities and challenges.

Effective policies and incentive schemes to reduce the climate change footprint of buildings require a solid understanding about the current building stock. The Buildings Performance Institute Europe intends to contribute to an improved understanding with this report – gathering facts and figures about the European building stock and aggregating the findings to allow meaningful analysis.

BPIE recognizes that the availability of data is far from ideal, and that dynamic policy processes in the EU Member States will outdate very quickly some of the information on policies and financial support schemes. This is why we are committed to providing updates on certain issues at regular intervals, and I hope that we can count on the collaboration of many experts in the field.

Today, the challenge of climate change does not get the same political and media attention as it did some years ago. However, that does not mean that the problem has gone away, quite the opposite. But to limit the discussion about energy efficient buildings only to climate change considerations would ignore the many additional benefits which are created through the retrofitting of the European building stock. The revitalisation of urban quarters, improved comfort levels and quality of living and working spaces, helping people out of fuel poverty and creating long term employment are just some of the many positive effects of a European renovation 'wave' which is modelled in the final part of this report.

In this respect, this report wants to encourage a wider debate on how stakeholders in the building sector can collaborate to transform the European building stock into a highly efficient living and working environment which enables society to become more sustainable, in all aspects of the word's meaning. BPIE proactively seeks dialogue with the many interested parties, and is looking forward to receiving your reaction.

Oliver Rapf
Executive Director
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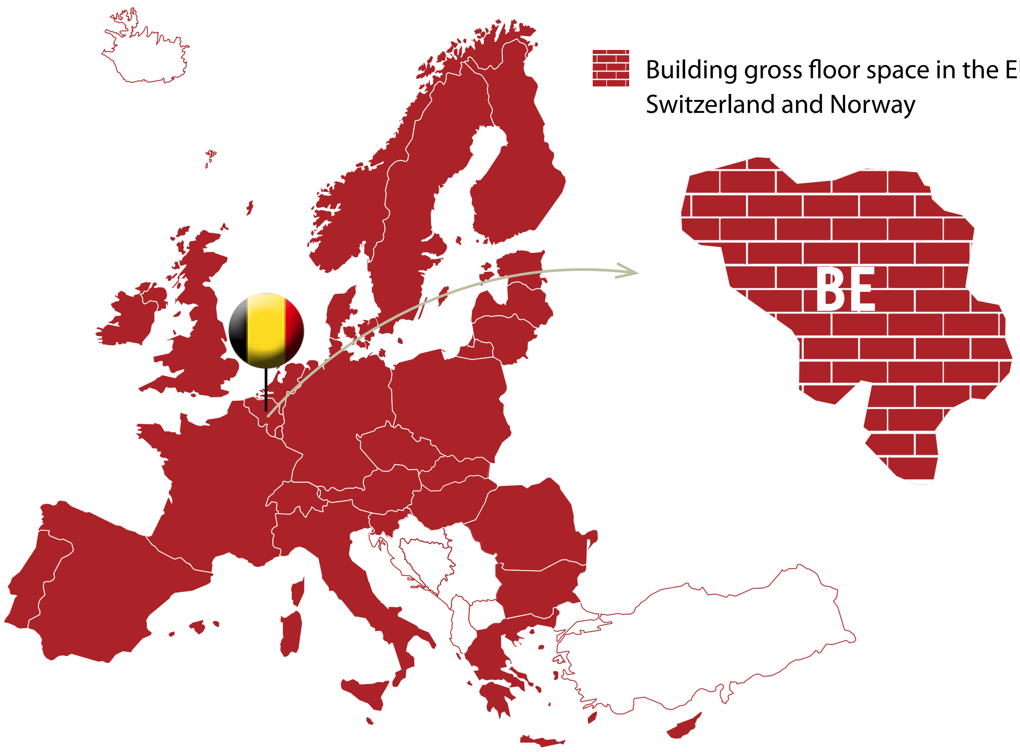
EXECUTIVE SUMMARY

From the emotional to the architectural value, buildings occupy a key place in our lives and society as a whole. Yet, the energy performance of our buildings is generally so poor that the levels of energy consumed in buildings place the sector among the most significant CO_2 emissions sources in Europe. While new buildings can be constructed with high performance levels, it is the older buildings, representing the vast majority of the building stock, which are predominantly of low energy performance and subsequently in need of renovation work. With their potential to deliver high energy and CO_2 savings as well as many societal benefits, energy efficient buildings can have a pivotal role in a sustainable future.

Achieving the energy savings in buildings is a complex process. Policy making in this field requires a meaningful understanding of several characteristics of the building stock. Reducing the energy demand requires the deployment of effective policies which in turn makes it necessary to understand what affects people's decision making processes, the key characteristics of the building stock, the impact of current policies etc.

Amid the current political discussions at EU level, BPIE has undertaken an extensive survey across all EU Member States, Switzerland and Norway reviewing the situation in terms of the building stock characteristics and policies in place. This survey provides an EU-wide picture of the energy performance of the building stock and how existing policies influence the situation. The data collected was also used to develop scenarios that show pathways to making the building stock much more energy efficient, in line with the EU 2050 roadmap.

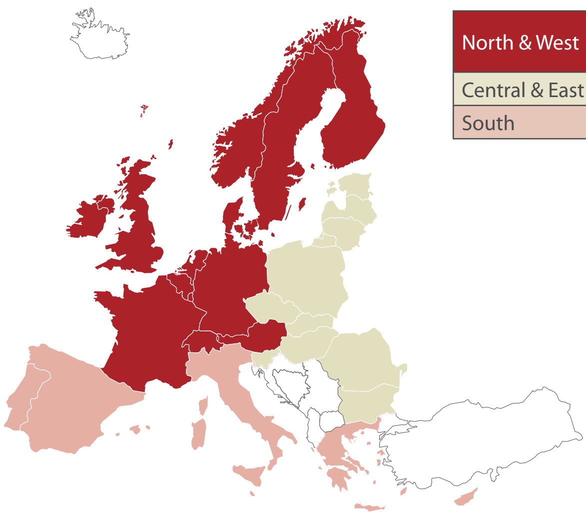
Building floor space in Europe



A VITAL PICTURE OF THE EUROPEAN STOCK

It is estimated that there are 25 billion m² of useful floor space in the EU27, Switzerland and Norway. The gross floor space could be concentrated in a land area equivalent to that of Belgium (30,528 km²). Half of the total estimated floor space is located in the North & West region of Europe while the remaining 36% and 14% are contained in the South and Central & East regions, respectively[1]. Annual growth rates in the residential sector are around 1% while most countries encountered a decrease in the rate of new build in the recent years, reflecting the impact of the current financial crisis on the construction sector.

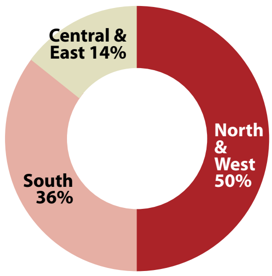
Regions considered in the study



North & West	AT, BE, CH, DE, DK, FI, FR, IE, LU, NL, NO, SE, UK	Population: 281 mil
Central & East	BG, CZ, EE, HU, LT, LV, PL, RO, SI, SK	Population: 102 mil
South	CY, GR, ES, IT, MT, PT	Population: 129 mil

Floor space distribution

Source: BPIE survey

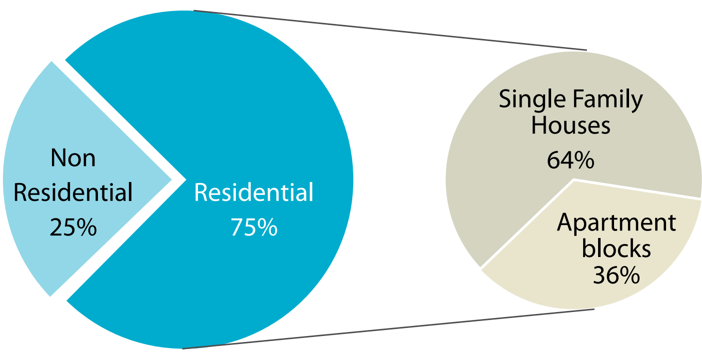


Non-residential buildings account for 25% of the total stock in Europe and comprise a more complex and heterogeneous sector compared to the residential sector. The retail and wholesale buildings comprise the largest portion of the non-residential stock while office buildings are the second biggest category with a floor space corresponding to one quarter of the total non-residential floor space. Variations in usage pattern (e.g. warehouse versus schools), energy intensity (e.g. surgery rooms in hospitals versus to storage rooms in retail), and construction techniques (e.g. supermarket versus office buildings) are some of the factors adding to the complexity of the sector.

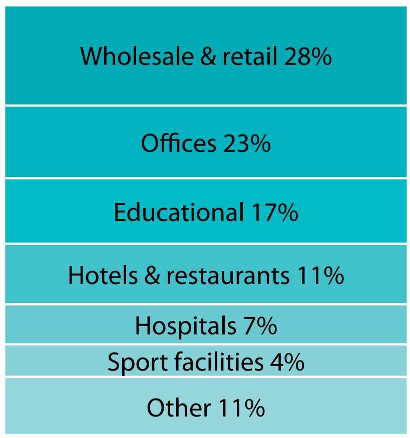
European buildings at a glance

Source: BPIE survey

Residential building stock (m²)



Non-residential building stock (m²)

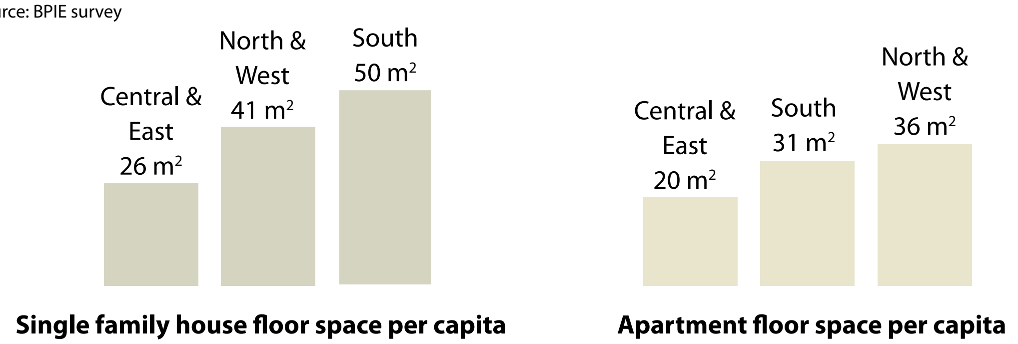


[1] The European countries have been divided based on climatic, building typology and market similarities into three regions

Space standards (expressed through the floor area per capita) are the highest in countries in the North & West while the countries of Central & Eastern Europe have the lowest residential space standards both in single family houses and apartment blocks. Economic wealth, culture, climate, scale of commerce, increased demand for single occupancy housing are some of the factors affecting the size of spaces we live and work in. The general tendency however is to seek larger floor spaces over time. This along with the increasing population projections has clear implications on future energy needs, emphasising the subsequent urgency for improving the energy performance of our buildings.

Residential floor space standards in Europe

Source: BPIE survey

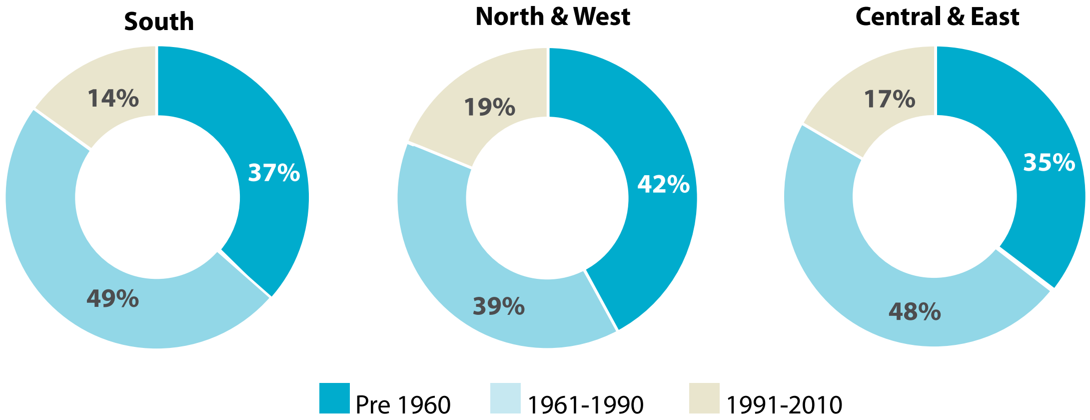


A substantial share of the stock in Europe is older than 50 years with many buildings in use today that are hundreds of years old. More than 40% of our residential buildings have been constructed before the 1960s when energy building regulations were very limited. Countries with the largest components of older buildings include the UK, Denmark, Sweden, France, Czech Republic and Bulgaria. A large boom in construction in 1961-1990 is also evident through our analysis where the housing stock, with a few exceptions, more than doubles in this period.

The performance of buildings depends on a number of factors such as the performance of the installed heating system and building envelope, climatic conditions, behaviour characteristics (e.g. typical indoor temperatures) and social conditions (e.g. fuel poverty). Data on typical heating consumption levels of the existing stock by age shows that the largest energy saving potential is associated with the older building stock where in some cases buildings from the 1960s are worse than buildings from earlier decades. The lack of sufficient insulation of the building envelope in older buildings was also reflected through the historic U-value data which comes with no surprise as insulation standards in those construction years were limited.

Age categorisation of housing stock in Europe

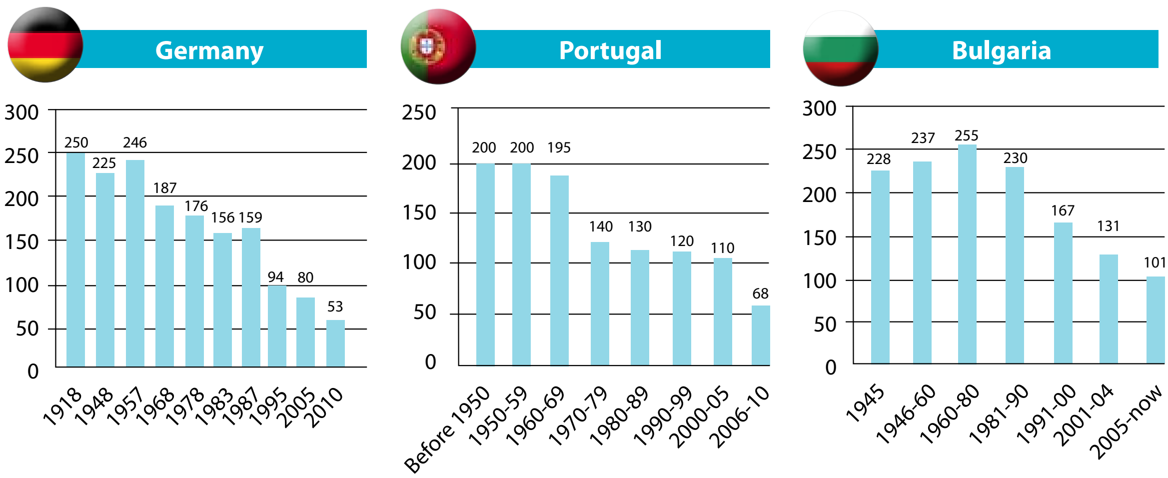
Source: BPIE survey



The building sector is one of the key consumers of energy in Europe where energy use in buildings has seen overall a rising trend over the past 20 years. In 2009, European households were responsible for 68% of the total final energy use in buildings[2]. Energy in households is mainly consumed by heating, cooling, hot water, cooking and appliances where the dominant energy end- use (responsible for around 70%) in homes is space heating. Gas is the most common fuel used in buildings while oil use is highest in North & West Europe. The highest use of coal in the residential sector is in Central & Eastern Europe where also district heating has the highest share of all regions. Renewable energy sources (solar heat, biomass, geothermal and wastes) have a share of 21%, 12% and 9% in total final consumption in Central & Eastern, South and North & West regions, respectively.

Average final consumption levels for heating (kWh/(m²a)) of single family homes by construction year

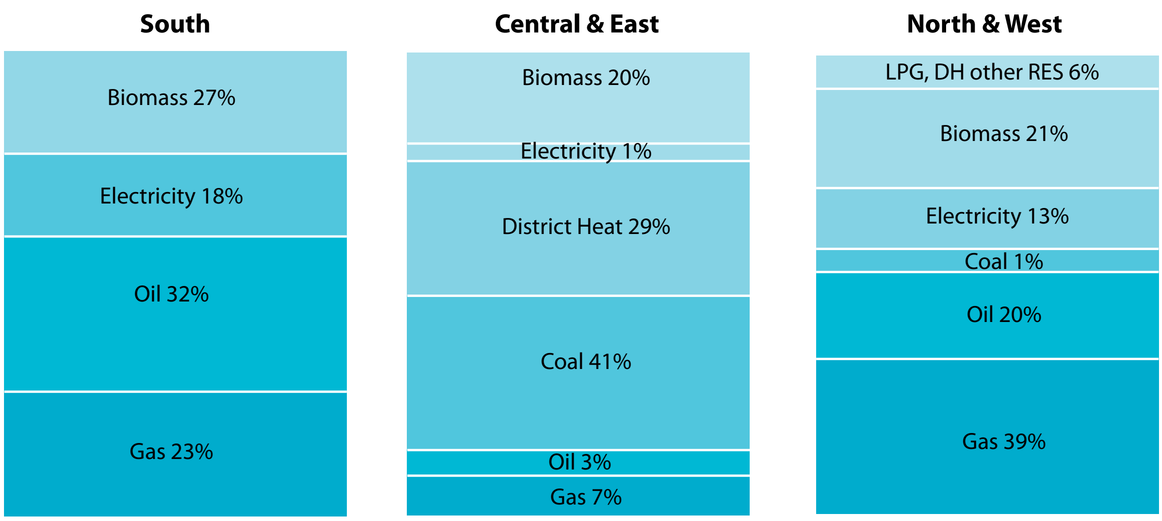
Source: BPIE survey



The average specific energy consumption in the non-residential sector is 280kWh/m² (covering all end-uses) which is at least 40% greater than the equivalent value for the residential sector. In the non-residential sector, electricity use over the last 20 years has increased by a remarkable 74%.

Energy mix in residential buildings by regio

Source: Eurostat

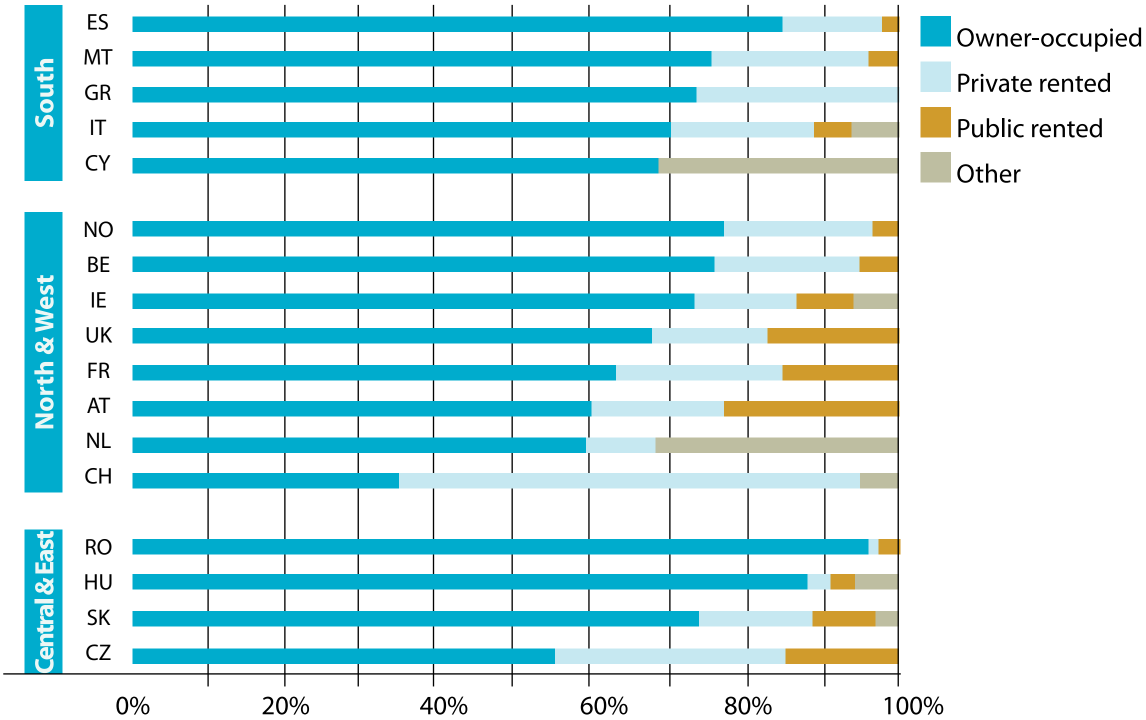


[2] Data extracted from Eurostat: http://epp.eurostat.ec.europa.eu

Buildings vary remarkably in terms of size where large variations are expected in the non-residential categories. From our data, we can see that policy measures applied only to non-residential buildings over 1,000 m^2 in floor area would miss a substantial portion of buildings in many countries, especially in educational buildings, hospitals and offices. The structure of ownership and occupancy has also a significant relevance on the ability to renovate. The largest share of the residential stock is held in private ownership while 20% is allocated to 'pure' public ownership. Social housing is typically fully owned by the public sector but there is an increasing trend towards private involvement as is the case in Ireland, England, Austria, France and Denmark while in the Netherlands social housing is fully owned by private sector. Moreover, at least 50% of residential buildings are occupied by the owner in all countries. Countries with the biggest share of private tenants are Switzerland, Greece and Czech Republic and countries with significant portions of public rented dwellings are Austria, the UK, Czech Republic, The Netherlands and France. The ownership profile in the non-residential sector is more heterogeneous and private ownership can span from as low as 20% to 90% from country to country.

Tenure of residential buildings in Europe

Source: BPIE survey



NOTES

Units are in number of dwellings except France which is in m^2.

AT: Data up to 2001.
CH: 'Other' consists of members of a building cooperative and others.
CY: Data up to 2001. 'Other' consists of 13,9% of rented (mixed ownership) and 17,9 of other arrangements.
CZ: Based on estimations.
HU: Data up to 2005. 'Other' includes public and private empty dwellings and other
IT: Data up to 2001
NL: 'Other' consists of social housing associations owned by private bodies for which conditions (e.g. rental prices) are heavily regulated by the government.
MT: Other consists of dwellings held by emphyteusis (notarial contract) and other used free of charge.
RO: Data up to 2002
SK: Based on 2001 data
ES: Social housing is mainly delivered through the private sector and is controlled through subsidies, subsidized loans and grants for both developers and buyers
UK: 'Other' consists of Registered Social Landlords (often referred to as housing associations) which are government-funded not-for-profit organisations that provide affordable housing.

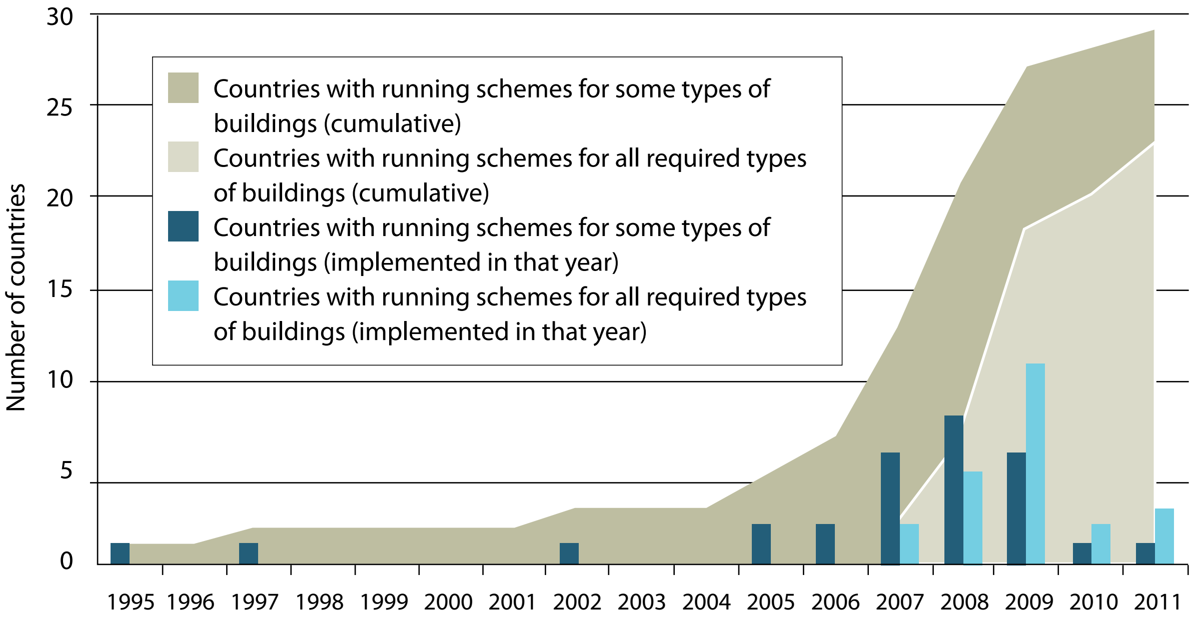
THE EUROPEAN POLICY SCENE

There are many reasons why investments in energy saving measures in buildings are often overlooked, rejected or only partially realised. Experience over several decades has identified numerous barriers that hinder energy saving investments. Financial, institutional and administrative, awareness/information and split incentives are the main categories of barriers identified by the BPIE survey which have a particular impact on existing buildings. Although financial barriers were one of the highest ranking barrier category among the country responses, alternative investments are in many cases preferred to energy saving measures due to the lack of awareness, interest or in fact, 'attractiveness' of energy efficiency as an investment option. For the market to work well, correct and appropriate information is essential. Ambitious renovations comprise a major decision and can only work if the right advice is available for the consumer. In addition, energy efficiency service industries should be fully capable of delivering those measures; and ultimately sufficient satisfaction levels should be guaranteed for the consumer. The split incentive is probably the most long-lasting barrier, particularly due to the complex structure of occupancy both in terms of the residential and non-residential sector.

At the European level, the main policy driver related to the energy use in buildings is the Energy Performance of Buildings Directive (EPBD, 2002/91/EC). Implemented in 2002, the Directive has been recast in 2010 (EPBD recast, 2010/31/EU) with more ambitious provisions. Through the EPBD introduction, requirements for certification, inspections, training or renovation are now imposed in Member States prior to which there were very few.

While all countries now have functional energy performance certification (EPC) schemes in place, five countries have not yet fully implemented the scheme for all requested types of buildings. Only eleven countries currently have national EPC register databases while ten countries have databases at regional/ local level or development plans underway. Data on the number of issued EPCs show that the current share of dwellings with an issued EPC in different countries can vary from under 1% to just above 24%.

Implementation timeline of EPC scheme (EPBD, 2002/91/EC)



The absence of previous requirements in most Member States meant that entirely new legislative vehicles were required and consequently that the first EPBD was typically implemented in stages over a number of years, from around 2006 to 2010. Despite the fact that significant developments happened over the last years, current EU legislation only partially covers the field of buildings renovation. The EPBD stipulates the implementation of energy saving measures only in case of deep renovation of the building without specifying the depth of renovation measures. It is clear that more targeted measures are required for fostering the deep renovation of the existing building stock.

A key driver for implementing energy efficiency measures are the building energy codes, through which energy-related requirements are incorporated during the design or retrofit phase of a building. While several Member States had some form of minimum requirements for thermal performance of building envelopes in the 1970s, the EPBD was the first major attempt requiring all Member States to introduce a general framework for setting building energy code requirements based on a "whole building" approach. Examining the requirements set by each Member State, it is clear that large variations exist in terms of the approach each country has taken in applying building energy codes. In some countries two approaches exist in parallel, one based on the whole building approach and the other one on the performance of single elements. In others, the single element requirements act as supplementary demands to the whole building approach. In some cases the requirements for renovating buildings can be as ambitious as the new build requirements. Major changes are expected through the application of the cost-optimality concept in energy performance requirements as introduced by the recast EPBD which should also gradually converge to nearly zero energy standards, a requirement for new buildings from 2020 onwards. An appropriate level of enforcement compliance with building energy codes should also be of concern and a point of attention for policy makers as it is necessary to ensure that enough rigour and attention to detail are undertaken when applying energy efficiency measures.

As Europe strives towards increasing building energy performance, the role of available financial programmes and innovative mechanisms become increasingly important. About 333 financial schemes have been screened through the BPIE survey. These cover a wide range of financial instruments from grants to VAT reduction and apply to a range of building types. The measures surveyed are encouraging, but many of them are only modest in their ambition. The major concern is that the use of financial instruments today only achieves the business-as-usual case in Europe with very few financial instruments providing enough funding for deep renovations, and ultimately do not correspond to Europe's 2050 aspirations.

Types of financial programmes and incentives on the energy performance of buildings

There are steps underway to improve the availability of new financing instruments. Innovative approaches include Energy Supplier Obligations, energy service companies, the use of EU Structural Funds more effectively and possible targets to renovate specific building sub-sectors (e.g. the proposal in the draft Energy Efficiency Directive to Member States to renovate a certain percentage of public buildings annually) which will require Member States to "unlock" funding for such renovations.

THE WAYS FORWARD

Building energy performance needs to be significantly improved in order to reduce overall energy demand and, importantly, reduce carbon dioxide emissions in line with the cost-effective potential and Europe's GHG emissions objectives. The question for policymakers is how to proceed.

To help policy makers determine the appropriate way forward, a renovation model has been specifically developed for this project. The scenarios illustrate the impact on energy use and CO_2 emissions at different rates (percentage of buildings renovated each year) and depths of renovation (extent of measures applied and size of resulting energy and emissions reduction) from now up to 2050. The model has assessed energy saved, CO_2 saved, total investment required, energy cost savings, employment impact and a range of cost-effectiveness indicators. These assessments allow policy makers the opportunity to focus on what they consider the highest priorities. The model considers features such as the age of buildings and quality of building energy performance. When considering the share of buildings that can undergo low energy renovation, a practical limit is applied in the residential and non-residential building sectors in the 2011 to 2050 timeframe. This practical limit is affected by a number of considerations such as demolitions, heritage buildings, recent renovations and new buildings. The model applies different discount rates, learning curves and future energy prices (based on Eurostat and Primes forecasts) in order to derive how costs will evolve from now until 2050. Two decarbonisation pathways are considered, a slow pathway based on what has been witnessed since 1990 and a fast pathway based on what is needed to achieve the levels of carbon reduction assumed in the EU 2050 Roadmap.

The model was used to create scenarios with various speeds (slow, medium and fast) and depths of renovation (minor, moderate, deep and nearly zero energy). All but one scenario assume that a building will be renovated once between 2010 and 2050. The so-called two-stage scenario allows for a second renovation during the 2010-2050 period. Individual scenarios combine different speeds and depths, and are compared to a business-as-usual scenario, which assesses what would happen if there were no changes from the approach taken today.

The results vary considerably as can be expected. Considering the results for 2020, the annual energy savings range from 94 TWh in the business-as-usual case to 527 TWh for the most ambitious deep scenario (and 283 TWh for both the medium and two-stage scenarios). In 2050, the corresponding annual energy savings of the deep and two-stage scenarios are 2795 TWh and 2896 TWh respectively while only 365 TWh annual savings are achieved in the business-as-usual case.

The results look significantly different for CO_2 savings where the deep and two-stage scenarios are much closer in impact. Under the assumption of fast decarbonisation of electricity and fossil fuels, the 2050 savings of the deep and two-stage scenarios correspond to the 90% which are in line with the European CO_2 reduction targets[3]. These levels of savings can only be achieved given that both renovation and power sector decarbonisation strategies are adopted. Yet, there is a significant difference in investment costs (on a present value basis). For the deep scenario the investment is €937 billion, while a significantly lower €584 billion for the two-stage scenarios is needed.

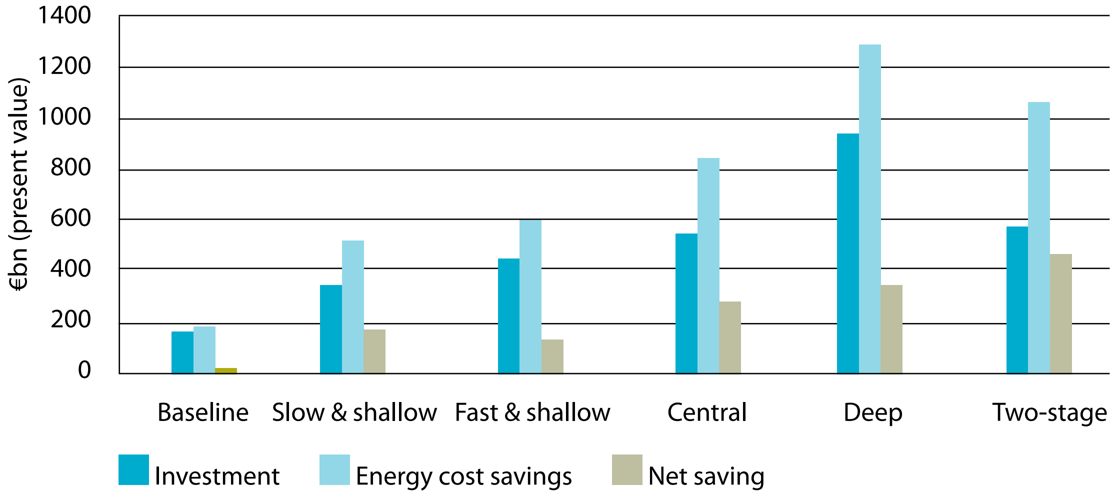
3 as described by the European Commission in its Roadmap 2050 paper

It is, however, not sufficient to only consider investment costs. These investments lead to a range of savings for individuals and society which are summarised in the figure below.

The figure below compares the present value investment and energy cost savings – the difference providing the net savings to consumers. While both the deep and the two-stage scenario achieve broadly the same level of CO_2 reduction, the deep scenario requires a significantly higher absolute investment level. In return, it also generates higher energy cost savings; however, the net savings are smaller than in the two-stage scenario. The high investment needs of the deep scenario are caused by a fast increase of deep renovation measures in the first decade. The two-stage scenario requires a lower investment due to a slower increase in the number of deep renovations while benefitting from a longer learning period which leads to cost reductions.

Lifetime financial impact for consumers (present value)

Source: BPIE model



The table on the next page gives an overview of the key results of each scenario. Beyond energy, CO_2 and cost savings, significant positive employment effects can be achieved, directly depending on the level of investment.

Overall results to 2050

Source: BPIE model

Scenario		0	1A	1B	2	3	4
Description		Baseline	Slow & Shallow	Fast & Shallow	Medium	Deep	Two- stage
Annual energy saving in 2050	TWh/a	365	1,373	1,286	1,975	2,795	2,896
2050 saving as % of today	%	9%	34%	32%	48%	68%	71%
Investment costs (present value)	€bn	164	343	451	551	937	584
Savings (present value)	€bn	187	530	611	851	1,318	1,058
Net saving (cost) to consumers	€bn	23	187	160	300	381	474
Net saving (cost) to society - without externality	€bn	1,116	4,512	4,081	6,451	8,939	9,908
Net saving (cost) to society - including externality	€bn	1,226	4,884	4,461	7,015	9,767	10,680
Internal Rate of Return	IRR	10.1%	12.4%	11.5%	12.5%	11.8%	13.4%
Fast decarbonisation							
Annual CO_2 saving in 2050	$MtCO_2/a$	742	821	814	868	932	939
2050 CO_2 saved (% of 2010)	%	71.7%	79.3%	78.6%	83.8%	89.9%	90.7%
CO_2 abatement cost	€/tCO_2	-20	-74	-68	-103	-136	-151
Slow decarbonisation							
Annual CO_2 saving in 2050	$MtCO_2/a$	182	410	391	547	732	755
2050 CO_2 saved (% of 2010)	%	18%	40%	38%	53%	71%	73%
CO_2 abatement cost	€/tCO_2	-89	-196	-185	-221	-238	-255
Average annual net jobs generated	M	0.2	0.5	0.5	0.7	1.1	0.8

In all the scenarios, the estimated CO_2 emission reduction by 2050 is determined by the energy savings but also by the decarbonisation of the energy supply sector. It is interesting to note that in the deep and two-stage scenarios there is a 71-73% CO_2 emission reduction even under the slow decarbonisation assumption, a figure which is close to the CO_2 emission reduction for the slow and shallow scenario under the fast decarbonisation assumption. This highlights the role of renovation measures in the decarbonisation strategy. The decarbonisation of the energy supply sector is significantly eased by decreasing the energy demand of buildings and is importantly more sustainable. Moreover, the costs for decarbonising the energy generation system will be significantly less if the consumption patterns of the building sector will dramatically reduce.

Each of the scenarios 1-4 represent a significant ramping up in renovation activity compared to the current situation (i.e. the baseline scenario 0). When looked at purely in terms of the investment required, these range from around double the baseline level for scenario 1a, through to over 5 times the baseline level for the deep scenario 3. These are significant increases, but certainly achievable if governments across the EU were to agree and implement respective policies and market stimulation mechanisms. The current practice is clearly not sufficient to trigger a renovation wave across Europe which would deliver the societal, economic and environmental benefits possible. At a time of rising unemployment and increased energy dependency, the employment and energy saving benefits to consumers from an accelerated renovation programme would provide a welcome boost to many countries continuing to suffer economic difficulties following the credit crunch.

The modelling exercise gives a clear indication that an ambitious renovation strategy for Europe's buildings is feasible. Taking into consideration the three most relevant factors, i.e. achievement of CO_2 reduction targets, investment considerations and positive employment effects, it seems that the results of the two-stage scenario provide the best balance of these factors, comparing all scenarios. The two-stage scenario therefore illustrates a pathway which should influence policy choices to stimulate the renovation of the European building stock.

For policy makers the challenge only begins at this point. The question now is how to break the policy inertia and set the necessary policies in motion to achieve this. The complex nature of the buildings sector with its many actors in the value chain requires effective policy actions at both EU level and Member State level.

At EU level, the recast of the EPBD will have to be implemented in a way which secures large energy savings and it will have to be monitored for revision at the earliest possible date. Other Directives, from Ecodesign to the Energy Efficiency Directive proposed in June 2011, will have to be aligned to maximise ambition. At the same time, Member States need to make significant efforts to transpose EU regulation and to implement it in a way that stimulates deep renovation of the building stock.

Beyond policy regulation, financing frameworks need to be effective and adequate. Innovative approaches are needed since the initial up-front investment costs for ambitious renovations can be a real barrier. Supporting measures at all levels of the building value chain, from a well-trained workforce (from designers to tradesmen), to a continuing and growing range of energy-efficient products and to effective awareness and information programmes are essential. These strategies are inter-connected and need to be carefully designed to stimulate the necessary growth of the European deep renovation market. The following recommendations provide a strategic framework and starting point for decision makers at both the EU and national level.

Main policy recommendations

- **Data collection:** harmonise national data collection systems relating to the energy performance of buildings and ensure sufficient data availability. A reliable and continuous data collection process is a necessary prerequisite for reliable policy making.
- **Renovation roadmap:** strengthen the existing legislation at EU level through binding measures and establish a roadmap for the renovation of the building stock with interim and long term binding targets as well as monitoring and reporting plans. At Member State level, it is necessary to detail deep renovation plans comprising regulatory, financial, information and training measures, with renovation targets based on the national financial and technical potential and tailor-made roadmaps with different phases moving from voluntary to binding measures.
- **Financing:** establish an EU Deep Renovation Fund (possibly via the European Investment Bank and designed for different building types) which can complement the national financing schemes and share the risks, offering more financial flexibility and additional confidence to the private investors. EU expenditure for the renovation of the building stock (i.e. by Structural and Regional Development Funds) should introduce the minimum requirement for implementing measures at cost-optimal levels. The development of innovative financial instruments at Member State level can trigger increased private investment by providing guidelines for financing, promoting best practice and stimulating Member State cooperation;
- **Member State policies:** eliminate market barriers and administrative bottlenecks for the renovation of the building stock and to develop long-term comprehensive regulatory, financial, educational and promotional packages addressing all the macro-economic benefits.
- **Monitoring/compliance/enforcement:** establish proper monitoring systems of compliance, enforcement and quality control processes through a qualified workforce for all policy packages fostering deep renovation.
- **Energy Performance Certificates:** strengthen the implementation of the buildings energy certification and audit schemes which can increase the value of efficient buildings and can stimulate the real-estate market towards green investments.
- **Public sector:** ensure that the public sector takes a leading role in the renovation revolution as envisaged by the draft Energy Efficiency Directive, which should kick start the market for renovation and help bring costs down for private households and businesses.
- **ESCOs and savings guarantee:** remove market barriers for the ESCOs and facilitate a faster and better development of deep renovation programmes through regulatory frameworks, encouraging the set up and development of a well-functioning energy services market which is not limited to commercial buildings. An innovative guarantee system should be developed for the performance of efficiency measures in order to provide confidence for the quality level of renovation measures to consumers and investors.
- **Training and education:** increase the skills in the construction industry by ensuring appropriate framework conditions for the Internal Market of construction products and services, improving resource efficiency and environmental performances of construction enterprises, and promoting skills, innovation and technological development.

INTRODUCTION

A VITAL PICTURE OF THE EUROPEAN BUILDING STOCK

"If you cannot measure it, you cannot improve it"

Sir William Thomson, Lord Kelvin

Buildings are at the centre of our social and economic activity. Not only do we spend most of our lives in buildings, we also spend most of our money on buildings. The built environment is not only the largest industrial sector in economic terms, it is also the largest in terms of resource flow[1]. Buildings are intrinsically linked to Europe's societies, Europe's economies, and their future evolution.

Energy security and climate change are driving a future that must show a dramatic improvement in the energy performance in Europe's buildings. The 27 Member States have set an energy savings target of 20% by 2020, mainly through energy efficiency measures. The European Union has also committed to 80-95 % GHG reduction by 2050 as part of its roadmap for moving to a competitive low-carbon economy in 2050[2]. Buildings currently represent almost 40% of total final energy consumption and, therefore, can make a crucial contribution to these targets.

In the Energy Efficiency Plan 2011[3], the European Commission states that the greatest energy saving potential lies in buildings. The minimum energy savings in buildings can generate a reduction of 60-80 Mtoe/a[4] in final energy consumption by 2020, and make a considerable contribution to the reduction of GHG emissions. This will be achievable only if buildings are transformed through a comprehensive, rigorous and sustainable approach.

The European policy framework for buildings has been evolving since the early 1990s. A wide array of measures has been adopted across individual Member States to actively promote the better energy performance of buildings. After 2002, the issue gained strong momentum when the Directive on Energy Performance of Buildings (EPBD) [Directive 2002/91/EC] was adopted. The EPBD was recast in 2010 to make the goals more ambitious and to reinforce the implementation.[5]

As the Commission stated in its Communication proposing the 2010 revision: "The sector has significant untapped potential for cost effective energy savings."[6]. Realising this potential will depend crucially on the commitment of Member States, and the involvement of stakeholders from government, industry and civil society.

The European Union stretches over many different climate zones, landscapes and cultures. Some 501 million inhabitants spread over 27 countries[7] reside in a wide array of building types with an equally wide

1 Paul Hawken - The HOK Guidebook to Sustainable Design.
2 Directive 2010/31 of the European Parliament and of the Council of 17 May 2010 on the energy performance of buildings and its amendments (the recast Directive entered into force in July 2010, but the repeal of the current Directive will only take place on 1/02/2012).
3 Energy Efficiency Plan 2011, Communication from the commission to the European Parliament, the council, the European economic and social Committee and the committee of the regions, European Commission, 2011.
4 Summary of the impact assessment accompanying document to the proposal for a recast of the energy performance of buildings directive (2002/91/EC).
5 Directive 2010/31 of the European Parliament and of the Council of 17 May 2010 on the energy performance of buildings and its amendments (the recast Directive entered into force in July 2010, but the repeal of the current Directive will only take place on 1/02/2012).
6 COM(2008) 780 final.
7 The data collection and analysis also include Norway and Switzerland, two countries that work closely with the EU and implement much of its legislation.

range of thermal qualities, in a constantly expanding building stock. From styles of living – single-family dwellings or multi-family dwellings, for example – to policies for the construction of buildings, there are significant differences between countries.

National approaches to monitoring the building stock have also evolved separately. Information is not only needed to track the progress of policy implementation, better information and data are required to help develop a European pathway and roadmaps to more energy efficient buildings. In order to define the energy and CO_2 reduction potential, we need to study and evaluate the technical and economic opportunities, feasibilities and limits.

Indeed, it is a major obstacle to strong policy making at EU level that there is a lack of data on the building sector for Europe as a whole.

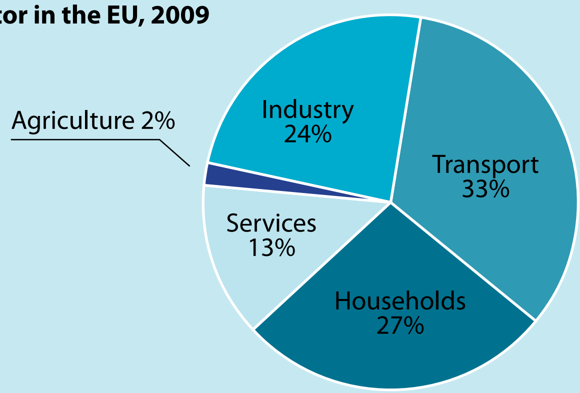
There has been significant Europe-wide legislation on buildings and there are several forthcoming initiatives underway to improve the energy performance of new and existing buildings. Yet, much of this is done with only a minimum of fact-based knowledge, analysis and evidence. As strategies for the energy performance of buildings evolve and become more complex, policy makers need more concrete and precise facts to be able to make cross-country comparisons and to put in place the monitoring systems that permit measurement of the progress of the various policy instruments.

Buildings in a European context

Buildings consume about 40% of total final energy requirements in Europe. In the context of all the end-use sectors, buildings represent the largest sector, followed by transport with 33%.

Figure 1. Final energy consumption by sector in the EU, 2009

Source: DG ENER



To create a sound basis for political debate and policy making at EU and Member State level, the Buildings Performance Institute Europe (BPIE) has embarked upon a major undertaking: to develop a vital picture of the European building stock, one that is as detailed and correct as possible. BPIE is convinced that effective policy making starts with an accurate picture of the challenge. This report is a first attempt at such a comprehensive approach.

THE CHALLENGE

Many experts agree that the most cost-effective way of meeting climate change targets is through improved energy efficiency. At this point, there is growing acceptance of this principle, but there is still an imbalance between the resources devoted to energy supply options and energy demand-reduction options. The scenarios usually developed are designed to highlight the potential for improved energy efficiency in buildings making a cost-effective contribution to achieving climate targets.

Typically, energy efficiency initiatives are crowded out by other more immediate priorities, in part because improving energy efficiency is a long-term policy commitment. In the buildings sector, policies are effective not over two or three years, but two or three decades. That is not easy to sustain. Today's headlines include financial crises in several EU Member States, wars in several countries and budget debates at national and European levels. While they all seem like competing priorities, in fact, improved energy efficiency could make a positive contribution to solutions in many policy areas while actually increasing rather than decreasing available resources.

Why improve energy efficiency in buildings?

The high level of energy consumption and GHG emissions in buildings in Europe makes this is an obvious sector to target in order to determine the potential and improve energy performance. While there has already been significant effort to improve energy performance in buildings, considerable potential still remains, as was noted by the European Commission's Communication on the proposal for the recast of the EPBD.

The justification for focusing on the energy efficiency in buildings can be summarised in the following arguments that relate to both the individual's point of view and the perspective of society as a whole:

- Security of energy supply; [Societal]
- Lower GHG emissions, which means a major contribution to climate change strategies; [Societal]
- Reduced energy costs for consumers, which can be important in avoiding "fuel poverty" (where energy costs represent a disproportionate and unsustainable share of disposable income); [Private]
- Cheaper than investing in increased energy capacity; [Societal]
- Improved comfort; [Private]
- Contribution to the rehabilitation of certain building types in the new Member States of Central and Eastern Europe; [Both]
- A major contribution to the objective of sustainable development, which is a formal commitment of European countries; [Societal] and
- Improving energy efficiency in buildings is important to the buildings energy service industries that are important employers in Europe. [Both]

Any assessment of the costs and benefits of building energy performance must account for the full range of benefits at both individual and societal level – which is often difficult to estimate.

One major challenge is changing the mind-set concerning buildings. If the building sector is to significantly contribute to the 80-95% GHG reduction target for 2050, each building, on average, will have to demonstrate very low carbon emission levels and consume very low energy in the context of a decarbonised power sector. For most of Europe's buildings, that probably means improving the current average energy consumption by a factor four or five and the installation of renewables. For some it could even mean a factor 10 improvement. This may be hard to imagine but is definitely doable.[8]

[8] The IEA analytical work related to policy recommendations show this could be both possible and economically rational. This has been presented, for instance at Climate Change: Global Risks, Challenges and Decisions, IOP Conf. Series: Earth and Environmental Science 6 (2009) in the paper "Global policy for dramatic reduction of energy consumption in buildings – Factor 3 is both possible and economic rational", by Jens Laustsen, International Energy Agency IEA.

Supporters of energy efficiency need better arguments which will encourage both the private and public sectors to take more interest in improving energy efficiency and to explain how this paradigm shift can occur. The main objectives of this study are to give policy-makers the facts and offer the arguments to make the case persuasively, and to provide useful data input to researchers who should base any political discussion upon science-based insights.

STRUCTURE

This report has three parts.

Part 1 surveys 27 Member States, together with Norway and Switzerland, examining the floor space area of residential and non-residential buildings, building typologies, characteristics and energy performance of current stock. The information is drawn from the statistical offices of national administrations and will be presented in a form that permits European comparisons and analysis. There are inevitably gaps, as certain administrations have not made a priority of this kind of data collection (c.f. Methodology chapter).

Part 2 provides detailed information and analysis relating to current barriers, the EPBD implementation, the European building codes and major programmes that are designed to improve energy performance in buildings.

In **Part 3** the available data were used to develop and assess the energy performance scenarios for the buildings sector in Europe with the aim of illustrating potential energy savings and CO_2 reduction pathways, reflecting the EU's 20% energy saving target for 2020, as well as the EU's long term 80-95% GHG emission reduction target for 2050.

The scenarios describe the impact of building retrofit strategies to achieve the 2020 and 2050 targets. The scenarios are built on different renovation rates and depths and illustrate the impact of different ambition levels regarding the European environment and economy.

METHODOLOGY

BPIE has recently screened all EU27 countries together with Switzerland and Norway with the aim of collecting existing data related to buildings and building policies. The exercise has been undertaken using a team of experts in each Member State plus Norway and Switzerland. The data collected were mainly extracted from official statistics and studies at Member State level supported by expert estimations wherever official data were unavailable. The information was gathered in the form of a questionnaire whose structure comprised five principal levels:

- Background
- Legal
- Financial
- Technical
- Monitor

The data have been used to give a fresh and up-to-date picture of where we stand in terms of the energy performance of our buildings and form the basis upon which our scenarios are built. Through the survey carried out by BPIE, information on the typology, characteristics (such as age, size, and ownership profile) and energy performance of the building stock have been collected for the EU27 countries together with Norway and Switzerland. The dataset represents one of the most comprehensive assembled in Europe to date and ranges from residential to non-residential buildings where the following categories were considered:

(a) Single family houses
(b) Apartment blocks
(c) Offices
(d) Educational buildings
(e) Hospitals
(f) Hotels and restaurants
(g) Sports facilities
(h) Wholesale and retail trade services buildings
(i) Other types of energy-consuming buildings

Data have been gathered on the floor area of the building stock where 25 countries reported residential and 19 reported non-residential floor area data in full. A further four countries reported partial data for the floor area of non-residential buildings. The reported totals represented 92% of the total floor area in the countries looked at and the final 8% have been estimated. For the latter, estimates have been made by taking the prevailing average across the dataset for floor area per person for the missing building category and multiplying this by the population of the country in question.

Care has been taken in the compilation of the data required to make additional estimations. For example, floor area data were reported at times in net floor area and other times in gross, net, useful or heated. Conversion factors were applied to aggregate all data in useful floor areas considering typical wall thickness levels as well as percentage floor space of buildings, which are non-heated and non-habitable areas. These factors were defined for different types of buildings. Comparisons were further complicated by inconsistent definitions of many building typologies where assumptions had to be made in order to broadly divide the reported data in the above function types. In some cases, appropriate division was not possible. For example, some countries reported industrial buildings in "other types of energy consuming buildings" while others did not. In those cases, it was not possible to extract or estimate the portion of industrial buildings in order to provide consistent information for this function type across all countries.

Data have also been gathered in terms of the age, size, ownership (private/public), tenure (owner occupied, private or social tenant) location (rural/urban) and typical energy performance levels of the building stock. Good responses have generally been obtained by several countries in residential stock while gaps in responses were more prominent in the characteristics of the non-residential stock.

THE CHALLENGES FOR THE FUTURE

As this is probably the first attempt to draw together a comprehensive and detailed picture of the residential and non-residential building stock throughout Europe, a number of issues have been identified, among which the two key issues are:

- **Common definition of floor area:**
  Countries often have different approaches to the measurement of floor area which can include external gross, internal gross, net, heated and treated parts of a building. The same term may not have the same meaning or definition in different countries. Moreover, assuming that two countries adopt the same definition, the different approaches for taking measurements (e.g. measuring the attic space) imply that comparing the resulting floor areas is difficult. For these reasons, it would be helpful to have agreement on a common measurement principle which should probably correspond to the concept of 'treated' floor area, referring to the portion of the building treated with some form of heating and/or cooling (but excluding areas such as plant rooms, car parks and other non-treated spaces). Some have proposed that building volume is a better metric when dealing with treated space because it is the volume of air that is heated or cooled. A small number of countries collect data on building volume and in any case it can be even more difficult to define, especially in the non-residential sector with suspended ceilings and raised floors complicating the measurement.

- **Common building categories:**
  Data were collected for this report using the above set of categories (a-i) for residential and non-residential buildings. Most countries were able to present data in the required format but several were only able to provide data broken down into nationally defined sets of categories. Agreement around a common set of building categories with a clear set of definitions of what should be included and excluded would make for more reliable and comparable data in the future, especially for non-residential types.

Addressing the above issues would require in many cases changes to the databases that countries are using and hence the underlying legislation. Although this would require considerable effort, monitoring and evaluating current policies related to buildings signify the urgent need for more data on the building stock. If the above issues are addressed in an appropriate way without overcomplicating the additional work, the case would be further reinforced for buildings being a driving sector for achieving the overall climate targets set for the EU. Without a solid foundation of data, it is difficult to monitor the impact and ultimately design effective policies.

PART 1

EUROPE'S BUILDINGS TODAY

"For strong policy making at EU and Member State level it is key to establish an efficient monitoring system of the European building stock assuring good data availability and data quality."

A. BUILDING TYPOLOGY

From large commercial offices to terraced single family houses, buildings in Europe vary remarkably in terms of their function type. They can be broadly divided into residential and non-residential sectors where each sector alone consists of multiple types – e.g. in Germany there are 44 reported types[7] within the residential sector alone.

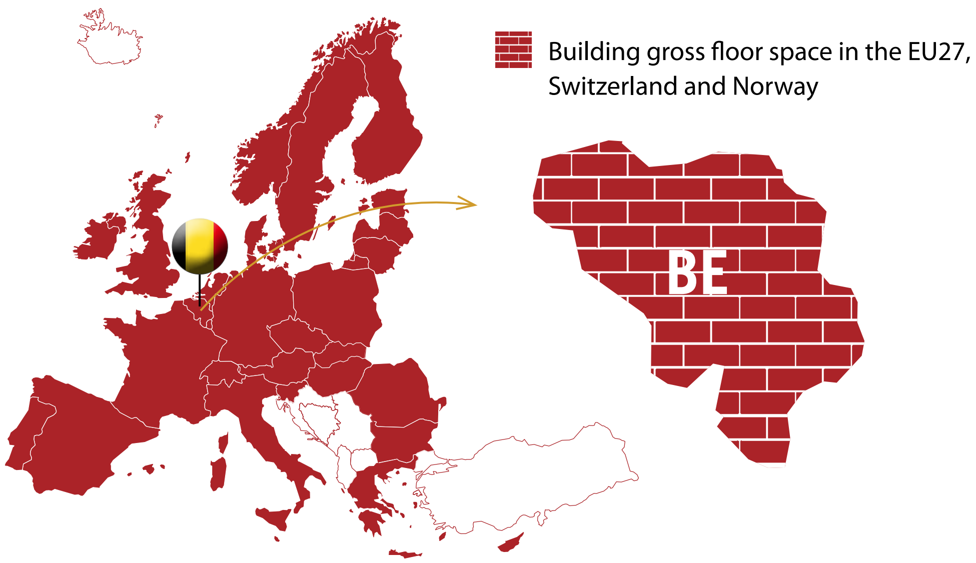
For the countries covered by this study[8], it is estimated that there are 25 billion m² of useful floor space, a figure that, it has been reported, is increasing at a rate of around 1% per year. To illustrate what this figure means in comparative terms, all EU buildings in terms of their gross floor space can be currently concentrated in a land area equivalent to that of Belgium (30,528 km²). In comparison to China and the US, Europe has the highest 'building density' (building floor space over land area) followed by China and then US. Floor space trends can be linked to a number of factors such as wealth conditions, culture and land availability. These factors can explain the significant differences between Europe, US and China where floor space per capita are around 48, 81 and 26 m², respectively. Within Europe, differences also exist from country to country.

The general tendency is to seek larger floor spaces over time, especially under favourable economic conditions. With increasing trends in floor space, the energy demand associated with our buildings is also increasing, which in turn highlights the need for improving the energy efficiency of our current stock, especially that of older stock.

Improving the energy efficiency of our buildings not only reduces energy consumption and subsequently energy bills but also improves the aesthetics of a building, increases the value of the asset and provides healthier conditions for the occupants.

Figure 1A1 – Building gross floor space in the EU27, Switzerland and Norway

Sources: Population figures: World Bank, Eurostat. Floor spaces: EU27 - BPIE survey 2011, US - Annual Energy Outlook 2011 with projections to 2035 (US Energy Information Administration), China - Energy Efficiency in Buildings, Facts & Trends (WBCSD)



	Population (2010)	Land area (km²)	Building Floor Space
EU27	501 million	4,324,782	24 billion m²
US	309 million	9,826,675	25 billion m²
China	1338 million	9,598,080	35 billion m²

[7] Based on extensive database for the German residential stock classified by construction year and building size published by IWU (Institut Wohnen und Umwelt - Institute of Housing and Environment).

[8] Focus countries are: EU27, Norway and Switzerland. Based on estimations through the BPIE survey for which 92% of floor area was reported. The EU27 useful floor area is 24 billion m².

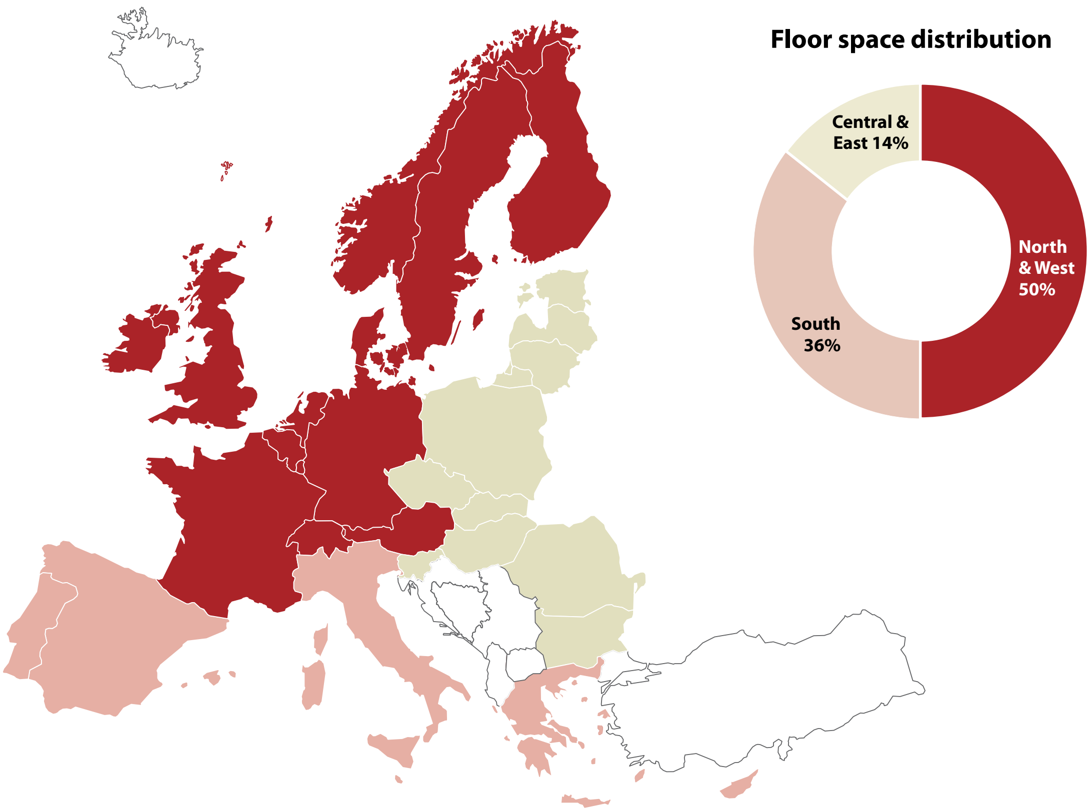
For the analytical purposes of this study, European countries have been divided up based upon climatic, building typology and market similarities into three regions:

- North & West
- South
- Central & East

Each region consists of the countries shown in the Table and map of Figure 1A2. It should be noted that half of the total estimated floor space is located in the North & West region while the remaining 36% and 14% are contained in the South and Central & East regions, respectively.

Figure 1A2 – Countries and regions considered herein with equivalent population and floor space figures

Source: BPIE survey



North & West	AT, BE, CH, DE, DK, FI, FR, IE, LU, NL, NO, SE, UK	Population: 281 mil.
Central & East	BG, CZ, EE, HU, LT, LV, PL, RO, SI, SK	Population: 102 mil.
South	CY, GR, ES, IT, MT, PT	Population: 129 mil.

The floor space breakdown per country is shown in Figure 1A3. The five largest countries (in terms of population: France, Germany, Italy, Spain and the UK) account for approximately 65% of the total floor space. This comes as no surprise since the corresponding share of population in these countries is equal to 61% of the total. As explained above, the relationship between population and building floor area is in fact a complex one which is influenced by a range of factors including economic wealth, culture, climate, scale of commerce, increased demand for single occupancy housing and many others.

Using the collected data, the floor space standards have been analysed by estimating the floor space per capita for each country. From this analysis, it appears that countries in the North & West region have higher total floor area per person than in the South and Central & East regions. Upon closer examination, the countries of Central & Eastern Europe tend to have lower space standards in terms of dwellings with a floor space of around 25 m²/person in comparison to the Northern and Southern European countries, which have space standards typically of around 40 m²/person. On the other hand, non-residential floor space per capita is nearly double in the North compared to other regions, which may suggest a link between non-residential floor space and economic wealth. The different approaches taken for defining and measuring floor area within this sector also have an impact on these numbers.

Figure 1A3 – Floor space distribution per country

Source: BPIE survey

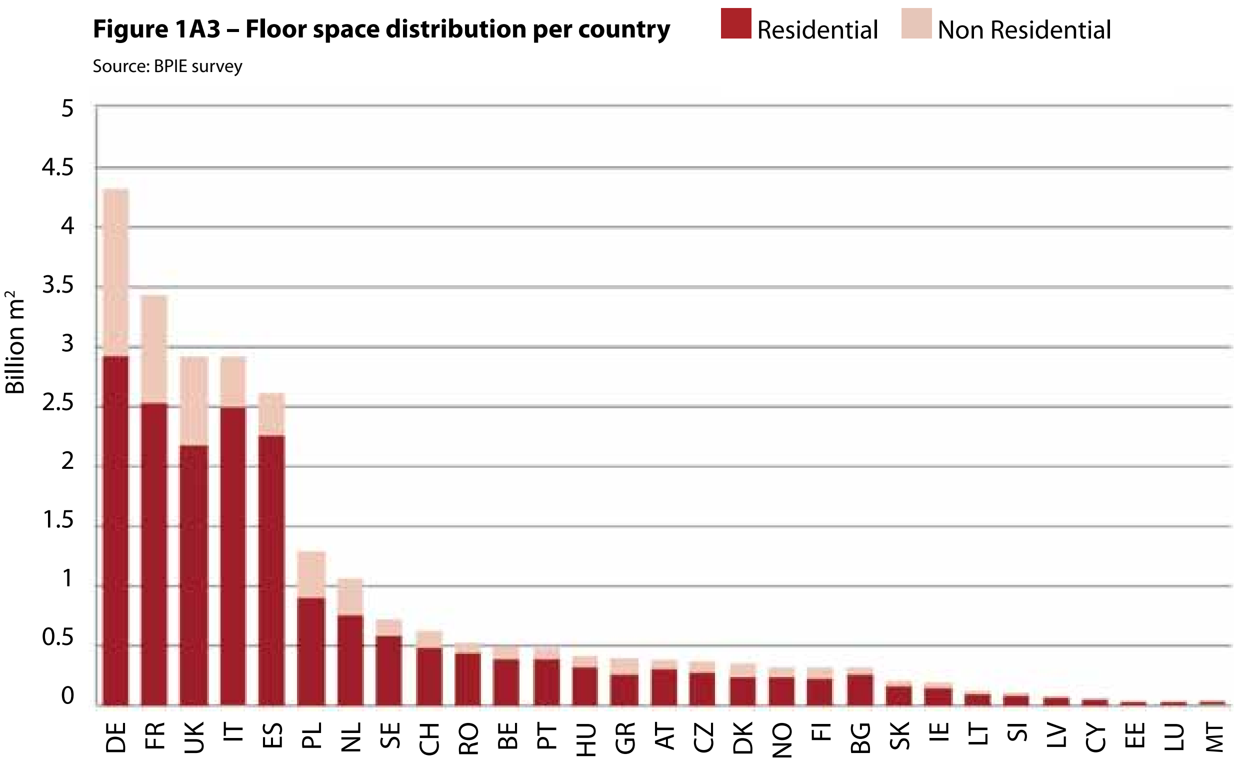
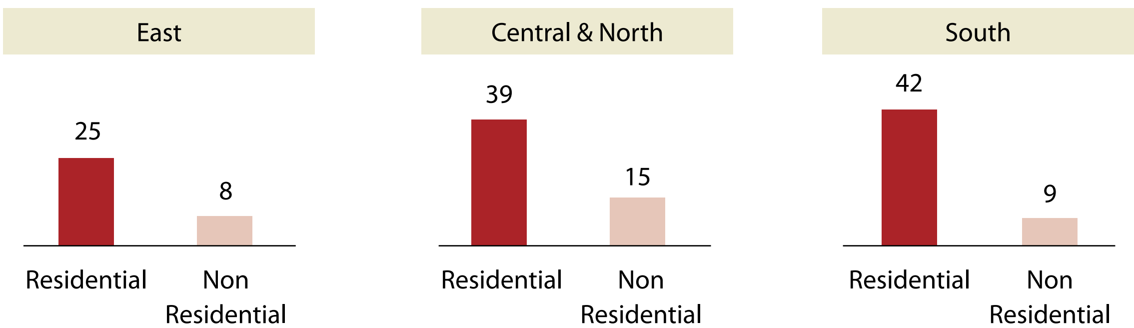


Figure 1A4 - Floor space per capita in the three regions in m²

Source: BPIE survey



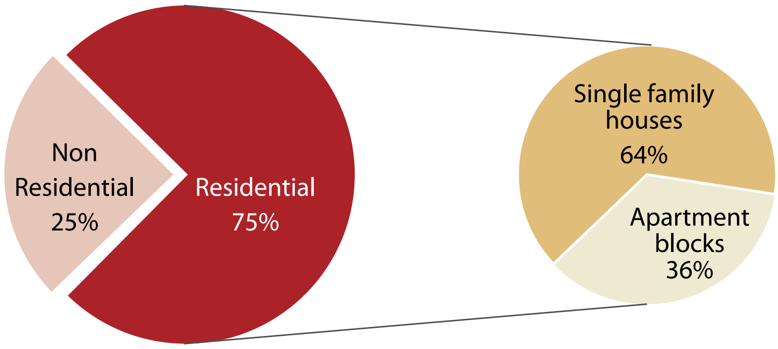
RESIDENTIAL BUILDINGS

The residential stock is the biggest segment with an EU floor space of 75% of the building stock (Figure 1A5). Within the residential sector, different types of single family houses (e.g. detached, semi-detached and terraced houses) and apartment blocks are found. Apartment blocks may accommodate several households typically ranging from 2-15 units or in some cases holding more than 20-30 units (e.g. social housing units or high rise residential buildings).

An analysis of this data indicates that, across the focus countries in this study, 64% of the residential building floor area is associated with single family houses and 36% with apartments.

Figure 1A5 – Residential floor space for the countries covered in the study

Source: BPIE survey



The split between the two main types of residential properties varies significantly from country to country as shown in Figure 1A6.

Austria, Bulgaria, Czech Republic, Germany, Lithuania, Poland, Sweden and Switzerland could be said to hold more even portfolios with similar floor areas for single family houses and apartments.

Greece, Ireland, Norway and the UK have the smallest proportion of floor area of apartments in the residential building stock, whilst Estonia, Latvia and Spain have the highest.

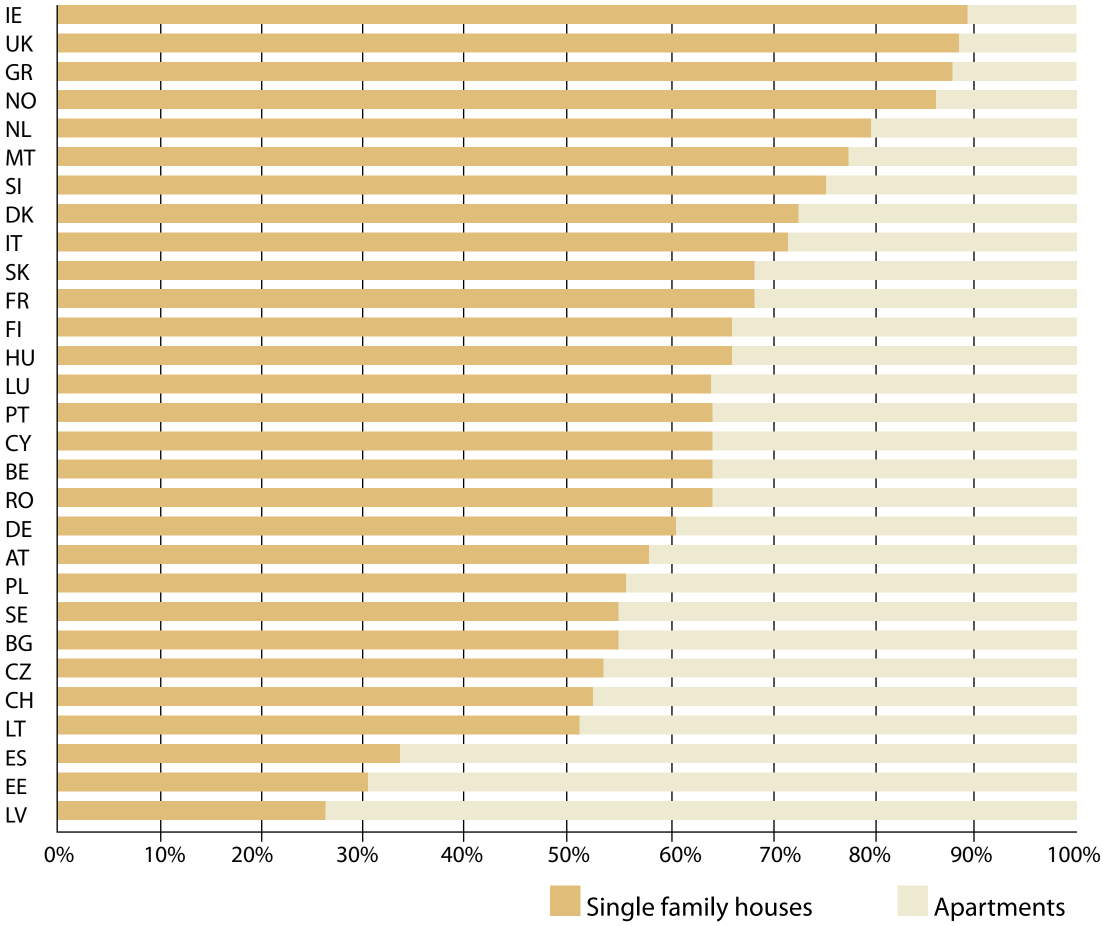
In terms of floor space per capita, the Central & East countries are among the countries with the lowest residential space in terms of both single family houses and apartment blocks.

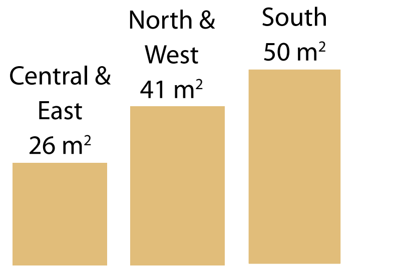
North & West countries have the highest residential floor areas per capita compared to other regions. Countries in the South have the highest single family house floor space per capita which perhaps indicates the frequency of holiday houses in those countries.

It is interesting to note that in all regions, the floor space standards in apartments are lower than in single family houses, a trend which perhaps reinforces the link between floor space and wealth conditions.

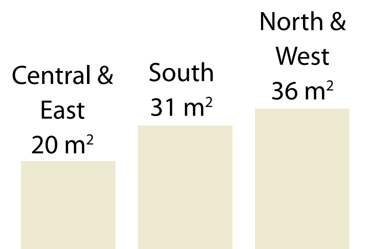
Figure 1A6 – Single family and apartment buildings in Europe

Source: BPIE survey / values for Luxembourg, Portugal, Cyprus and Belgium were estimated





Single family house floor space per capita



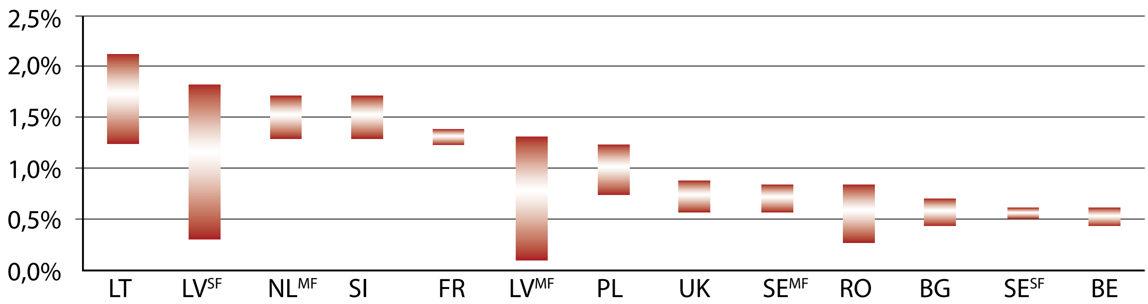
Apartment floor space per capita

An apartment block in Europe

A typical single family house in Europe

Figure 1A7 – Range of new build rates in the residential sector (2005-2010) where SF and MF denote single family and multi-family houses, respectively.

Source: BPIE survey



In terms of growth, annual rates in the residential sector are around 1% as depicted in Figure 1A7 which shows the range of new build rates in the residential countries for a range of countries over the period between 2005 and 2010.

Except The Netherlands (in the case of multi-family houses), all other countries experienced a decrease in the rate of new build in recent years, reflecting the impact of the current financial crisis in the construction sector. Notably, this impact seems to be more pronounced in countries in Central & Eastern Europe as is the case in Latvia, Romania and Poland.

NON-RESIDENTIAL BUILDINGS

The diversity in terms of typology within the non-residential sector is vast. Compared to the residential sector, this sector is more complex and heterogeneous. It includes types such as offices, shops, hospitals, hotels, restaurants, supermarkets, schools, universities and sports centres while in some cases multiple functions exist in the same building. Moreover, differences from country to country are more pronounced, which in turn, makes the cross-country comparison of the definitions of various building categories more challenging.

In our survey, we have considered the following broad categories: educational buildings, offices, hospitals, hotels and restaurants, sports facilities, wholesale and retail trade services buildings and other types of energy-consuming buildings. In each of these categories, a broad division between various subcategories has been considered based on the list of Figure 1A8.

Figure 1A8 reveals the split between these categories at the European level. The retail and wholesale buildings comprise the largest portion of the non-residential stock. These buildings are somewhat different from others as heating and cooling conditions may differ substantially from other categories due to large areas of wholesale buildings often being used only for storage purposes.

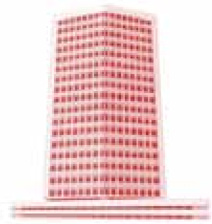
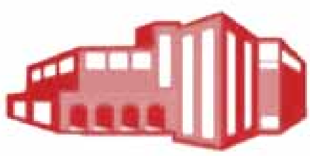
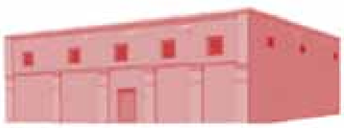
In addition to this, differences are also pronounced within this sector where there is no homogeneity in terms of size, usage pattern (use hours) and construction style. This requires special attention when looking at the retail and wholesale sub-sectors.

Office buildings are the second biggest category with a floor space corresponding to ¼ of the total non-residential floor space. Offices have similar heating and cooling conditions to residential buildings although they are of shorter use. Similar usage pattern as offices are found with educational buildings which count for less than 20% of the entire non-residential floor space.

Hospitals (7% of total non-residential floor space) have continuous usage patterns, where energy demand can vary substantially depending on the services provided (from consultation rooms to surgery rooms).

Figure 1A8 - The non-residential sector in Europe

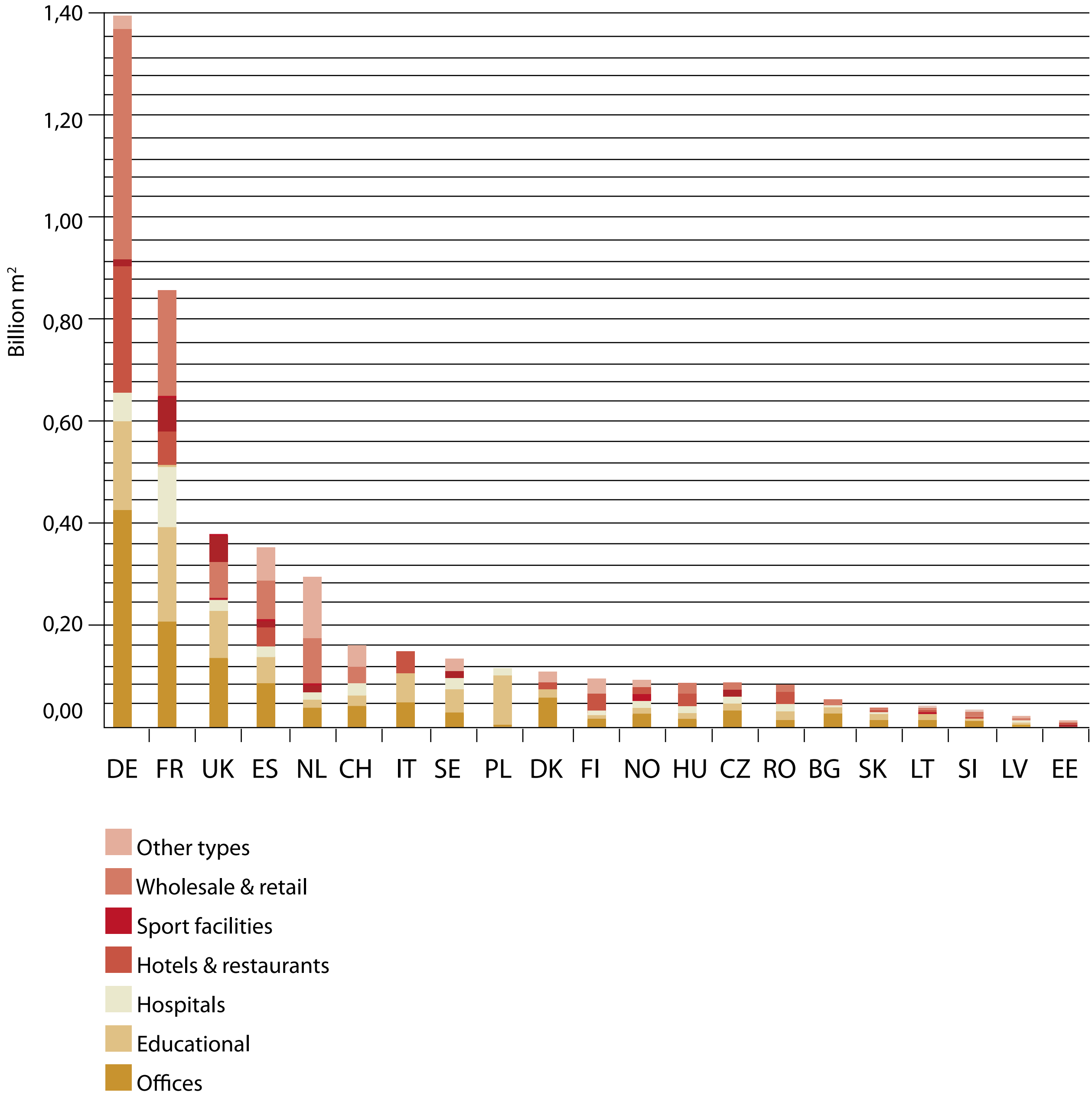
Source: BPIE survey

	Wholesale & retail 28%	Detached shops, shopping centres, department stores, large and small retail, food and non food shops, bakeries, car sales and maintenance, hair dresser, laundry, service stations (in gas stations), fair and congress buildings and other wholesale and retail.
	Offices 23%	Offices in private companies and offices in all state, municipal and other administrative buildings, post-offices.
	Educational 17%	Primary and secondary schools, high schools and universities, research laboratories, professional training activities and others.
	Hotels & restaurants 11%	Hotels, restaurants, pubs and cafés, canteens or cafeterias in businesses, catering and others.
	Hospitals 7%	Public and private hospitals, medical care, homes for handicapped, day nursery and others.
	Sport facilities 4%	Sport halls, swimming pools, gyms etc.
	Other 11%	Warehousing, transportation and garage buildings, agricultural (farms, greenhouses) buildings, garden buildings.

The division between the non-residential building categories varies significantly from country to country as seen in Figure 1A9. Offices and wholesale & retail trade buildings make up the largest component in most countries. Many countries have reported a large component in the category of 'other' buildings and this probably indicates that further effort is required in the future to separate this floor area into one or more of the other categories wherever possible.

Figure 1A9 - Breakdown of non-residential floor space in selected countries

Source: BPIE survey



While the dataset of residential buildings is fairly comprehensive, the non-residential stock is far less covered, as the sector is associated with higher uncertainty levels due to the difficulties in tracking the existing stock of all different non-residential types and developing an appropriate statistical database.

Public buildings are in the limelight at the moment due to the policies requiring the public sector to lead by example where all new constructions in the sector are required to be of nearly zero energy standards by end of 2018[9] while a sectoral renovation rate of at least 3% is recommended[10].

The exercise carried out by BPIE has reinforced the need for collecting better data and urge a call for the establishment of guidelines and requirements under which Member States should gather more extensive and consistent data on the typology of their non-residential stock.

B. CHARACTERISTICS

In addition to typology, buildings vary greatly in terms of age, size and location. The data collected through our survey has allowed us to draw up a picture of these characteristics. These are discussed in more detail below.

AGE

Buildings across Europe are associated with different time periods dating even before the 1900s. Historical buildings certainly have a significant heritage value while construction techniques and building regulations such as building codes imposed at the design phase have a great influence on the energy performance of a building built in a specific period.

In the residential sector, the age of a building is likely to be strongly linked to the level of energy use for the majority of buildings that have not undergone renovation to improve energy performance.

The BPIE survey has classified buildings in different age bands (specific chronological periods) for each country. In order to allow some comparison between the age profiles of the residential building stock of different countries, the floor area data for each country has been consolidated into three representative age bands[11]:

- Old: typically representing buildings up to 1960
- Modern: typically representing buildings from 1961 to 1990
- Recent: typically representing buildings from 1991 to 2010

Figure 1B1 shows the share of residential floor space by age band. The specific energy use within these age bands is likely to differ between countries in different regions of Europe due to a number of political, economic and social factors. The average composition for each region has been estimated by summing the floor area by age band for all countries in the respective region where detailed data have been made available. The variations in the age profile between the three regions appear to be small where older buildings (before 1960) have the biggest share in the North & West region. In particular, the countries with the largest components of older buildings are the UK, Denmark, Sweden, France, Czech Republic and Bulgaria. It is also evident that all countries experienced a large boom in construction in the 'modern' period (1961-1990) and with a few exceptions, the housing stock more than doubled in this period.

Significant country-by-country variations are also evident. The countries with the most recently constructed buildings (1990-2010) appear to be Ireland, Spain, Poland and Finland, while countries with the highest rate of construction in the 'modern' period (1961-1990) seem to be Estonia, Hungary, Latvia and Finland.

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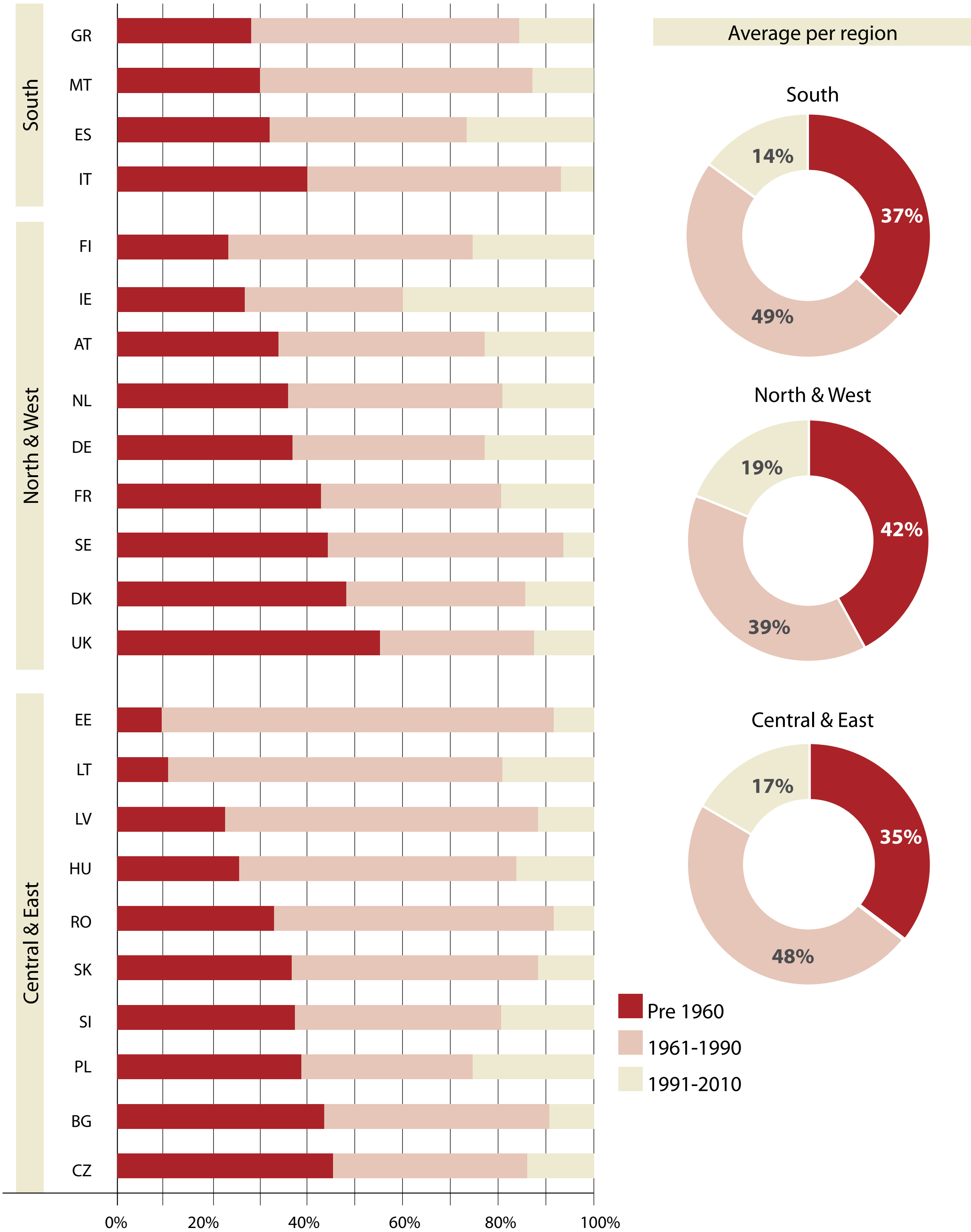
9 Based on the EPBD recast
10 Based on the 'Energy Efficiency Plan' 2011
11 A more detailed age breakdown was available in individual countries. When sorted at the regional level, it was possible to deduce the breakdown in the three age groups identified herein.

Figure 1B1 - Age profile of residential floor space

Source: BPIE survey



NOTES

BG: Based on estimations
EE: Data from 1951 onwards.
GR: Data only till 2000.
IT: Values exclude heritage buildings before the 1950.
LT: Data from 1941 onwards.

MT: Based on a sample survey with data until 2002.
PL: Based on estimations
ES: Based on primary residences (i.e. excluding secondary houses)
SE: Data only from 1921 till 2005

SIZE

Information on the size of non-residential buildings is helpful in understanding the impact of policy measures that are targeted at non-residential buildings with different floor area thresholds.
Through the BPIE survey, data was available from 13 countries (AT, BG, CY, CZ, EE, IE, IT, LT, NL, SE, SI, SK, UK). The following five key building categories have been considered:

- Offices
- Educational buildings
- Hospitals
- Hotels and restaurants
- Retail buildings

The analysis of the size of non-residential buildings is presented in Table 1B1, either as a percentage of the floor area or as a percentage of the number of buildings in that size band.

Table 1B1 – Share of non-residential buildings size (%)
Source: BPIE survey

All types of consuming non-residential buildings

number	< 200 m^2	200 - 1000 m^2	> 1000 m^2
EE	10	50	40
SI	89.8	8.8	1.4
LT	42	55	3
CY	79		21
AT	11	52	37

NOTES
The figures in the above tables are in % and add up to 100%.

AT: Values based on registered certificates, accounting for 1007 data sets of non-residential buildings, most of which are office buildings.
CY: Values refer to non-residential building permits issued from 2003-2009 (and % refers to <900 m^2 and > 900 m^2 of surface area)
SI: The data refer to all real estate units in non-residential use
EE, LT: Values based on estimations by national experts

From this table, it can be deduced that policy measures applied only to non-residential buildings over 1000 m^2 in floor area would miss a substantial portion of buildings in many countries, especially in educational buildings, hospitals and offices. Policy measures however applied to buildings over 200 m^2 (for instance in offices) would hit the majority of buildings in most countries. The largest non-residential buildings are typically hospitals, followed by educational buildings and sports facilities while in wholesale, retail, hotels and restaurants the distribution is more even across the different size bands.

Table 1B1 is continued on next page

Table 1B1 – Share of non-residential buildings in each country (figures are shown in %)
Source: BPIE survey

Break down by function type

Offices

Area	< 200 m²	200 - 1000 m²	> 1000 m²
BG	60	30	10
UK	26	27	47
NL	12	24	64
IT	5	28	67
SK	1	12	88

Number	< 200 m²	200 - 1000 m²	> 1000 m²
IE	95		5
CZ	30	55	15
IT	33	50	17
LT	0	79	21
SE	4.7	25.9	69.4

Hospitals

Area	< 200 m²	200 - 1000 m²	> 1000 m²
BG	0	30	70
SK	0	4	96
UK	0	1	99

Number	< 200 m²	200 - 1000 m²	> 1000 m²
LT	0	78	22
CZ	0	70	30
SE	4.4	28	67.5
IE	0	0	100

Sport facilities

Area	< 200 m²	200 - 1000 m²	> 1000 m²
UK	0	12	88
SK	0	10	90

Wholesale & retail

Area	< 200 m²	200 - 1000 m²	> 1000 m²
BG	35	55	10
UK	42	22	36
SK	1	12	86

Number	< 200 m²	200 - 1000 m²	> 1000 m²
CZ	25	60	15
SE	3.7	37.4	68.9

Educational buildings

Area	< 200 m²	200 - 1000 m²	> 1000 m²
BG	0	40	60
NL	5	4	91
SK	0	6	93
UK	1	5	94

Number	< 200 m²	200 - 1000 m²	> 1000 m²
IE	84.5		15.5
CZ	0	55	45
SE	5.3	37.3	57.4

Hotels & Restaurants

Area	< 200 m²	200 - 1000 m²	> 1000 m²
BG	10	50	40
UK	27	23	52
SK	0	4	95

Number	< 200 m²	200 - 1000 m²	> 1000 m²
CZ	5	65	30
SE	11.2	45	43.9

NOTES

AT: Values based on registered certificates, accounting for 1007 data sets of non-residential buildings, most of which are office buildings.

CY: Values refer to non-residential building permits issued from 2003-2009 (and % refers to <900 m² and > 900 m² of surface area)

CZ: Estimations based on past official data, extrapolated to present time.

IE: Office values concern buildings under the responsibility of the Office of Public Works. Educational values concern only public primary and secondary schools. Hospital values include publicly owned acute and non-acute hospitals and private nursing homes

SI: The data refer to all real estate units in non-residential use

SE: Values presented are based only on certified non-residential buildings.

UK: All presented values refer only to England and Wales and the categories <200 m² correspond to <250 m² and the categories 200-1000 m² corresponds to 250-1000 m².
Office values concerns only commercial offices, hospital values exclude health centres and surgeries, and sports facilities include only LA sports centres

BG, EE, LT, NL: Values based on estimations by national experts

OWNERSHIP AND TENURE

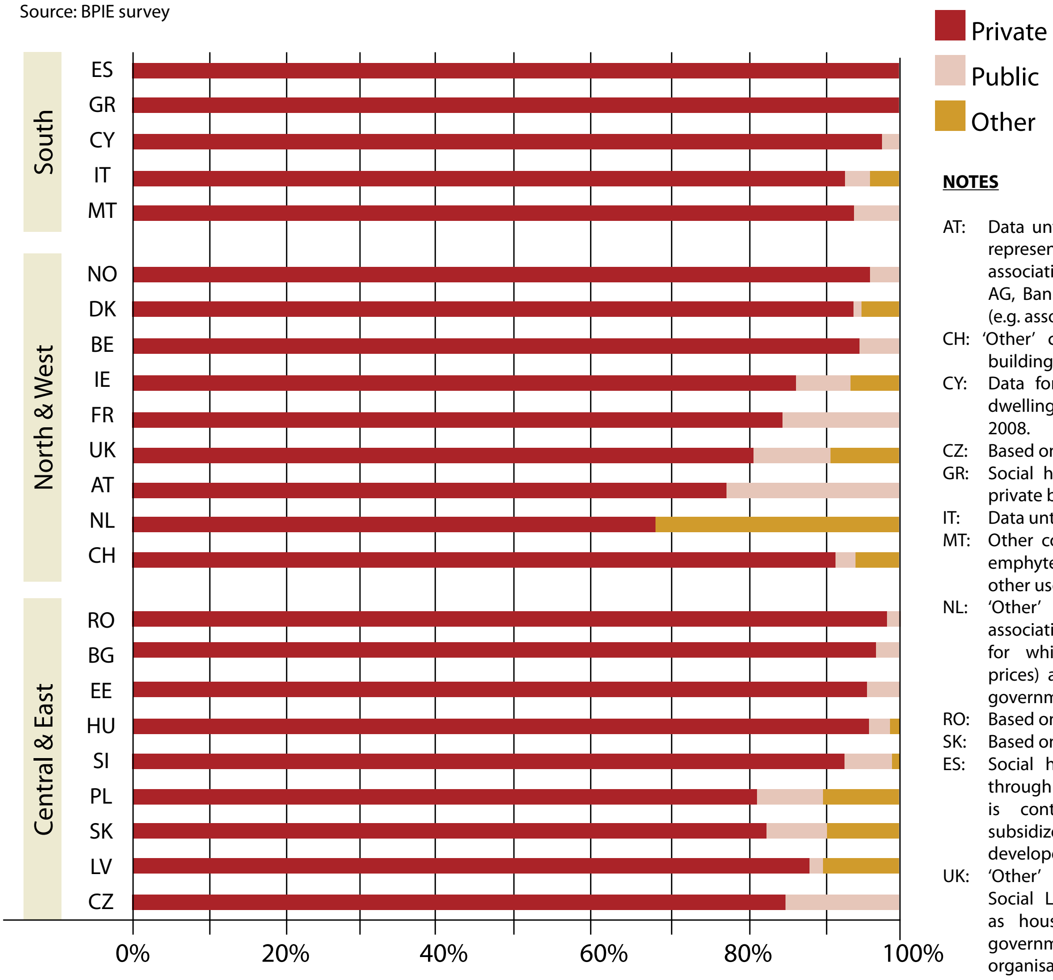
The ownership of buildings have a bearing on the rate at which renovations are undertaken and the depth of the energy savings measures that may be included in renovation projects. Arguably, the public sector should be taking the lead in 'deep renovations' and its large portfolio of buildings provides many opportunities for economies of scale. Private owners may be reluctant to act early and may require encouragement, incentives and regulations to stimulate reasonable rates and depths of renovation.

Data was sought on the division of ownership in residential and non-residential buildings between the public and the private sector of the EU27 together with Switzerland and Norway. Analysis of the data provided on the split between public and private ownership of residential buildings revealed that across the 23 countries from which data was available the largest share is held in private ownership while 20% is allocated to 'pure' public ownership.

Figure 1B2 shows the country-by-country variations where only Austria reports more than 20% of residential dwellings held in public ownership. It should be noted that in many countries, social housing is fully owned by public bodies but there is an increasing trend toward private involvement. This trend is for instance found in Ireland, England, Austria, France, Denmark and The Netherlands where, in the case of The Netherlands, the social housing is fully owned by private bodies (housing association)[12].

Figure 1B2 – Ownership of residential buildings in Europe by number of dwellings (except France which is in m²).

Source: BPIE survey



NOTES

AT: Data until 2001. Mixed ownership is represented by non-profit building associations, other companies (e.g. AG, Bank, GmbH) and other owners (e.g. associations).

CH: 'Other' consists of members of a building cooperative and others

CY: Data for public and private sector dwellings constructed between 1998-2008.

CZ: Based on estimations.

GR: Social housing units are owned by private bodies

IT: Data until 2001

MT: Other consists of dwellings held by emphyteusis (notarial contract) and other used free of charge

NL: 'Other' consists of social housing associations owned by private bodies for which conditions (e.g. rental prices) are heavily regulated by the government.

RO: Based on 2006 estimations

SK: Based on 2001 data

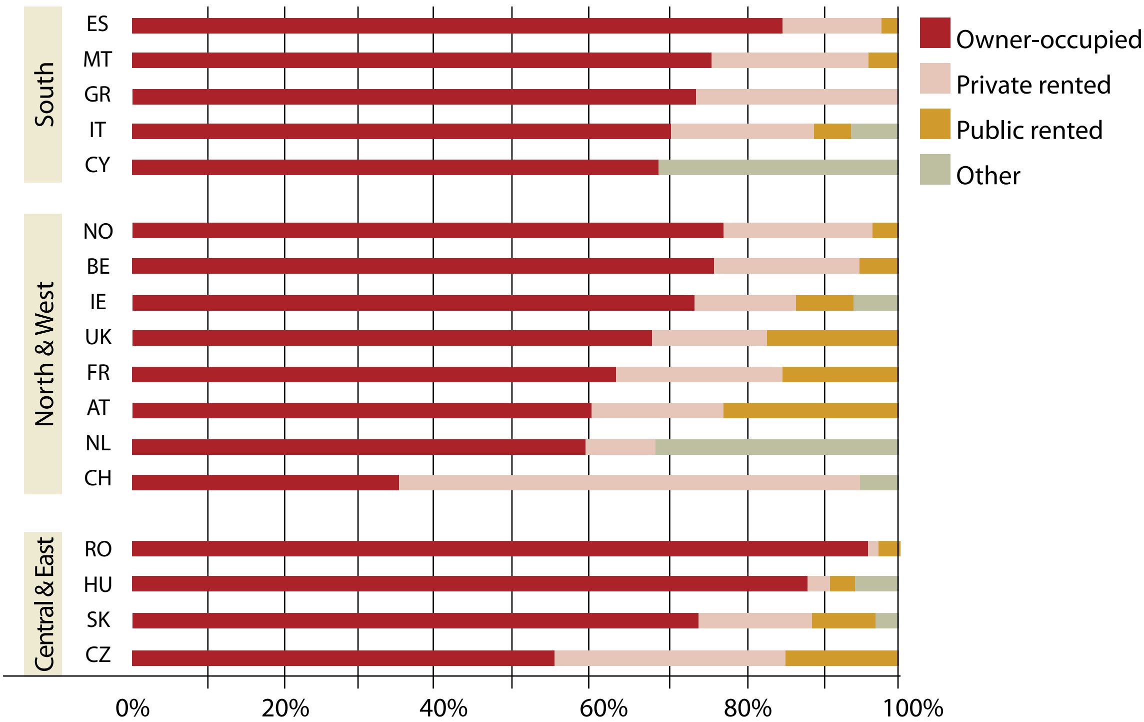
ES: Social housing is mainly delivered through the private sector and is controlled through subsidies, subsidized loans and grants for both developers and buyers

UK: 'Other' consists of Registered Social Landlords (often referred to as housing associations) that are government-funded not-for-profit organisations that provide affordable housing.

[12] Social Housing in Europe, Christine Whitehead and Kathleen Scanlon, LSE London, London School of Economics and Political Science

Figure 1B3 – Tenure of residential buildings by number of dwellings in Europe (except for France which is in m²)

Source: BPIE survey



NOTES

AT: Data up to 2001.
CH: 'Other' consists of members of a building cooperative and others
CY: Data up to 2001. 'Other' consists of 13,9% of rented (mixed ownership) and 17,9 of other arrangements
CZ: Based on estimations.
HU: Data up to 2005. 'Other' includes public and private empty dwellings and other
IT: Data up to 2001
MT: Other consists of dwellings held by emphyteusis (notarial contract) and other used free of charge
NL: 'Other' consists of social housing associations owned by private bodies for which conditions (e.g. rental prices) are heavily regulated by the government.
RO: Data up to 2002
SK: Based on 2001 data
ES: Social housing is mainly delivered through the private sector and is controlled through subsidies, subsidized loans and grants for both developers and buyers
UK: 'Other' consists of Registered Social Landlords (often referred to as housing associations) which are government-funded not-for-profit organisations that provide affordable housing.

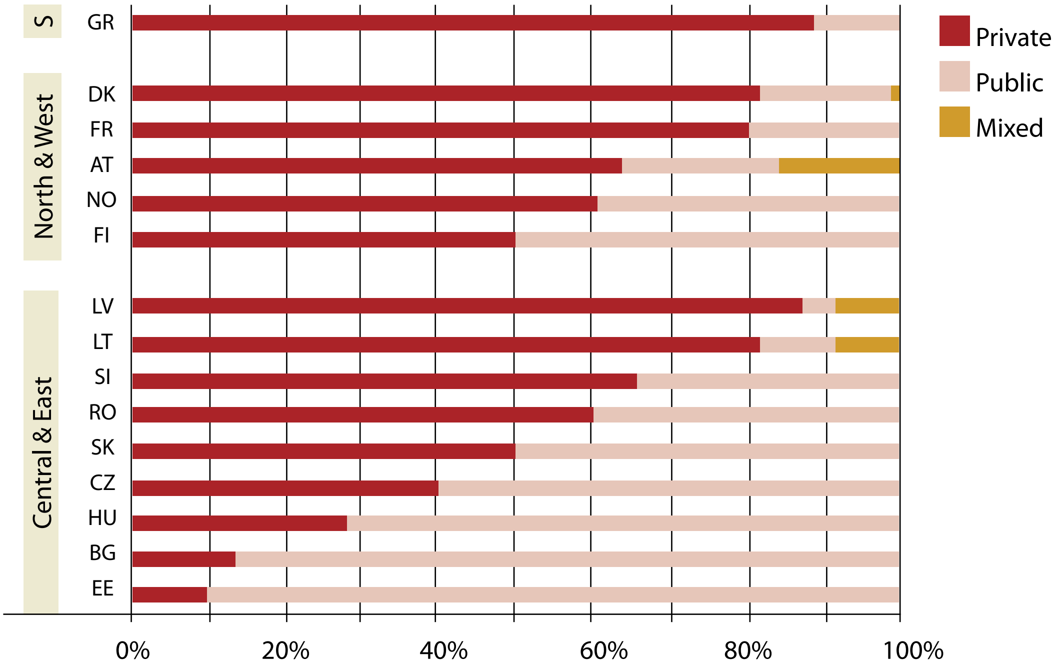
Another key factor which undoubtedly influences the willingness and ability to take action on renovation measures to improve energy performance in the residential building stock is the question of tenure. Data was available from 17 countries on the division between owner occupied properties and those rented from private landlords, public landlords or a mixture of the two.

Figure 1B3 shows that at least 50% of residential buildings are occupied by the owner in all countries. Among the countries with the biggest share of private tenants were Greece and Czech Republic while countries with significant portions of public rented dwellings (in most cases these are occupied by social tenants) are Austria, the UK, Czech Republic, The Netherlands and France. It should be noted that the division between private landlords and public landlords was not always clear and several countries reported the rented portion of the stock as having 'mixed landlords'.

Data availability on the ownership of non-residential buildings was more limited and only in detail from 15 countries. These are presented in Figure 1B4, which shows the average ownership of non-residential buildings across these countries. It is clear that the ownership profile in the non-residential sector is more heterogeneous than that in the residential buildings, where private ownership can span from as low as 10% to nearly 90% depending on the country. The extent of public ownership of non-residential buildings suggests that this would be a good target for public policy to begin large-scale renovation to deliver significant reductions in energy use but the impact would be higher in some countries.

Figure 1B4 – Ownership of non-residential buildings by number of buildings except FR, SK, SI which are in m² and FI which is in m³

Source: BPIE survey



NOTES

BG: Based on audited and/or certified buildings of floor area above 1000m² (by the Energy Efficiency Agency experts)

CZ: Based on estimations.

EE: Buildings included: culture, sports, education, healthcare building. Buildings excluded: Offices (which are estimated to be 50% private and 50%public).

GR: Note that a share of private buildings is used by the public sector which is either purchased or rented under special conditions.

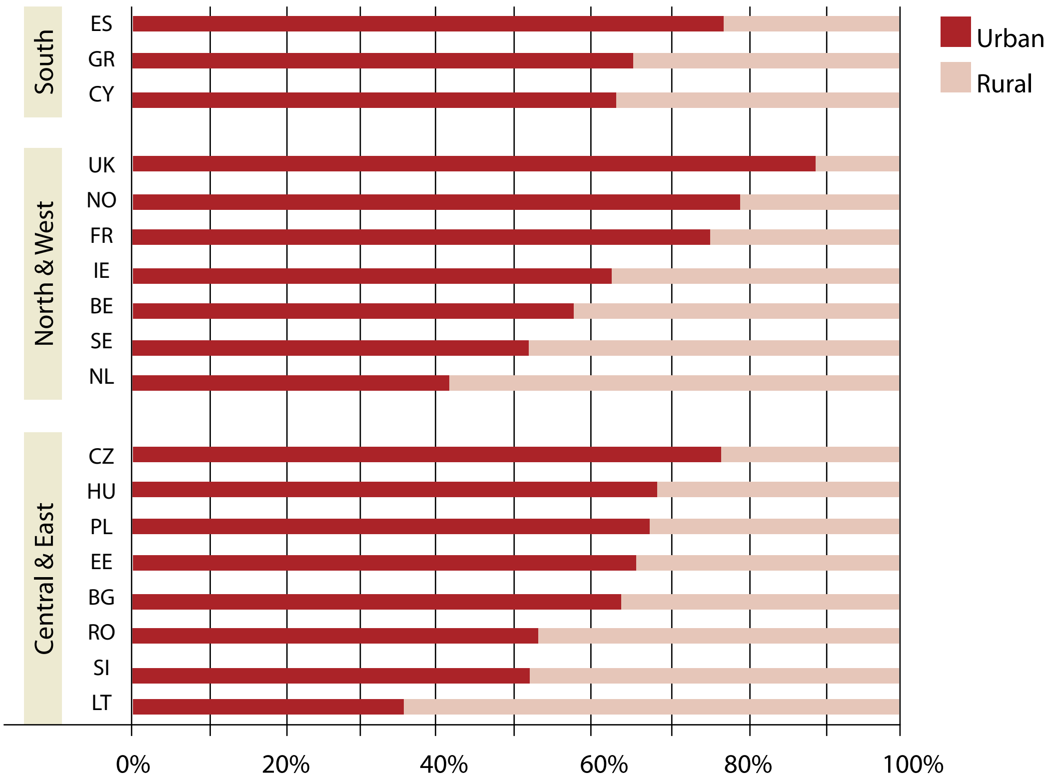
LOCATION

The location of buildings is of interest as typically the willingness and ability to take up renovation measures to improve energy performance can be affected by a number of factors including the location of a building. In the urban environment, economies of scale will come into play with large-scale renovation programmes able to act on streets, districts and localities. In rural environments, projects may be more widespread and hence benefit from economies of scale to a lesser extent while labour rates are often lower in these areas.

Data on the location of residential buildings was made available from 18 countries. Figure 1B.5 shows that countries having the majority of residential buildings in rural locations include Lithuania, The Netherlands, Sweden, Romania and Slovenia while countries having the highest level of urban residences include the UK, Norway, Spain, France and Czech Republic. These findings should be considered in conjunction with the relevant occupancy patterns for rural and urban areas as rural areas are typically less populated meaning that the permanent occupancy rate in these areas is lower. At the EU level, 49% of population lives in densely populated areas (at least 500 inhabitants/km^2), 26% in intermediate (100-499 inhabitants/km^2) and the rest in thinly populated areas (less than 100 inhabitants/km^2)[13] where the countries with the largest shares of thinly populated areas are Sweden, Romania and Lithuania.

Figure 1B5 – Location of residential buildings (urban vs rural) by number of dwellings

Source: BPIE survey



NOTES

CY: Data concerns only built dwellings between 1980 and 2009

FR: Urban units are in territories of a minimum of 2000 inhabitants where the distance between buildings does not exceed 200 m.

LV: Data regards all buildings (residential and non-residential)

NO: Urban units are in territories of a minimum 200 persons (60 - 70 dwellings), where the distance between buildings normally does not exceed 50 metres.

NL: Urban units are located in territories with uninterrupted built-up area typified by the number of residents (more than 100 000), the number of jobs (more than 50 000) and the number of potential customers (more than 150 000)

SE: Data provided covers only existing buildings in 1990.

[13] Based on Eurostat

C. ENERGY PERFORMANCE

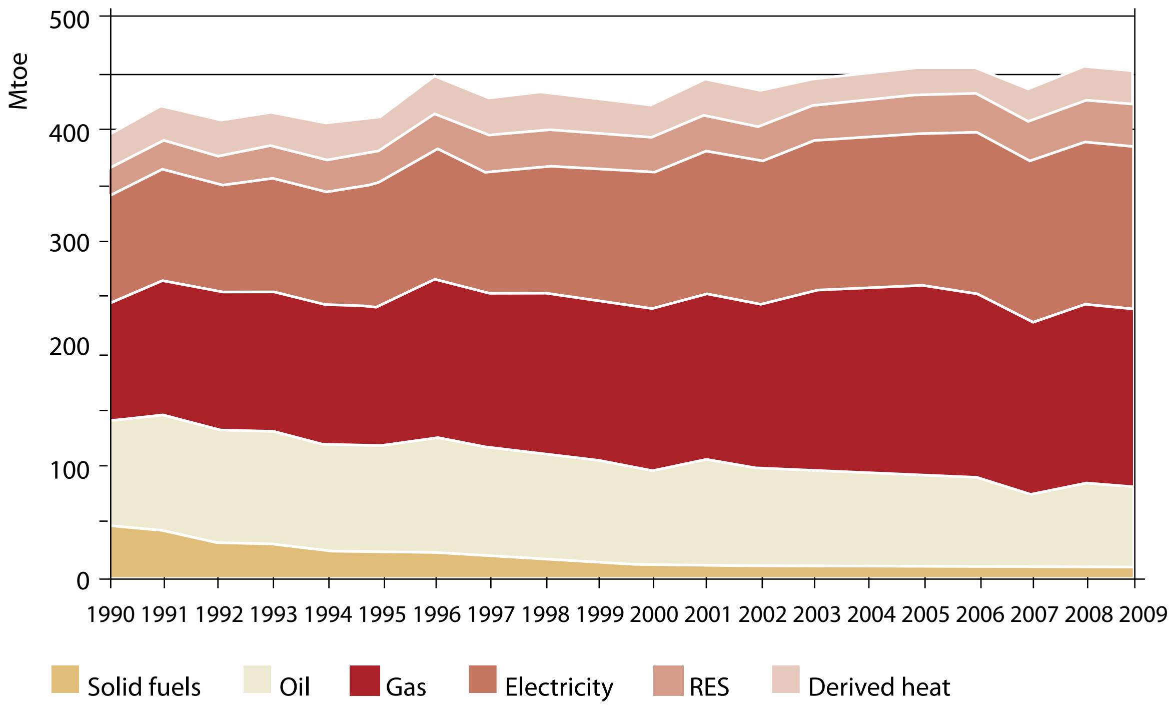
It is widely recognised that the building sector is one of the key consumers of energy in Europe.

Understanding energy consumption in buildings requires an insight into the energy levels consumed over the years and the mix of fuels used. Figure 1C1 shows the historical final energy consumption in buildings in EU27, Norway and Switzerland since the 1990s. The consumption is made up of two main trends: a 50% increase in electricity and gas use and a decrease in use of oil and solid fuels by 27% and 75%, respectively.

Overall, the energy use in buildings is a rising trend with an increase from around 400 Mtoe to 450 Mtoe over the last 20 years. This is likely to continue if insufficient action is taken to improve the performance of buildings.

Figure 1C1– Historical final energy consumption in the building sector since 1990s for the EU27, Switzerland and Norway

Source: Eurostat database



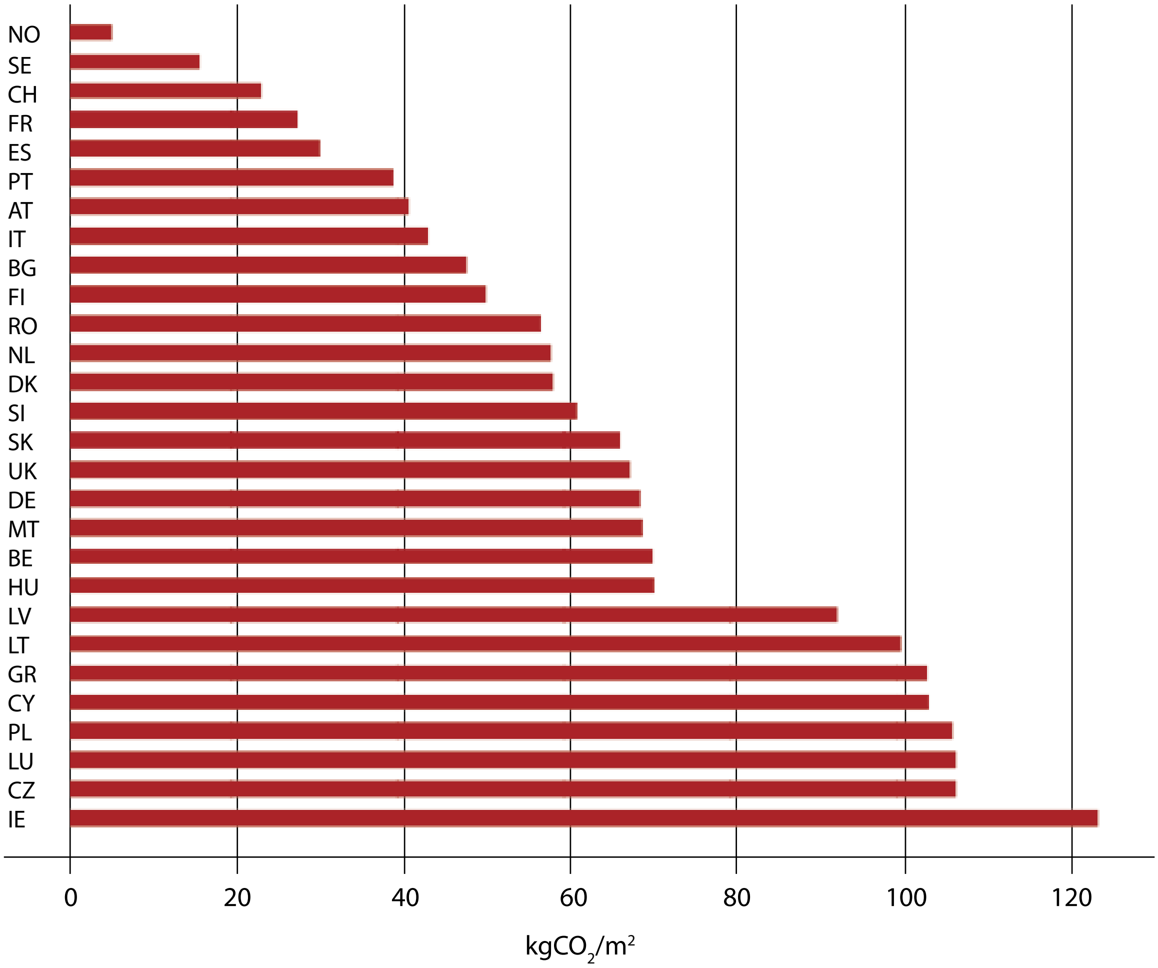
In terms of CO_2 emissions, buildings are responsible for around 36% in Europe[14]. The average specific CO_2 emission[15] in Europe is 54 kgCO_2/m^2 where the national values of kgCO_2 per floor space vary in the range from 5-120 kgCO_2/m^2 as shown in Figure 1C2. The building performance is a key component in this. In addition, CO_2 emissions are linked to the particular energy mix used in buildings in a given country. For example, the extent to which renewable energy is employed in the buildings, the use of district heating and co-generation, the sources of electricity production in each country affect the CO_2 emissions related to buildings. Variations in the energy supply mix highly influence the CO_2 performance of buildings where, for instance, Norway and France are among the lowest in Europe as shown in Figure 1C2 due to their dependence on hydroelectricity and nuclear energy, respectively.

[14] Based on information published on the European Commission's website on energy efficiency in buildings http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

[15] The CO_2 emissions have been calculated using CO_2 emission factors for different energy products published by the Carbon Trust UK and CO_2 emission factors for electricity production published by the International Energy Agency.

Figure 1C2 – CO_2 emission per useful floor area

Source: BPIE survey, Eurostat database



RESIDENTIAL BUILDINGS

Residential buildings comprise the biggest segment of the EU's building stock and are responsible for the majority of the sector's energy consumption.

In 2009, European households were responsible for 68% of the total final energy use in buildings[16]. Energy in households is mainly consumed by heating, cooling, hot water, cooking and appliances where the dominant energy end-use in homes is space heating. The final consumption of these end-uses is shown in Figure 1C3 divided between all fuels and electricity. The strong correlation between heating degree-days and fuel consumption emphasises the link between climatic conditions and use for heating as the year-to-year fluctuations in heating consumption largely depend on the climate of a particular year. The significant increase in use of appliances in households is also evident through the steady increase in electricity consumption (38% over the last 20 years), as shown in Figure 1C3.

[16] Data extracted from Eurostat: http://epp.eurostat.ec.europa.eu

Figure 1C3 – Historical final energy use in the residential sector in EU27, Norway and Switzerland

Source: Eurostat database

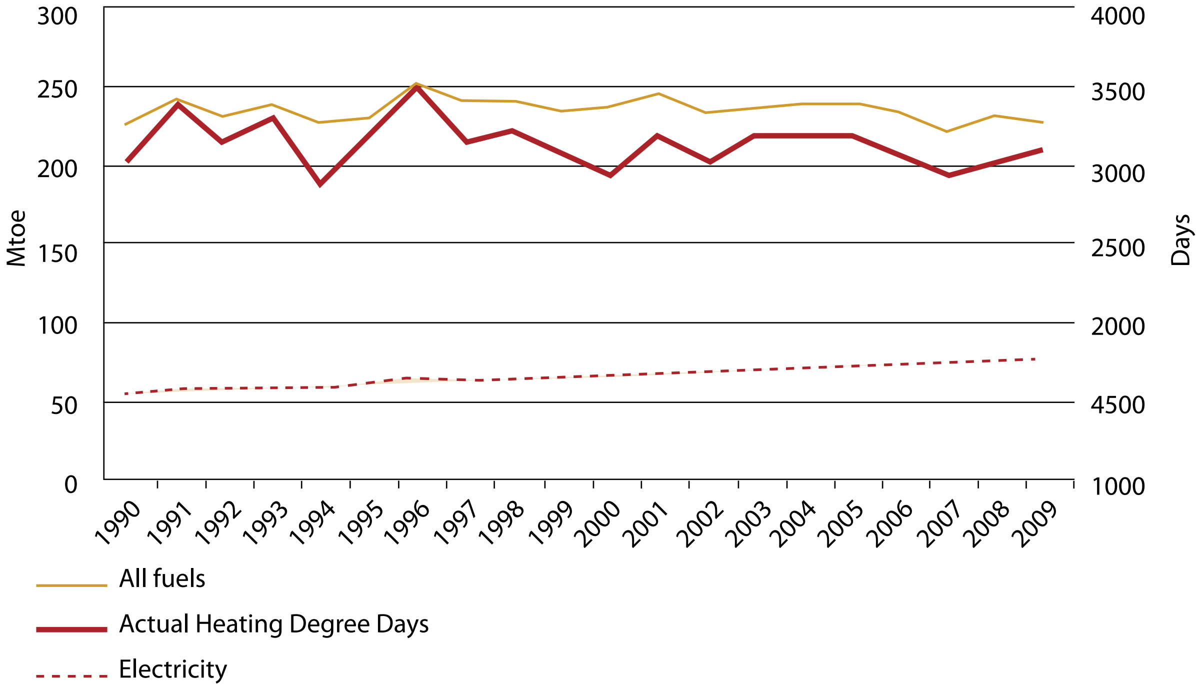


Figure 1C4 shows the energy product per region in 2009 and by end-use in the three regions. Gas is the most common fuel in all regions which stands at 41%, 39% and 26% in North & West, South and Central & East regions, respectively. The highest use of coal in the residential sector is found in Central & Eastern Europe where the largest share is used in Poland. Oil use is highest in North & West Europe where Germany and France are the biggest consumers (inevitably due to the size of these countries). District heating is most common in Central & Eastern Europe and least in Southern countries while renewable energy sources (solar heat, biomass, geothermal, wastes) have a share of 21%, 12% and 9% in the total final consumption of Central & Eastern, South and North & West regions, respectively.

Space heating is the most energy intense end-use in EU homes and accounts for around 70% of our total final energy use. The percentage use for heating in Spain, Poland and France (a representative country per region), is indicated in Figure 1C6. This share is typically less in warmer climates (e.g. Spanish homes consumed 55% of the total final energy consumption in 2009 – see figure 1C6) and also fluctuates from year to year as indicated by figure 1C6. These examples shown in figure 1C6 signify the vast differences from country to country in terms of the corresponding energy mix.

The energy mix for heating consumption is an indicator for the overall performance of a building and the breakdown of the heating energy for the examples given in Figure 1C6 reflect this (e.g. Poland depends on 41% coal use for covering the residential building stock's heating needs, a fact which is also reflected by the high $kgCO_2/m^2$ value corresponding to Poland in Figure 1C3).

Figure 1C4 – Final energy mix in residential buildings (thousand toe) by region

Source: Eurostat database

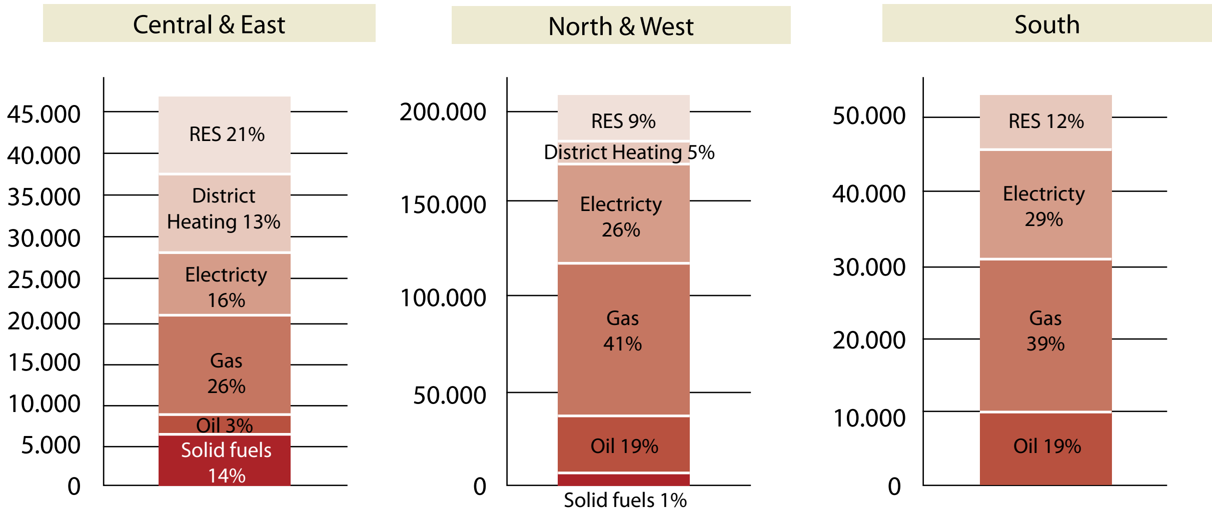
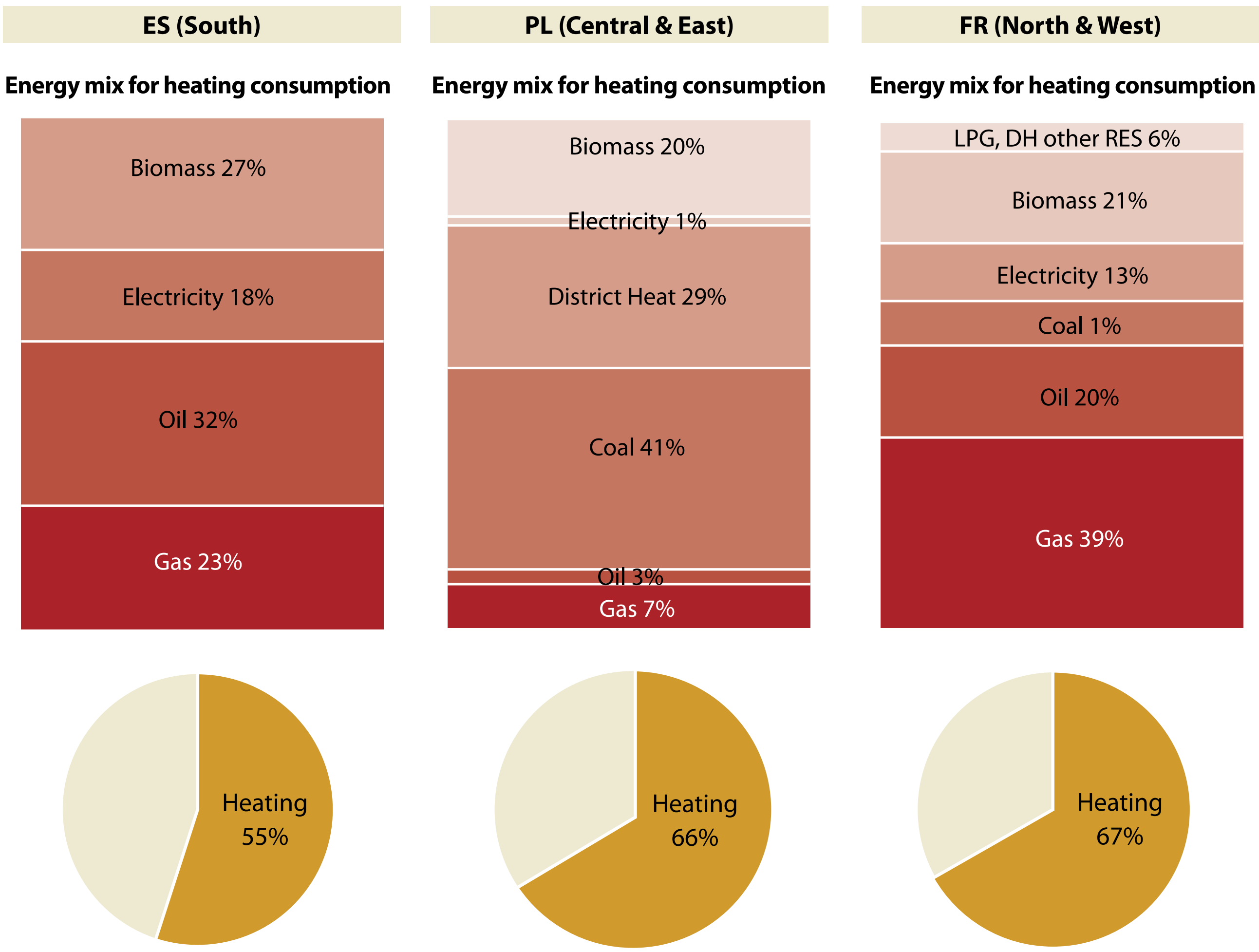


Figure 1C5 – Share of heating consumption in terms of final energy use in residential buildings with corresponding energy mix

Source: BPIE Survey

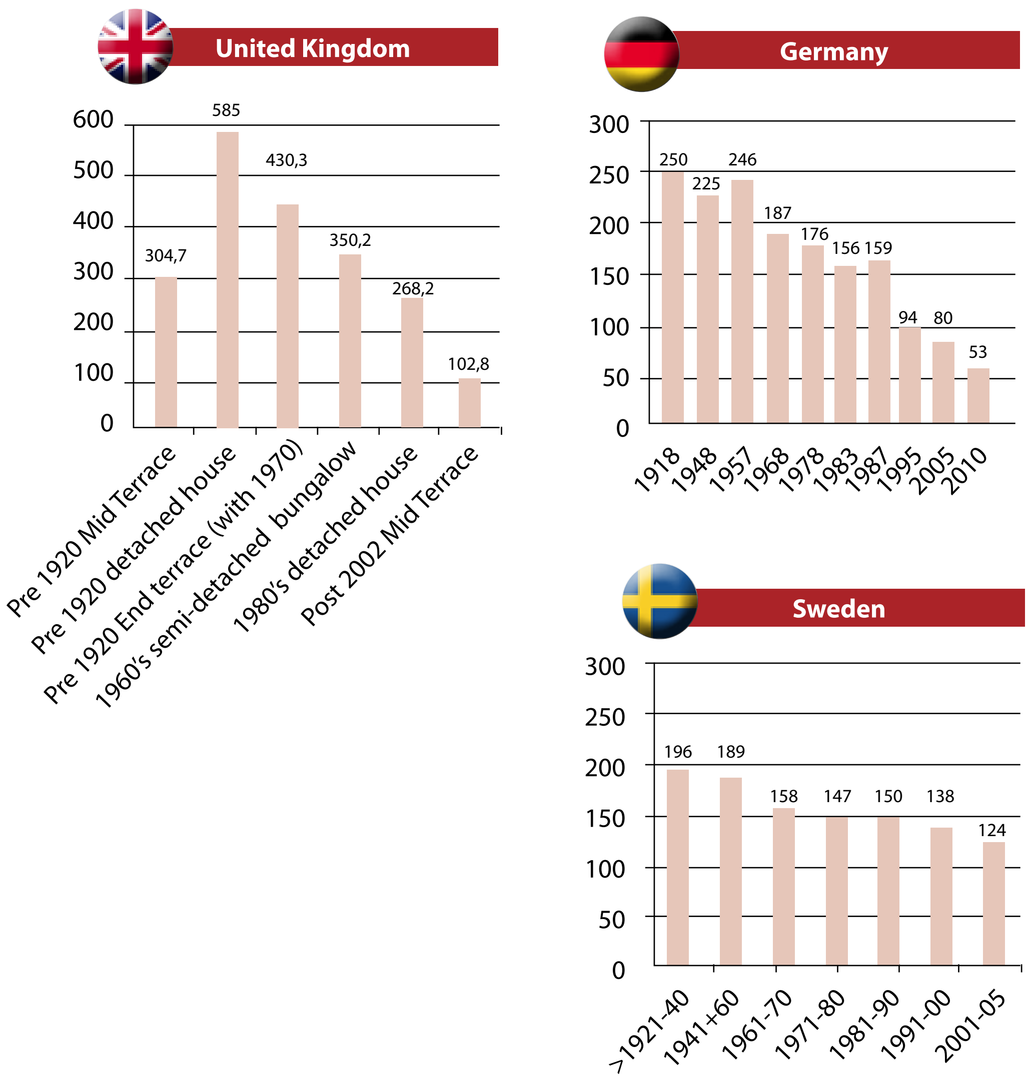


The performance of households depends on a number of factors such as the performance of the installed heating system and building envelope, climatic conditions, behavioural characteristics (e.g. typical indoor temperatures) and social conditions (e.g. fuel poverty meaning that not all buildings are used at maximum capacity). Despite different improvements in, for instance, heating systems, there is still a large saving potential associated with residential buildings that has not been exploited. These technologies are easily implemented in new buildings, but the challenge is mostly linked to our existing stock which forms the vast majority of our buildings.

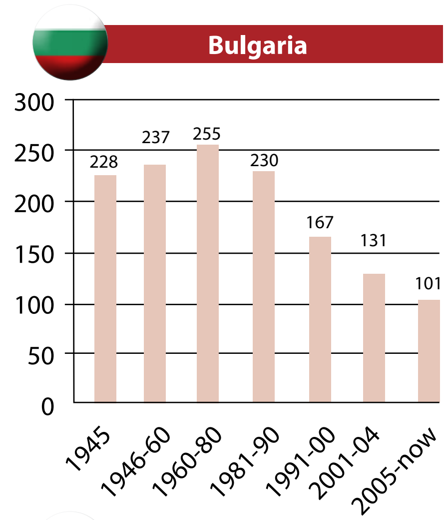
Figure 1C6 – Average heating consumption levels in terms of final energy use (kwh/(m²a) of single family homes by construction year

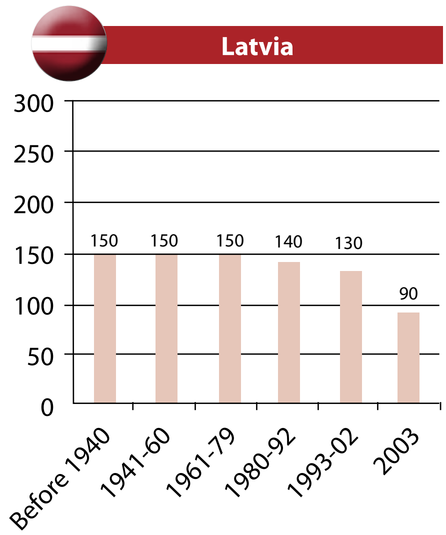
Source: BPIE survey

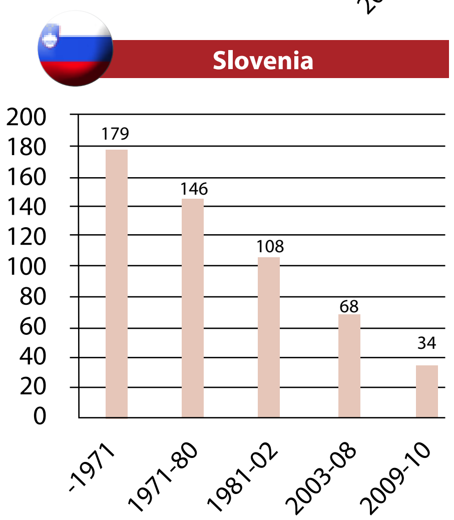
North & West



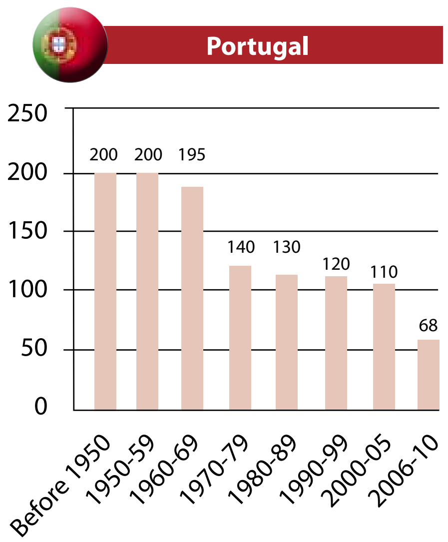
Central & East

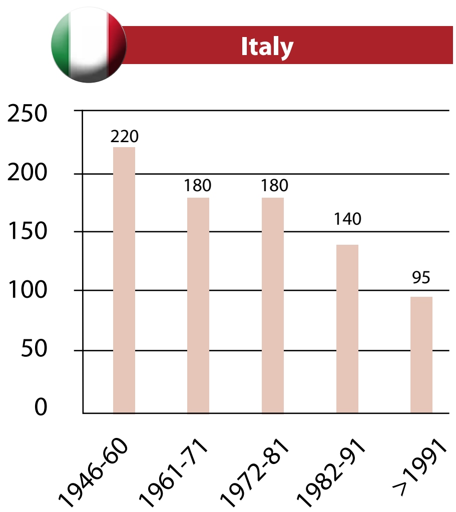






South





Within the existing European stock, a large share (more than 40%[17]) is built before 1960s where there were only few or no requirements for energy efficiency and only a small part of these have undergone major energy retrofits, meaning that, these have low insulation levels and their systems are old and inefficient.

The oldest part of the building stock contributes greatly to the high energy consumption in the building sector. Older buildings tend to consume more due to their low performance levels.

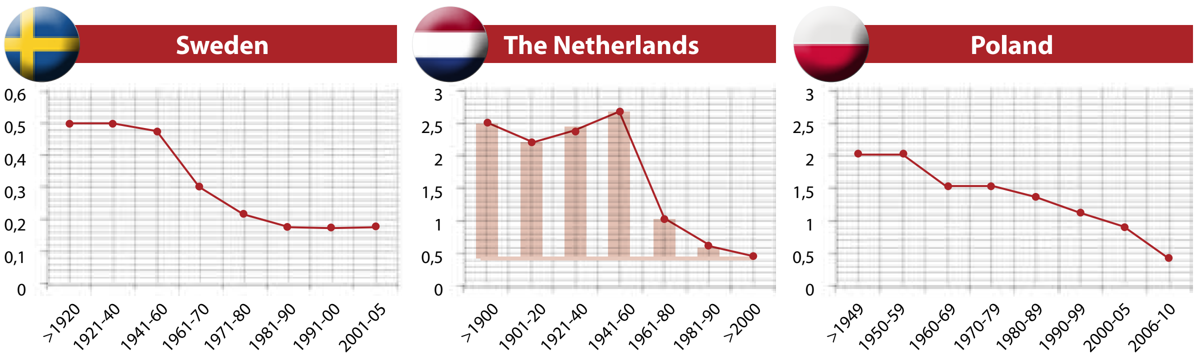
This is clearly demonstrated in Figure 1C6, which shows data on typical heating consumption levels of the existing stock by age for several countries collected through the BPIE survey. Cross-country comparisons of the performance are difficult to make due to the multiple factors affecting heating consumption as explained above.

It is however clear that the largest energy saving potential is associated with the older building stock. This is a trend observed in all countries where in some cases buildings from the 1960s are worse than buildings constructed in the years before that (c.f. Bulgaria and Germany). It is interesting to note the large consumption levels for heating in the UK, indicating the very poor performance of UK buildings.

Moreover, although heating needs in Southern countries such as Portugal and Italy are lower due to milder winters, the energy use in these countries is relatively high, which can be an indication of lack of sufficient thermal envelope insulation in their building stocks. For those countries, cooling becomes an important contributor to the overall consumption, where homes are, in many cases, equipped with air-conditioning systems.

Figure 1C7 – U values (W/(m²K) for external walls in different countries for different construction periods.

Sources: SE- Mundoca & Neij (2011), NL: Kwalitatieve Woningregistratie (2006), PT: ADENE, BPIE survey



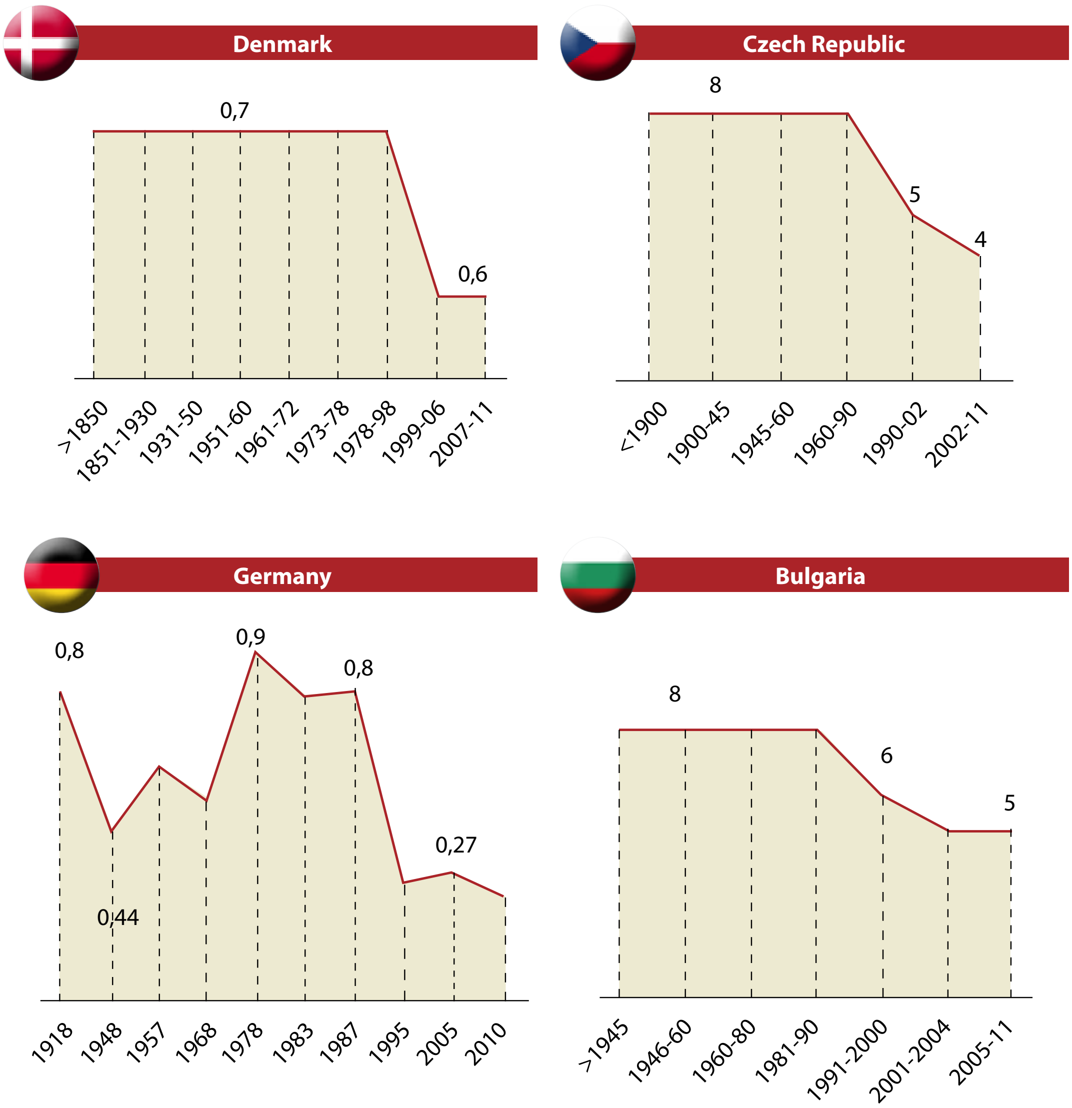
Sufficient thermal insulation of the building envelope is in fact essential for shielding the interior of the building from the exterior environment and minimising thermal transfer (heat losses or gains) through the envelope during the winter and summer periods. Figure 1C7 compares typical U values of exterior walls in a number of countries for different construction periods and compares these with the respective requirements for today's new build. The lack of proper insulation in older buildings is clear in all countries due to the lack of insulation standards in those construction years.

[17] This is a figure deduced from our analysis – see section 1B for further details.

The effect of the EPBD implementation can also be demonstrated especially in countries with no previous embedded regulations for insulation such as Portugal where a 50% reduction in the U values has been applied over the past five years. This is in contrast to Northern and Western countries where long traditions of thermal insulation requirements existed prior to the EPBD with stringent requirements being implemented around the 1970s after the oil crisis (c.f. sharp decrease in 1960-1970s in The Netherlands). In Sweden, national requirements concerning energy performance of buildings were in place as early as 1948.

Figure 1C8 - Air tightness levels (n50 measured in h^{-1}) of single family houses built over last century

Sources: DK- SBi, CZ –SEVEn, DE- IWU, BG-BSERC



In addition to the lack of sufficient thermal insulation, gaps at connection points between different elements of a building envelope (e.g. window frame and surrounding wall) can lead to considerable energy wastage. This highlights the importance of appropriate air tightness levels in a building. A building with high air tightness levels (that is, high air leakage levels and high n_{50} values[18]) typically suffers from high energy consumption levels while a building with very high air tightness levels can cause unhealthy conditions for its occupants, especially if there is inadequate ventilation. The latter is typically linked to poor indoor air quality and the so-called sick building syndrome. Establishing the appropriate level of air tightness in buildings is, therefore, a key aspect from the viewpoints of energy usage and comfortable occupant conditions. Poor detailing in past construction techniques means that older buildings encounter high leakage levels.

This is illustrated by Figure 1C8 which shows typical values of air tightness levels (measured at 50 Pa in h^{-1}) of single family houses for a number of countries across Europe. It is evident that in countries with long traditions in energy regulations (such as Germany and Denmark), the older stock demonstrates far lower air leakage levels compared to the old stock in Central & Eastern regions (such as Czech Republic, Latvia and Bulgaria). However, even with today's levels of air tightness levels, studies have shown that envelope leakage can increase the heating needs by 5 to 20 kWh/m^2/a in a moderate climate (2500 to 3000 degree-days)[19].

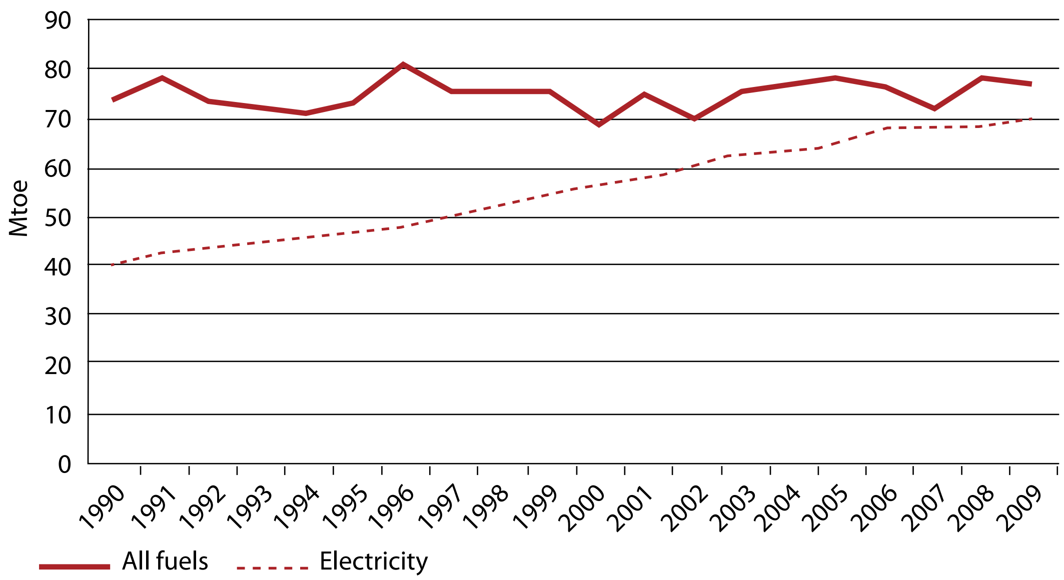
NON-RESIDENTIAL BUILDINGS

Understanding energy use in the non-residential sector is complex as end-uses such as lighting, ventilation, heating, cooling, refrigeration, IT equipment and appliances vary greatly from one building category to another within this sector.

Over the last 20 years in Europe electricity consumption in European non-residential buildings has increased by a remarkable 74%, as depicted in Figure 1C9. This is compatible with technological advances over the decades where an increasing penetration of IT equipment, air conditioning systems etc. means that electricity demand within this sector is on a continuously increasing trajectory.
(c.f. absolute difference in electricity use between 1990-2009).

Figure 1C9 – Historical final energy use in the non-residential sector in the EU27, Norway and Switzerland

Source: Eurostat database



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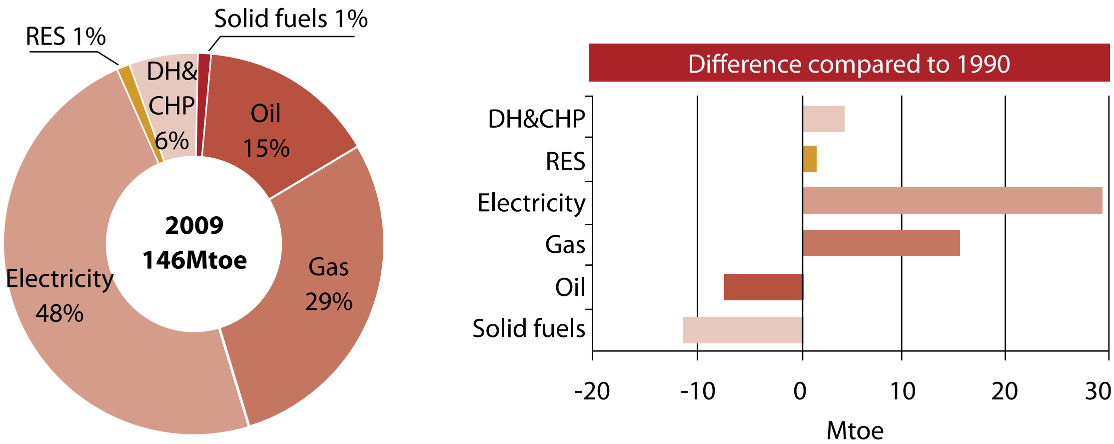
[18] n_{50} represents the total air change rate in a building caused by pressure difference of 50 Pa
[19] As quoted in the ASIEPI project (www.asiepi.eu)

Figure 1C10 – Energy mix in the non-residential sector in the EU 27 together with Switzerland and Norway and corresponding difference compared to 1990 profile

(DH denotes district heating and CHP denotes Combined Heat and Power)

Source: Eurostat database

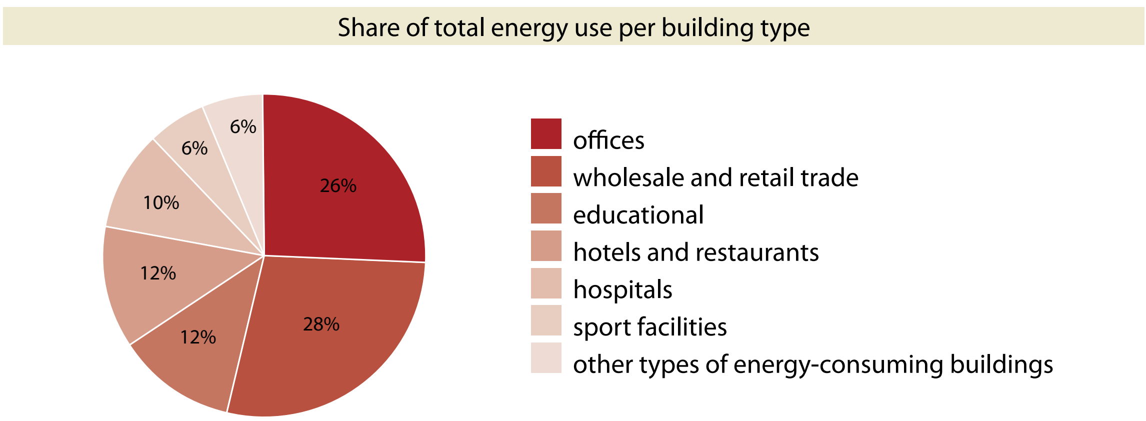


Based on our data, it is estimated that the average specific energy consumption in the non-residential sector is 280kWh/m² (covering all end-uses). This is at least 40% larger than the equivalent value for the residential sector. Within the non-residential sector, variations are expected from country to country and also from one building type to another.

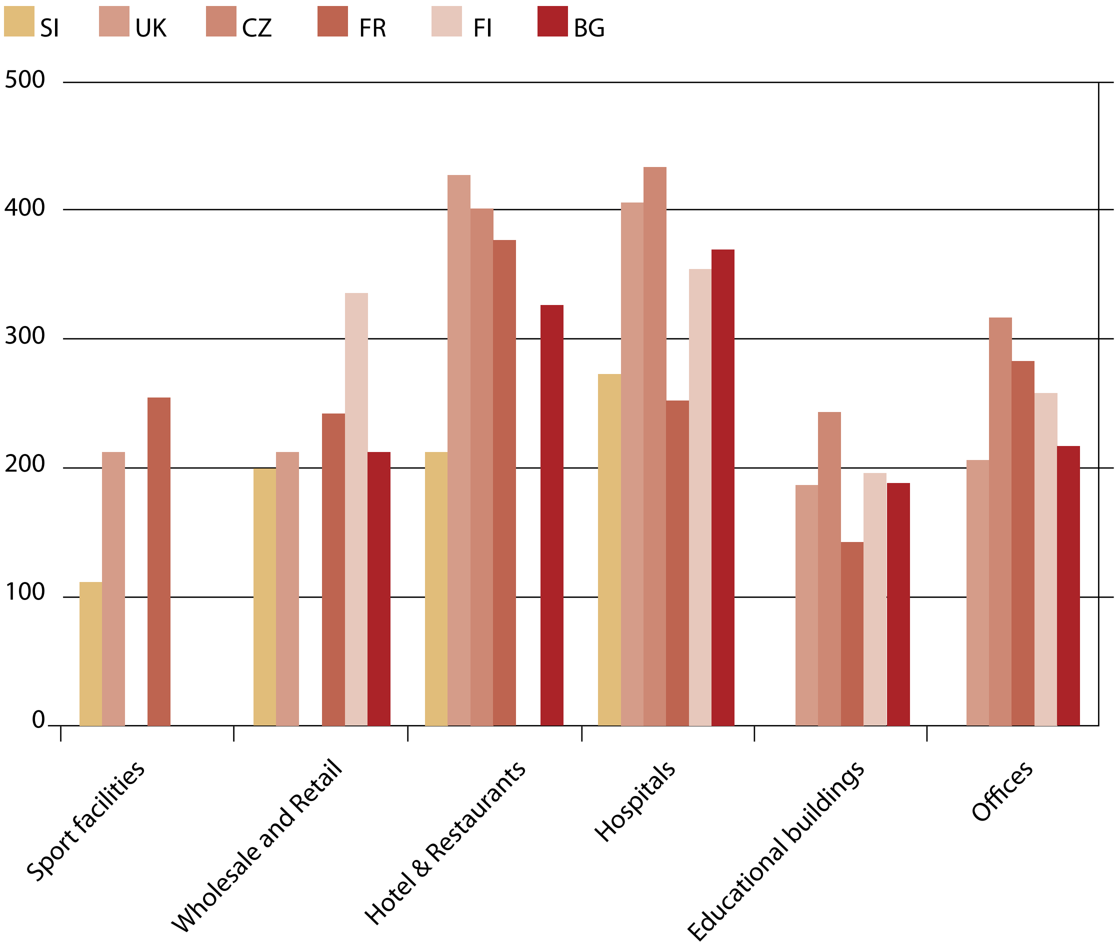
These variations are clearly illustrated in Figure 1C11, where the specific energy use in offices, educational buildings, hospitals, hotel & restaurants and sports facilities are presented for a number of countries. While hospitals are, on average, at the top of the scale with continuous occupancy and high-energy intensity levels, their overall non-residential consumption is small. This is also the case with hotels & restaurants, which are equally energy intensive. While these two categories represent the highest energy intensive type in specific terms, offices, wholesale & retail trade buildings, on the other hand, represent more than 50% of energy use. Education and sports facilities account for a further 18% of the energy use while other buildings account for some 6%.

Figure 1C11–Final energy use in non-residential building types for different countries across Europe

Source: BPIE survey



Specific energy use (kWh/m²a) in non-residential buildings



Construction techniques of non-residential buildings are in large similar to those in residential buildings as the majority of data collected have illustrated similar performance characteristics (e.g. U values, air tightness levels) between the two types built during the same period.

While the energy performance discussion for the residential buildings above applies also to the non-residential sector (hence similar renovation measures should be considered), the installation of smart energy management systems in non-residential buildings becomes more important due to their high share of electricity use. For example, the deployment of efficient lighting control systems has substantial potential in the non-residential sector as electricity consumption for office lighting, which has been estimated to be 164 TWh in 2007 in the EU27[20], is among the highest end-use in this sector. The replacement of incandescent lamps with CFLs in office and street lighting as a stand-alone measure has been reported to have an annual savings potential of 38 TWh by 2020, which in turn illustrates the high savings potential in lighting end-use.

[20] Characterization of Residential Lighting Consumption in the Enlarged European Union and Policies to Save Energy, Paolo Bertoldi & Bogdan Atanasiu, DG Joint Research Centre, Institute for Environment and Sustainability, 2008

PART 2

POLICIES AND PROGRAMMES FOR IMPROVING ENERGY EFFICIENCY IN BUILDINGS

"EU legislation has set out an ambitious legal framework for greening European buildings.
The challenge will be for Member States to make this happen with the necessary drive, through efficient building policies, codes and attractive programmes addressing the many barriers existing today."

A. BARRIERS & CHALLENGES

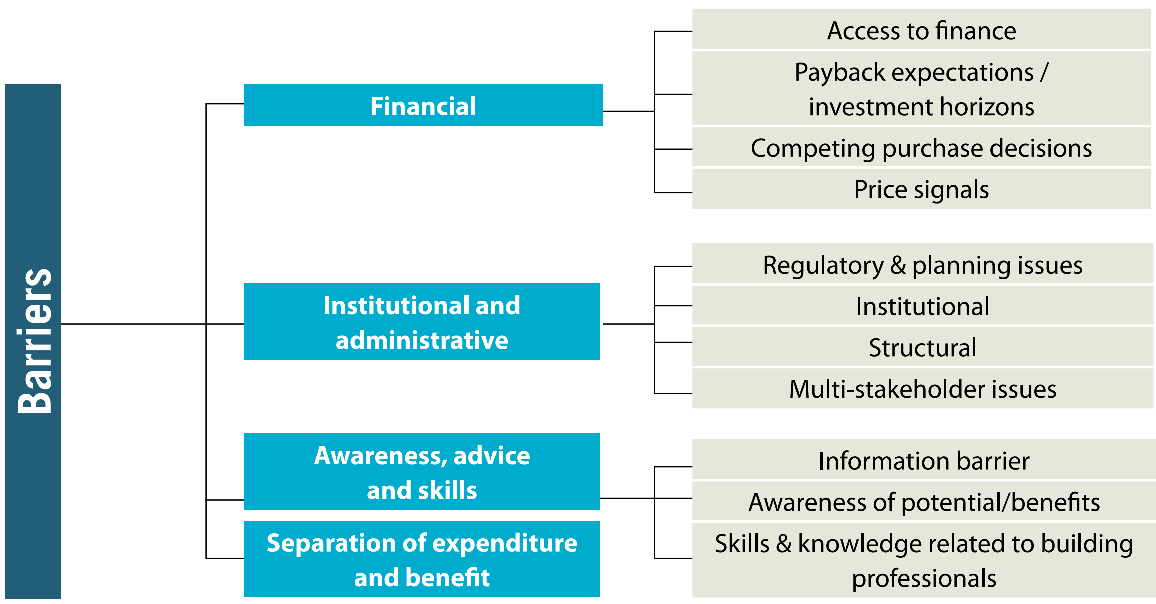
Improving the energy performance of buildings is determined by the decisions of a large number of people. There are literally millions of building owners and also very large numbers of decision makers – managers, developers – who decide what happens in all buildings, but particularly in multi-family, commercial and public buildings. What is important for policy making is to better understand the factors that affect those decisions in order to design and implement policies that will more effectively promote energy efficiency investments and actions. The BPIE survey included the collection of information on specific barriers within the individual countries, reflecting the priorities and differing circumstances affecting implementation and improvements

BARRIERS

Experience over several decades has identified numerous barriers that hinder the uptake of renovation measures. In simple economic terms, the fact that there is a large untapped cost-effective potential for improving the energy performance of buildings is evidence that consumers and investors, as well as society in general, are not keen on investing in energy saving. Market dynamics, however, do not always follow a straight path and there are a multitude of reasons why consumers or building owners make specific decisions. There is a need for a better understanding of why consumers act the way they do, often defying the logic of conventional economic theory. This human dimension combined with a variety of other factors that affect decisions need to be understood and addressed if an ambitious retrofit strategy is to be successful. It is a complex set of issues that impact all actors in the buildings chain.

The primary focus in this section are barriers affecting the renovation of existing stock, given that these represent the vast majority of buildings and the biggest potential in energy savings.

Figure 2A1 – Classification of barriers as identified by the BPIE survey



In this study, individual experts and several organisations throughout Europe reported barriers of particular relevance to their countries as part of the in-depth BPIE survey undertaken. This information gathering has been supplemented by literature developed over the past decades. Despite some excellent initiatives to improve the energy performance of Europe's building stock, it is clear that a multiplicity of barriers is severely limiting the achievement of the full potential.

A combination of barriers is responsible for this underperformance. There are many ways to classify barriers and over the years they have been described in many different ways. The BPIE survey identified the following four main categories of barriers that have a particular impact on existing buildings:[21]

I. Financial
II. Institutional and administrative
III. Awareness, advice and skills
IV. Separation of expenditure and benefit.

I. Financial Barriers

Financial barriers were one of the highest ranking barrier category in the majority of countries, with 21 giving it a high priority (amongst the top three). Undoubtedly, any investment in renovation requires money. This priority for financing barriers is consistent with the findings of a report and roundtable discussion that BPIE realised in 2010.[22] As shown in Part 3 of this study, ambitious renovations take considerable capital and this has implications for policy making. Understanding the underlying issues related to financing is fundamental for developing good policy solutions.

Lack of funds or access to finance
Lack of funds and/or inability to secure finance on acceptable terms is generally one of the most cited barriers to investing in energy efficiency measures. This applies at the level of the individual householder, businesses (large or small), social housing providers and the public sector, particularly in the aftermath of the credit crunch. In many cases it is more due to the lack of awareness or lack of interest rather than the lack of funds. Whilst the demand for a new kitchen or appliances from the consumer's perspective is high, there is no similar demand for energy efficiency. Even though they will in most cases be cost-effective over the long run (with a positive NPV), the initial investment costs can be high and this is seen as an obstacle to consumer investment decisions. The most ambitious retrofits will undoubtedly require considerable upfront funding. This upfront funding will have a positive impact on the asset value, especially for older buildings where energy efficiency retrofits not only improve significantly their energy consumption but also their aesthetics. Investing in energy efficiency now also offers some protection against increasing energy prices in the future. Some of the 'access to financing' issues have also been identified as administrative issues, as described below.

The current financial crisis is hitting all European countries, some more than others, while the lending markets have also been badly affected. Consumers and financial institutions are less willing to take risks. Compared to many alternative forms of investment, however, investing in energy efficiency measures has proven to be a prudent route.

Payback expectations/Investment horizons
Even though many energy savings measures are financially rational in that they have a positive Net Present Value (NPV) or a high Internal Rate of Return (IRR), the time taken for the initial outlay to be recouped is a major barrier. For most households, energy bills for the home account for 3-4% of disposable income, hence they are not a major concern. Householders will be mindful that they may move home in the next few

[21] There were also several specific barriers not falling into the main categories that were identified as well. Sometimes specific barriers also fit into more than one category.
[22] For more information, go to http://www.bpie.eu/financing_energy_efficiency.html

years, while many businesses will not consider non-core investments that do not pay for themselves within 3-5 years. Alternative financing mechanisms which try to ensure that the benefit from energy efficiency improvements are paid by those that benefit from them (e.g. recovering initial capital over 25 years through the energy bill) may have a role to play here. As noted by the answers received from Poland in the BPIE survey, there is insufficient common awareness about profitability of renovation in terms of life cycle costs.

Competing purchase decisions

Business will prioritise what are perceived as core investments in staff and equipment over energy costs, which (with the exception of energy intensive businesses) typically make up only a small fraction of business costs. For householders, investments in energy saving measures will struggle to compete with the latest electronic gadgets or a new kitchen or bathroom, which are not particularly cost-effective investments but yield a much higher perceived 'social benefit'. Some see this obstacle as an issue related to awareness; others deal with it separately as a financial issue. Moreover, many energy efficiency measures are not visible (unlike, say, photovoltaic systems) which makes them less 'attractive' as an investment option. The lack of attractiveness is sometimes reinforced by more generous subsidies which are more readily available for PVs compared to energy efficiency measures. Undoubtedly, consumers have a lot of choice and the case for reducing costs or improving other benefits (such as comfort) has to be seen in that context.

Price signals

Many of the financial barriers identified concern consumer price signals. If the financial incentive associated with investing in energy savings measures was sufficiently large, households, businesses and the public sector would have a higher propensity to undertake such investments. Put simply, energy costs often represent a small share of household expenditure resulting in lack of motivation for the vast majority of consumers to take meaningful action to reduce consumption levels.[23] Furthermore, energy-pricing structures do not reflect the full environmental costs of producing energy, in particular the costs associated with climate change, and hence there is a sub-optimal level of investment which was raised by the responses for Switzerland and the UK. One of the concerns reported for Hungary was the high degree of uncertainty about future prices, which seriously hampered consumer decisions.

II. Institutional and administrative barriers

There is a wide range of barriers related to institutional and administrative issues that can have an effect on the rate and ambition of renovation. This category was considered the third most important barrier category in the survey, although second in terms of the highest priority.

Regulatory & planning regimes

A variety of regulatory and planning obstacles have been identified. These range from various degrees and speeds at which EU Directives, including the EPBD, have been implemented by autonomous regions within a Member State, through to energy market barriers, such as the approvals process for building integrated renewable technologies. Evidence from Italy indicates that fragmentation, delay and gaps in the regulatory action of public planning have not allowed the public sector to be the driver for improved energy efficiency in buildings that it should be.[24]

Institutional

There is a bias among institutional investors more familiar with (and hence more comfortable with) supply- side investments and large-scale financing, rather than generally smaller (and "more risky") projects on the demand side. This was singled out by Hungary.

[23] This is definitely not the case for those in fuel poverty, where energy costs represent at least 10% of their household expenditures.
[24] BPIE database

With respect to the demand side, Latvia highlighted the complex estate administration of privatised apartment buildings. It noted that there was an unequal ability of owners to pay for renovations and some groups (e.g. pensioners) showed no interest in investment. Latvia also noted that the European standards for building energy efficiency have been adopted more slowly than planned and that those standards were not adapted to national needs. Because of the delays, no common software for building energy efficiency calculations for designers and engineers was available. Slovenia pointed out that scattered ownership in apartment buildings (with privatisation only taking place in the 1990s) raised many organisational barriers where there must be a 75% consensus in multi-owned buildings for undertaking technical improvements. This leads to complex protocols and the lack of consensus. There can also be institutional barriers in the public sector using energy service companies. This was raised by Slovenia but is a problem in several other countries.

Structural

Evidence from Belgium illustrates a dilemma that is probably found in several other Member States. The main barrier identified by our analysis of the Belgian responses is the age of the building stock because of a low demolition rate. As the average age of Belgium's building stock is forecast to increase further than that of European counterparts in the next 25 years, the relative energy efficiency of the building stock is also likely to decrease. The analysis goes on to state that the high upfront cost and the annual cap on most incentives have the consequence that the refurbishments are spread over a long time period, which is a barrier to improving energy efficiency. Because of the age of buildings, the landlord-tenant dilemma makes it difficult to ameliorate the existing building stock. Many of the new Member States from Eastern Europe have a legacy of poor quality "panel" buildings from the 1960s and 1970s that need serious upgrading.

Multi-stakeholder issues

Various barriers exist where there are multiple owners and/or occupiers of buildings. Ownership and responsibility can be opaque, while it can be very difficult to agree on energy saving investments in multi-family residential buildings if many different property owners have to either approve a decision or make a financial contribution.

III. Awareness, advice and skills barriers

There are many barriers relating to awareness, information and technical expertise. This was the second most identified barrier category, with 15 of 26 countries giving this a high priority (amongst the top three). Undoubtedly, for the market to work well, correct and appropriate information is essential. Ambitious renovations comprise a major decision which can only work if the right energy advice to take action is available and that the energy efficiency service industries are capable of delivering those measures and ultimately that sufficient satisfaction levels can be guaranteed for the consumer. Current ESCO companies are not designed to deliver deep renovations where the complex process, small project size and multi-stakeholder involvement discourage ESCOs from having a real interest in deep renovation projects. Without the right combination of necessary conditions, the consumer may only choose to undertake renovation measures when it is absolutely necessary, as is the case for the replacement of equipment when it breaks down. There were many observations in the survey about consumers not taking action and not being interested. Not being interested is a complex issue and generally takes more investigation to fully understand the consumer's motivation (or lack of motivation).

Lack of advice/information
Even with all the years of experience and the campaigns undertaken by government, industry and civil society, awareness of cost-effective energy saving opportunities is still low. The issue is exacerbated in this period of rapidly advancing technological development, where it can be difficult even for professionals to keep abreast of prevailing best practice. Dissemination techniques need to keep pace with the evolution of consumer needs and media. The market place is complex, and energy efficiency investments have to compete effectively. Due to miscommunication issues, in some cases consumers are not aware of or do not fully comprehend the effectiveness of specific technologies. This may lead to scepticism over implementing a technology especially if two or more professionals give supposedly conflicting advice as to the best way to renovate. This can be overcome, as noted by the Slovenian response, through demonstrations and information campaigns. Denmark raises an important point that all too often the focus is on individual products and not on entire end-to-end, holistic solutions.

Awareness of energy savings potential
While there is a general appreciation that energy saving is a "good thing", there remains a lack of understanding of the energy, cost and carbon savings from different measures. Householders may, for example feel they are helping the planet by installing CFLs, without realising that far greater savings could be achieved from fabric insulation or boiler upgrades. The notion (at the household level) that fitting CFLs helps save the planet may also have been perpetuated by energy supply companies which have in the past provided free or low cost CFLs – perhaps focusing less on prioritising the more effective but also more costly measures like fitting thermal insulation.

Skills & knowledge related to building professionals
Skill shortages exist in both the contractor market responsible for effective installation of energy saving measures, as well as in professional services, with few architects and designers familiar with how to specify a low energy renovation. Evidence from Norway indicates that, while there is a lack of knowledge and competence, there is also lack of focus on energy efficiency among building professionals.[25] Estonia, France and Ireland, amongst others, noted that the limited know-how of contractors regarding energy efficiency led to unsatisfactory retrofits.

[25] BPIE database

IV. Separation of expenditure and benefit

This is probably the most complex and long-standing barrier relating to existing buildings, particularly in countries where there is a high share of rental accommodation in the residential sector, but also because of the structure of occupancy in the non-residential sector. This barrier has been known under various names throughout the years. Most recently it is known as the 'split incentives barrier' or the 'landlord/ tenant barrier', the 'investor/user barrier' and the 'principal/agent barrier', to name the main ones.

This barrier was identified as the fourth most important barrier in the BPIE survey, although there were no first place positions amongst the countries. This barrier is sometimes considered a financial barrier and, understandably, there are financial implications. It is also sometimes considered to be an institutional barrier. This is presented separately herein due to its importance in retrofit strategies.

The problem originates from the fact that one person or organisation owns a building and someone else uses it. For the owner, any investment has to bring a benefit which is not necessarily through energy savings, unless it is a situation where the landlord pays the energy bills (this may sometimes be the case). Since the tenant does not own the facility, any investment in lowering energy bills has to be seen as financially advantageous for both actors. This often leads to a stalemate with nothing happening.

There are many examples where the party investing in a building may not be the party reaping the financial returns (in full or in part). Examples include:

- Landlords investing in a property where tenants pay the energy bill;
- Landlords' inability (through legislative restrictions or other reasons) to raise rents after a building renovation; and
- Developers constructing a new building or renovating an existing one, where market prices do not reflect the energy performance of the building.

As evidence from Germany[26] has shown, this is one of the most relevant barriers needing increased attention, particularly since many leases include heating charges and so the actual consumer has a lack of understanding of actual energy consumption. A comprehensive analysis on split incentives undertaken by the International Energy Agency in 2007 showed that this barrier accounts for about 30% of sectorial energy use, which is highly significant. It stated, however, that no single policy instrument can address it. The IEA stated[27]:

"Neither regulatory mechanisms, (e.g. minimum energy performance standards, or regulated contract design), nor information-based instruments (i.e. awareness campaigns) alone will resolve them. Instead, governments should help design well-targeted policy packages to address PA problems in their specific national contexts, and within the particular constraints of a given sector. These packages should include measures to: a) address contract design to ensure end-users face energy prices, b) regulate the level of energy efficiency in appliances and buildings, c) improve access to information about energy efficiency performance."

This is an important point to remember in designing renovation policy pages, as will be seen in Part 3.

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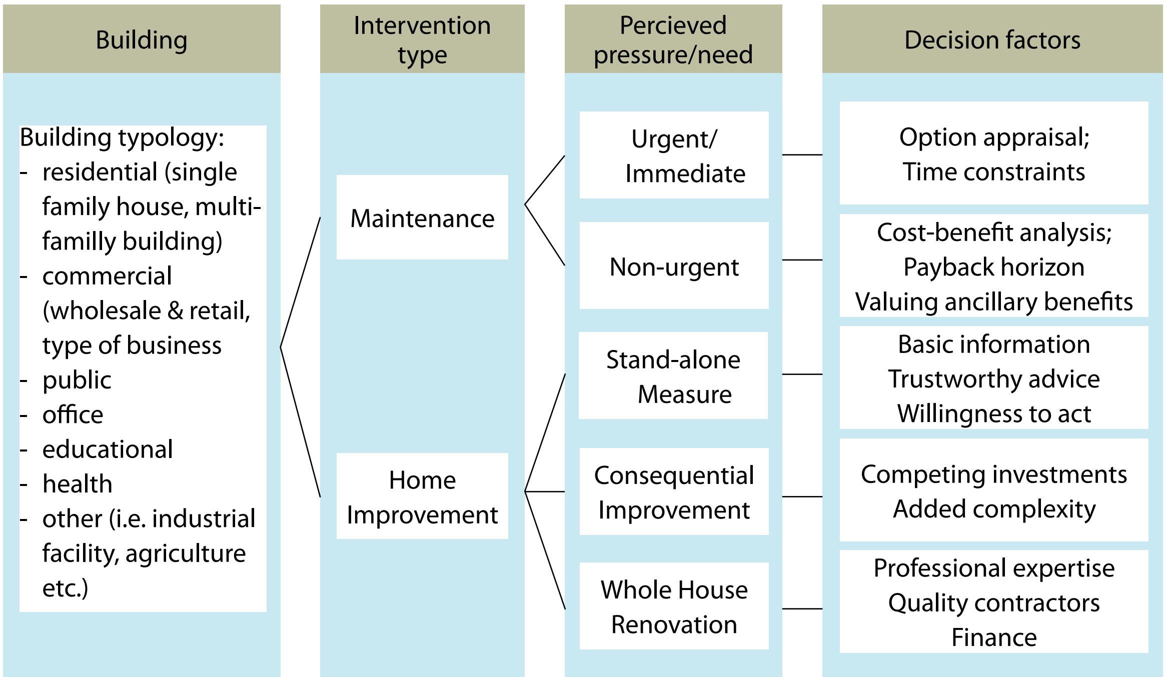
[26] BPIE database
[27] IEA, Mind the Gap, IEA/OECD, Paris, 2007, p. 12.

Figure 2A2 – Building owner's decision-making process for undertaking renovation work



In summary, there is a multiplicity of reasons why building owners do not routinely consider options for improving their home's energy performance, and even when there are convenient "trigger points", the energy saving options can often be overlooked, ignored, rejected or only partially realised. From the consumers' viewpoint, it is important to consider their decision-making process, which has been roughly illustrated in Figure 2A2 where the final column highlights some of the most prevalent barriers for a given scenario.

CHALLENGES

Almost none of the above barriers relate to market or technical issues. This is understandable since the lack of activity resulting from the financial, structural and other barriers have not allowed many, if any, of the market and technical barriers to emerge or become apparent. The barriers undoubtedly exist as latent risks. If conditions were to change dramatically and demand for low energy renovations suddenly increased there would inevitably be issues regarding shortages of materials, components and human resources. Additionally, the supply chains and delivery systems would struggle to adapt and would undoubtedly operate inefficiently for a period of time. These issues are not permanent barriers because over time the market and the supply chain would respond to demand by building greater capacity and developing more efficient supply chains and delivery systems. The speed at which markets are able to respond will depend upon the speed of change and the extent to which clear, consistent and believable signals of change are given in advance.

The following represent some of the major challenges that have to be factored in (as shown in Figure 2A3), in developing a robust and comprehensive retrofit strategy.

Figure 2A3 – An illustration of the main risks which need to be addressed for market uptake

CHALLENGES

Supply chain	Quality of workmanship	Technical failure	Disturbance

I. Supply chain

Market and supply chains will certainly develop over time but short term we are facing risks. For example, a significant shortage of material, components and suitably skilled labour could lead to renovation work not including low energy measures. Opportunities will be missed that may not reappear for many decades ('lock-in effect'). Alternatively, low energy renovation projects may be abandoned because they cannot be delivered within a specific window of opportunity.

II. Quality of workmanship

Another side-effect of a significant increase in demand could be the rapid growth of contractors offering to undertake low energy renovation work, which if not appropriately regulated or managed, could give rise to poor workmanship and even some serious short term failures. Both these outcomes would generate negative feedback which in turn could stem the demand for renovation projects (in England in the 1970s the World in Action TV programme exposed shoddy working practices in timber frame house building that virtually stopped them being built and the industry took decades to recover).

III. Technical failure

A similar and potentially more troubling concern that has been voiced by many in the industry is the risk of building-in long term failure risks that may not emerge for a decade or more. Whilst not a barrier in the short term, if such failures began to occur on a large scale in several years they could result in a massive loss of confidence and a halt in major renovation programmes; to say nothing of major costs to building owners and insurers. Most new construction materials and more importantly construction techniques and processes go through a long period of testing and development before they gain approval for widespread application in new buildings. This would also be true of the materials being used in low energy renovations but not necessarily the construction techniques and processes. Many of these have had little testing and development. A major concern is the potential for building-in interstitial condensation risk when installing internal wall insulation.

IV. Disturbance

Another barrier that has yet to emerge is the practical issue of what happens to the building occupier when a major renovation is being undertaken. It is probably seen a barrier at the moment given that occupants may not want to entertain the disruption involved in a major building renovation. In most cases deep renovation can only be implemented in a vacant building which will involve practical and financial barriers associated with re-locating the occupant for the period of the retrofit (4-10 weeks).

B. REGULATORY AND LEGISLATIVE FRAMEWORK

Improving the energy performance of buildings is a key factor in securing the transition to a 'green' resource efficient economy and to achieving the EU Climate & Energy objectives, namely a 20% reduction in the GHG emissions by 2020 and a 20% energy savings by 2020. By reducing the energy consumption of the buildings, a direct reduction of the associated GHG emissions will be obtained and a faster and cheaper implementation of renewable energy sources will be triggered. The 2006 Energy Efficiency Action Plan[28] identified residential and commercial buildings as being the sector with the largest cost-effective savings potential by 2020, estimated at around 27% (91Mtoe) and 30% (63Mtoe) of energy use, respectively. In addition, the Action Plan indicates that, in residential buildings, retrofitting walls and roofs insulation offer the greatest saving opportunities, while in commercial buildings, improving energy management systems is more important. The Eco-design of the Energy-Related Products Framework Directive 09/125/EC (recast of Energy-Using Directive 32/2005/EC), the End-use Energy Efficiency and Energy Services Directive 32/2006/EC (ESD), the Energy Performance of Buildings Directive 2010/31/EU (EPBD, recast of 2002/91/EC) as well as the Labelling Framework Directive 2010/30/EU (recast of 75/1992/EC) aim to contribute significantly to realising the energy-saving potential of the European Union's buildings sector. The main legislative instrument in Europe is the 2002 Energy Performance in Buildings Directive (EPBD) and its 2010 recast. This section is divided into two parts. First there is a review of the overall state of implementation of the EPBD. This is followed by a review of the main components of the building code requirements.

EPBD: MAIN PROVISIONS, IMPLEMENTATION AND RECAST

Main provisions

The 2002/91/EC Energy Performance of Buildings Directive (EPBD) is, at European level, the main policy driver affecting energy use in buildings. As originally formulated in 2002, the EPBD sets out the following key requirements for Member States:

- minimum standards on the energy performance of new buildings and large (>1000 m^2) existing buildings undergoing 'major renovation';
- a general framework; for a methodology for calculating the integrated energy performance of buildings;
- energy certification for both new and existing buildings whenever they are constructed, sold or rented out;
- implement an inspection and assessment regime for air conditioning and medium and large size heating systems or, in the case of the latter, develop information campaigns on the subject.

While no full assessment of the EPBD impact has been done, it is estimated that, if fully and properly implemented, the energy savings could be as much as 96 Mtoe final energy in 2020, this being 6.5% of EU final energy demand[29].

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[28] COM(2006) 545. Communication from the Commission - Action Plan for Energy Efficiency: Realising the Potential
[29] Impact assessment document accompanying the Proposal for a Recast of the EPBD

Implementation (Energy Performance Certificates (EPC's), Inspections and impacts)

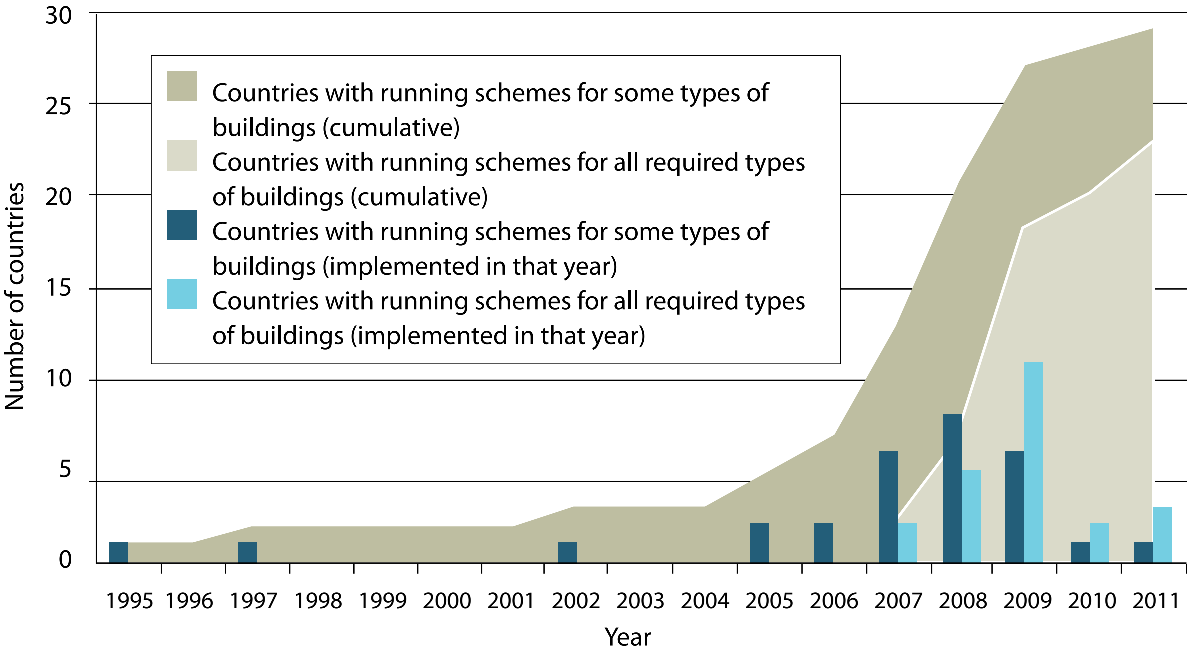
Whilst most Member States already had some form of minimum requirements for thermal performance of building envelopes before the introduction of the EPBD introduction, few had any prior requirements for certification, inspections, training or renovation. Indeed, the absence of these requirements meant that entirely new legislative vehicles were required in most Member States, often with responsibilities split across different government departments, and in many cases, devolved to regional authorities. As a result, EPBD was typically implemented in stages over a number of years, from around 2006 to 2010. For information on the implementation of the energy performance requirements please refer to the following section (Part 2B Building Codes).

Energy Performance Certificates (EPCs)

The implementation of the EPC schemes has been gradual in almost all Member States due to the nature of application of the certificates. While most countries set up the first certification relating to new buildings, the scheme for renovated, existing and new and existing public buildings were usually left for later implementation. Figure 2B1 shows the timeline of EPC implementation in Europe showing when countries have started to implement and run EPC schemes, as well as the number of countries completing and fully implementing the EPC requirements set by the EPBD.

Figure 2B1 - Timeline of the Energy Performance Certificate implementation (EPBD 2002/91/EC)

Source: BPIE survey



Before the EPBD was created, both The Netherlands and Denmark had already set up energy certification schemes for buildings at national level (in 1995 and 1997 respectively). Germany started in 2002 (having recast it in 2009) and from then on, most of the countries started the implementation and enforcement of the EPC schemes from 2007 to 2009. Generally, Member States found it easier to introduce requirements for new buildings, as there are already processes in place to approve new buildings. However, greater benefit can be derived from identifying and stimulating uptake of energy savings measures within the existing stock.

At the moment all countries have implemented the certification process but five of them still haven't implemented it for all buildings required by the EPBD back in 2002. Greece, Romania, Spain and the Brussels Region of Belgium are due to implement the remaining requirement in 2011, while Hungary is due in 2012 and the Flanders Region of Belgium in 2013.

Also, some countries already have an up and running database for the registered EPCs as can be seen on Table 2B1 below.

Table 2B1 – Existence of EPC register/database at national level

Source: BPIE survey

AT	No	Data held individually by each region. Centralised system to be introduced in 2011.
BE	No	Database existing only for the Flemish and the Walloon regions
BG	Yes	
CH	No	
CY	No	
CZ	No	
DE	No	There are data protection concerns
DK	Yes	Offentlige Informationsserver
EE	Yes	Building Register
ES	No	Only the Autonomous Communities of Andalucía, Galicia, Canarias, Extremadura, Navarra, Valencia and Cataluña have set registries.
FI	No	
FR	No	Register under final development by ADEME
GR	Yes	Database competency of the Ministry of Environment, Energy and Climate Change (YPEKA)
HU	No	Existing database not fully operational
IE	Yes	National Administration System maintained by SEAI
IT	No	No national database, some at local/regional levels
LT	Yes	Available at the Certification Center of Building Products (SPSC - Statybosprodukcijossertifikavimocentras)
LV	No	A Construction Information System is to be introduced in 2012 to include an EPC register
MT	No	
NL	Yes	Maintained by NL Agency (www.ep-online.nl or www.energiecijfers.nl)
NO	No	There are plans to build a database which collects data on EPCs.
PL	No	Only hard copies are collected at the Poviat Building Inspectorates
PT	Yes	Administered by ADENE
RO	No	
SE	Yes	The National Register of Energy Certificates (Griffon) administered by the National Board of Housing, Building and Planning
SK	Yes	Administered by the Building Testing and Research Institute - TSUS
SI	No	
UK	Yes	England & Wales: collected by Landmark Scotland: the Home Energy Efficiency Database, maintained by the Energy Saving Trust (www.epbniregister.com) Northern Ireland: www.epbnindregister.com

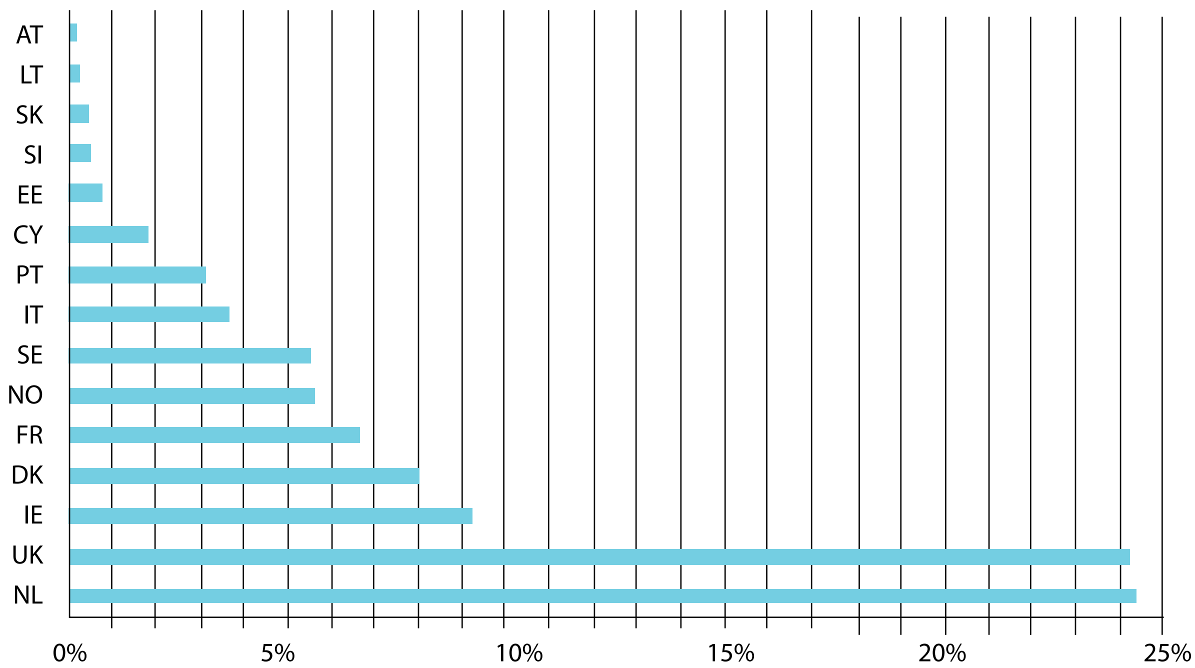
Figure 2B2 - Number of countries with an operational EPC database

Source: BPIE survey

With the reported data from the operational registers/databases and other EPC calculation systems, the number of registered residential EPCs as a share of the total number of dwellings can be seen in Figure 2B3.

Figure 2B3 – Share of dwellings with a registered EPC

Source: BPIE survey



NOTES

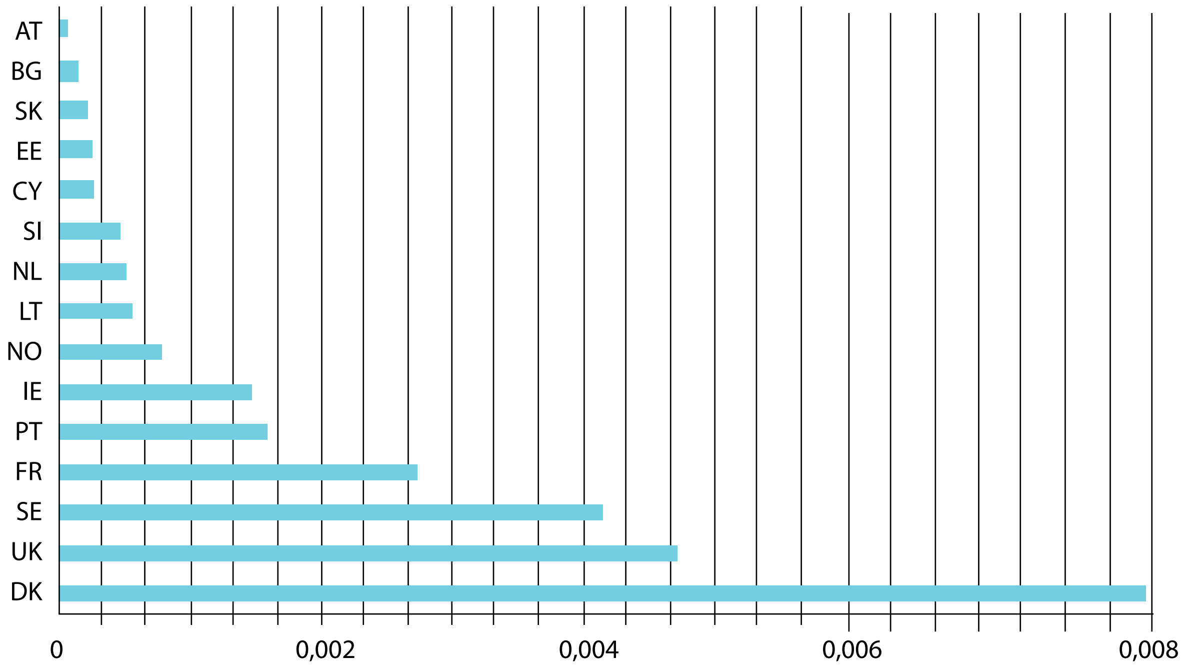
AT: Accounted certificates only from the ZEUS EPC database
CY: Data from 1/1/2010 to 6/5/2011
CZ: Value for 2009 and 2010 (number is about)
DK: Data refers to the current EPC scheme (certificates issued between 1997 and 2006 are not included)
FR: Some figures are from CEREN data, some others are from the country consultant personal expertise
GR: Registered EPC's till July 2011
HU: Estimation for completed energy certificates
IT: Values are based on collected data from 2 regions (Piemonte and Lombardia) and extrapolated to national level (by ENEA).
SK: Data refer to certificates issued only after 1st January 2010 (certificates issued before that date were not registered)
UK: For domestic certificates values are as of May 2011

Although the certification schemes have been working for only a couple of years, the proportion of dwellings not yet certified remain above 90% for all countries with the exception of The Netherlands and the United Kingdom. Note that The Netherlands has had a certification scheme for new buildings in operation since 1995.

As for the issued and registered EPCs of non-residential buildings, Figure 2B4 provides an overview of the relative share of certified buildings against the population in each country.

Figure 2B4 – Non-residential registered certificates per capita

Source: BPIE survey



NOTES

AT: Accounting only certificates from the ZEUS EPC database

CY: Data from 1/1/2010 to 6/5/2011

DK: Data refers to the current EPC scheme (certificates issued between 1997 and 2006 are not included)

FR: Some figures are from CEREN data, some others are from the country consultant personal expertise

SK: Data refers to certificates issued only after 1st January 2010 (certificates issued before that date were not registered)

Denmark has without doubt the largest proportion of certified non-residential buildings, followed by the UK, Sweden and France, while the other countries still have a low share of certified buildings.

Belgium has reported having issued 302,570 EPCs in total, the Czech Republic 4,000 (approximate value for 2009 and 2010), Greece 32,420 (registered EPCs up to July 2011), and Hungary 1,400 (estimation for completed energy certificates).

Table 2B2 summarises the costs, where available, of acquiring an energy performance certificate across Europe, as well as whether penalties are foreseen for EPC non-compliance.

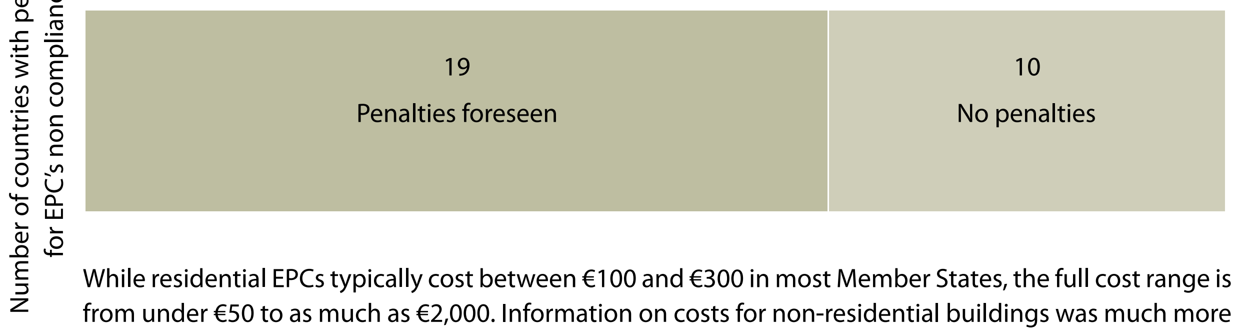
Table 2B2 – EPC costs (€ unless otherwise stated) and existence of penalties in the event of non-compliance

Source : BPIE survey complemented with data from EPBD Concerted Action 2010 Report

	Single family	Multi-family	Non-residential	Penalties foreseen for EPC non-compliance
AT	300-420	About 1/m²	Office buildings about 1/m².	No
BE				Yes
BG	0,5-1,5/m² (cost for the energy audit needed to issue a certificate)			Yes
CH	400-600CHF	500-800CHF	700-1,200CHF (up to 1000 m²)	No
CY				Yes
CZ	200-500	1000-5000	Others: 1000-5000	Yes
DE	150-300 (considerably lower if the EPC is online-based)	250-600 (considerably lower if the EPC is online-based)		Yes
DK	Up to 730 for 100 m² dwellings, up to 875 for 300 m² dwellings		1-3/m²	Yes
EE	130-300		200-3000	No
ES	From 100		Up to 4000	Yes
FI	150-500	600-1000		No
FR	250	80/dwelling	300-1000	Yes
GR	1,5/m² (200 minimum)	1-2/m² (150 minimum)	300-2,500 (up to 1000 m²) From 2,500 (for buildings above 1000 m²)	No
HU	40-100/dwelling			No
IE				Yes
IT	300-10000 (all buildings)			Yes
LT	From 70		Up to 2,500	Yes
LV		300-500		No
LU	500-1,300	125-250/dwelling		Yes
MT	250-750			Yes
NL	100-250		0,5-1/m²	Yes
NO				Yes
PL	50-150		Up to 750	No
PT	45 for EPC registration + 1-3/m² (charged by the inspection expert)		50 for registration of an EPC + 1-3/m² (charged by the inspection expert)	Yes
RO				No
SE	About 400	1,000-1,500 for an average sized buildings	About 1/m² for uncomplicated/simple buildings	Yes
SI	300-500			No
SK	About 250		Up to thousand/s euros	Yes
UK	£30-100		From £200	Yes

Figure 2B5 – Number of countries with penalties foreseen for EPC non-compliance

Source: BPIE survey



While residential EPCs typically cost between €100 and €300 in most Member States, the full cost range is from under €50 to as much as €2,000. Information on costs for non-residential buildings was much more limited. Where quoted, the values range from €0.5 to 3/m². Where available, these registers have proven to be extremely useful in monitoring and analysing the opportunities for energy performance improvement. In the longer term, they will also prove invaluable in assessing trends in energy performance. A total of 18 countries out of 29 foresee penalties in the event of non-compliance with the certification process.

Inspections

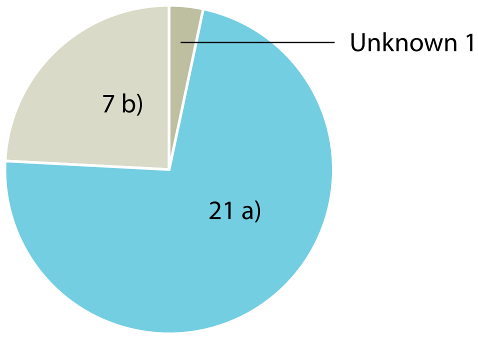
Although most of the countries have already inspection schemes for boilers and/or air conditioning systems, data collection on the number of inspections done by each Member State is still at a very low level. Insufficient data makes it difficult to formulate an appropriate evaluation.

Italy and the Brussels Region of Belgium have experienced delays in implementing the requirements for the certification of air conditioning systems.

As can be seen on Figure 2B6 countries have chosen to implement Article 8 of the initial EPBD (on the inspection of boilers) by taking steps to ensure the provision of advice to the users on boilers and heating systems (option b) instead of implementing an inspection and assessment regime (option a).

Figure 2B6 - Share and number of countries having implemented Article 8 of the EPBD (on the inspection of boilers) by the method chosen

Source: BPIE survey



Finland, France, Ireland, The Netherlands, Slovenia, Sweden and the UK have chosen option b (advice to the users) regarding the EPBD requirement for inspection of boilers, while for Switzerland it was not reported. All the other Member States have implemented inspection and assessment systems, mainly because many of the countries already had a boiler inspection system in place prior to the EPBD.

Impact reported by countries in 2011

Some of the main contributions of the EPBD have been bringing energy efficiency in buildings onto the political agenda, integrating energy performance requirements and bringing it to the attention of citizens. On Table 2B3, the main impacts and benefits of the EPBD implementation reported by each country are presented.

Table 2B3 – Reported main impacts and benefits of the EPBD implementation by country

Source: BPIE survey

AT	Achieved harmonisation of building codes and integration of ventilation, cooling and lighting into the certificate. Also, some lessons learned were: the need to improve the quality of energy certificates, ensuring proper qualification of energy consultants, enforcing the obligation to present the energy certificate, and increasing the level of acceptance of the energy certificate by the real estate sector. In this regard, there are substantial weaknesses which should be corrected in the course of revising the respective documents and regulations according to the requirements of the EPBD Recast.
BE	Strengthened or new requirements for insulation, ventilation and technical installations. Some tendencies after the EPBD implementation appear to be: condensing boilers are more and more being used for heating, buildings tend to be better thermally insulated, increased use of mechanical ventilation systems with heat recovery, more attention to the air tightness of the envelope (mostly in low energy buildings, performing (much) better than the common average in the past) and increased interest in heat pumps.
BG	Strengthened requirements for insulation and glazing U-values; raised national consciousness of energy saving opportunities
CH	The cantonal regulations in the field of buildings had an additional annual impact of about 3.1 PJ/a between 2000 and 2007 (additional impact every year; final energy use). The expected additional annual impact after the implementation of the "MuKEn 2008" is quantified at 4.2 PJ/a.
CY	The implementation of the EPBD was the first attempt ever made to regulate energy consumption in buildings. Thermal insulation requirements were introduced for the first time in 2007 along with greater importance given to efficient technical systems and solar strategies (shading). After the EPBD implementation, the following impacts and benefits were observed: improvement of the quality of information on the building products and better competition between producers and vendors in supplying materials of improved thermal properties, integration of the importance of efficient technical systems in the energy performance of buildings, also more designers have shown interest in heat pumps and condensing boilers. Also the EPBD is expected to stimulate energy savings of 19.9 toe from the residential section and 28.5 from the non-residential sector by 2020.
CZ	The performance requirements of renovated buildings have been set at the same level as for new buildings. Increased energy efficiency standards can contribute more than 220 billion CZK (energy savings, new work possibilities etc.) to the Czech State budget.
DE	Thermal performance requirements had been in place since 1977. EPBD introduced requirements for building renovations. Efficiency plays a more important role in building services, the need for better coordination among all actors has been perceived and the aim of realizing an integrated planning approach seems to have been boosted.
DK	Energy requirements in place since 1961 were extended to include other regulated energy as a result of the EPBD
EE	Prior to 2008, there had been no legal requirement for insulation levels or technical systems.Depending on the EPBD implementation scenario, energy savings in buildings can be up to 5% of total energy consumption. Transposition of the EPBD has not affected investments or investment support schemes targeted at energy efficiency upgrades in the buildings.
ES	Considerably tougher requirements for building envelopes; use of renewable energy made compulsory in new buildings
FI	Thermal requirements have been in place since 1976. Energy performance is now based on overall primary energy consumption.New building regulations were introduced at the beginning of 2010 which will lead to 30% efficiency improvement in heat consumption in new buildings. Revised energy efficiency parts of the building code are expected to enter into force at the beginning of 2012. This would mean a further improvement of 20 % in the efficiency of heat consumption in buildings.
FR	20% improvement due to introduction of requirements for air conditioning, lighting, active solar, renewable, CHP and natural lighting. The absence or delay in implementing the inspection of boilers has reduced the quality and precision of Energy Performance Certificates in collective dwellings.
GR	Tighter energy performance requirements
HU	Revised methodology has led to tougher energy performance requirements

IE	Methodology changed from maximum permissible heat loss, to overall energy performance, in 2005. Energy performance targets were introduced for the first time into building regulations. Certification schemes are helping to provide industry professionals with improved skills and insights into the determinants of the energy performance of buildings. Overall the EPBD is seen as a significant lever for improving the energy, environmental and economic performance of Irish buildings.
IT	Energy savings achieved from 2005 to February 2010 were 10,170 GWh (1.9 Mtoe) of primary energy, due essentially to the requirements on the residential sector.
LU	The obligation for certifying the energy performance of buildings had an important impact on the building and rental market. Real estate agencies have taken the EPC to be a promotional instrument for energy efficient buildings.
LV	Whilst there have been some improvements in energy performance requirements, the full benefits have not been realised due to only partial implementation of the EPBD. For most of the existing buildings, i.e. with ventilation without heat recovery systems, requirements were considered to be raised to quite optimal levels.
MT	Prior to 2008, there was no minimum energy performance requirement for buildings.
NL	Previous requirements for minimum energy performance, in place since 1995, have been replaced by a whole building requirement.
PL	Introducing the EPBD has raised awareness of building energy efficiency.
PT	Additional requirements introduced, including mandatory use of renewable energy.
RO	Tougher standards and greater awareness of energy efficiency opportunities.The analysis of the real estate market indicates that residential sellers/buyers appreciate that thermally retrofitted buildings have more value than non-retrofitted ones. Their willingness to pay for added value generated by energy performance is linked to both the willingness to save operating expenses and the desire to have a modern, healthy, comfortable property.
SE	National requirements have been in place since the 1950s, though the EPBD mandated, for the first time, maximum energy use levels for buildings
SI	Stimulated much better understanding of building energy indicators
SK	30% reduction in energy requirements

Among the EPBD's impact benefits, the following were identified as major:

- Energy performance requirements were set for the first time as a direct result of implementing the EPBD in the case of Cyprus, Malta and Estonia;
- Existing standards were tightened in the majority of Member States;
- The approach to specifying building codes shifted from one typically expressed as a maximum permitted U-value to one based on overall building performance, including requirements for technical systems such as HVAC plant and lighting;
- A degree of harmonisation where previously different regions/provinces had adopted different approaches to setting building codes was achieved within some Member States;
- Standards for building renovation were introduced for the first time in most Member States;
- Requirements for certification of buildings, and for the inspection of boilers and air conditioning systems, were introduced for the first time, apart from one or two Member States with prior systems in place.

[30] According to the Directive 2010/31/EU, major renovation means the renovation of a building where:
(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or (b) more than 25 % of the surface of the building envelope undergoes renovation;

EPBD recast (main provisions, impact and implementation)

Main provisions

Despite the actions already undertaken, a large cost-effective energy savings potential was not exploited. As a result, many of the social, economic and environmental potential benefits at EU and national level are still not fully explored. In addition to the complexity of the sector and the existence of market failures, the limitations of the initial EPBD implementation represented a supplementary obstacle.

To tackle these challenges, in 2010, amendments to the EPBD were finalised and published. In addition to the previous requirements, the EPBD recast added several new or strengthened requirements, in particular:

- **Setting up EU–wide nearly Zero Energy Buildings requirements:** by the end of 2020 all newly constructed buildings will have to consume 'nearly zero' energy and the energy will have to be 'to a very large extent' from renewable sources. As for new buildings occupied and owned by public authorities, this requirement must be met from the beginning of 2019 onwards.
- **Development of national plans for increasing the number of nZEB buildings:** the Member States 'shall draw up national plans for increasing the number of nearly Zero Energy Buildings. These plans may include targets differentiated according to the category of building' and will also include information on national policies, measures and targets on nearly Zero Energy Buildings.
- **Abolishment of the 1000 m^2 threshold for major renovations:** The recast extended the scope of the initial EPBD to almost all existing and new buildings and removed the 1000 m^2 threshold for major renovations (this threshold excluded 72% of the building stock). When existing buildings undergo 'major renovation[30]', their energy performance should be upgraded in order to meet the minimum energy performance requirements. Member States shall furthermore follow the leading example of the public sector by developing policies and take measures such as targets in order to stimulate the transformation of buildings that are refurbished into nZEB.
- **Setting up energy performance requirements at cost-optimal levels:** Member States need to ensure minimum energy performance requirements for buildings and to set them at cost-optimal levels. This level shall be calculated based on a comparative methodology framework that will be defined in detail by the Commission.
- **Independent control systems for EPC and inspection reports:** the authorities responsible for the implementation of the control system shall make a random sampling check of the quality of the energy performance certificates and inspection reports issued annually.
- **Requiring an inspection report for heating and air-conditioning systems:** an inspection report shall be issued after each heating or air-conditioning system inspection containing the results of it and including recommendations for the cost-effective improvement of the energy performance of the inspected system and handed over to the owner or tenant of the building.
- **Reinforcement of the energy certification of the buildings:** energy certification was already foreseen in the initial version of the Directive but experienced an unsatisfactory level of implementation within EU27 Member States. The new Directive requires the energy performance certificates to be issued for any new building and for any building that is traded on the market (sold or rented), to include a recommendation for energy performance improvements based on economic consideration.

Impact assessment

The following savings/impacts are predicted to be achieved through the new or reinforcement provisions of the EPBD recast.

Table 2B4 – Calculated impacts and benefits to be achieved with the EPBD recast reinforcements

Source: Proposal for a recast of the EPBD (2002/91/CE) – Impact assessment

	Final energy savings in 2020 (Mtoe/a)	CO_2 emission reductions in 2020 (Mt/a)	Job creation in 2020
Abolition of the 1,000 m² threshold for major renovations	20	51	75000
Setting up energy performance requirements at cost-optimal levels	5 (up to 10 in 2030)	13 (up to 24 in 2030)	Up to 82000
Setting up EU–wide nearly Zero Energy Buildings requirements and development of national plans	>15	>41	+++
Independent control systems for EPCs	21	57	60000
Requiring an inspection report for heating and air conditioning systems	5	15-20	46000

Implementation

The EPBD recast calls EU Member States to use a new cost-optimal methodology for calculating the energy performance of buildings (Article 5 of EPBD recast). As defined by the Directive, cost-optimal level means 'the energy performance level which leads to the lowest cost during the estimated economic lifecycle' and 'shall lie within the range of performance levels where the cost benefit analysis calculated over the estimated economic lifecycle is positive'.

The EU Commission shall establish by means of delegated acts by 30 June 2011 (currently delayed) a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements. The comparative methodology framework shall differentiate between new and existing buildings and between different categories of buildings. At the moment there is a delay in the process of elaborating the cost-optimal framework methodology and according to the EU Commission timeline the final version is due to be published in autumn 2011. Member States will have to report regularly (starting from July 2012) their specific application of the methodology to the Commission and these reports may be included in the National Energy Efficiency Action Plans under the Energy Services Directive (Directive 2006/32/EC). Based on this framework methodology, the EU Member States should calculate cost-optimal levels of minimum energy performance requirements using the comparative methodology framework and other relevant parameters such as climatic conditions and the practical accessibility of energy infrastructure. The result of the cost-optimal calculation at the Member States level shall be used as a reference to compare with the minimum energy performance requirements in force and to enhance them accordingly if is the case.

Moreover, the EPBD recast introduces the obligation that all the new buildings should be nearly zero energy by the end of 2020. In order to show the leader example, the new buildings occupied by public authorities shall be nearly zero energy by the end of 2018. According to the EPBD recast, "nearly zero-energy building means a building that has a very high energy performance where 'the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby'. The EU Member States shall draw up national plans for increasing the number of nearly Zero Energy Buildings, potentially with targets differentiated according to the building categories. As requested by the EPBD recast, these plans shall include a national definition of nearly Zero Energy Buildings, intermediate targets for improving the energy performance of new buildings by 2015 and information on policies, financial or other measures adopted for the promotion of the nearly Zero Energy Buildings, including details on the use of renewable sources in new buildings and existing buildings undergoing major renovation. The current steps undertaken towards the EPBD recast implementation, as reported by our country experts, are presented in Table 2B5.

Table 2B5 – Reported steps in the period October 2010-June 2011 planned to be undertaken towards the EPBD recast implementation by country

Source: BPIE survey

	Steps being taken towards implementation of EPBD recast
AT	The basis document for the revision of building codes and for the development of Austrian Standards, the OIB Richtlinie 6, is in the process of being revised according to the requirements of the EPBD Recast.
BG	The implementation of the new provisions of the Directive has started. A national definition of nZEB is in a stage of preparation.
CH	The cantons have launched a study (planned to be finalised till the end of 2011) to analyse the impact of the recast EBPD on Switzerland and propose various scenarios on how to develop the Swiss energy policy in the building sector in the context of the recast EBPD.
CY	The Energy Service has launched inquiries in the residential sector for detached houses, terrace houses and apartment buildings in four meteorological areas of Cyprus. Moreover, in cooperation with the Cyprus Land Development Corporation, The Energy Service has agreed to build dwellings with nearly zero energy.
CZ	Czech Green Building Council prepares proposal to upgrade decree 148/2007 Coll. with gradual transformation of new building and major renovations from today´s standards via low-energy and passive building to nearly Zero Energy Buildings till 2020.
DE	In the 2012 amendment to the Energy Saving Ordinance (Energieeinsparverordnung) a "climate-neutral" building standard (based on primary energy indicators for all new buildings by 2020) will be introduced as required by the recast of the EPBD 2010.
DK	A definition of nearly Zero Energy Buildings and an action plan for increasing the number of nearly Zero Energy Buildings are being drafted by the Danish agencies responsible for the policy.
EE	No official steps towards implementation of EPBD recast, but more detailed analysis on how to ensure application of standards for low energy buildings and nearly Zero Energy Buildings has started. The legislation will be reviewed on the basis of information received from latest studies on application of minimum energy performance requirements in Estonia and the EPBD recast.
ES	The responsible committees for reviewing the DB-HE, the Technical Building Code and the RITE (Regulation of Thermal Installations in Buildings) have strated their work. The first revision of the codes were planned for end 2010, the second for 2015-2016 and the last -with nZEB requirements- for 2020..
FI	The revision of the energy efficiency part of the building bode is now being finalised for entering into force in the beginning of the year 2012. It will bring the specific heat consumption of the new buildings to a low-energy level.
FR	The Grenelle Energy and Environment law has set a goal of net zero energy constructions in 2020. The next coming (2011-2013) energy code – BBC (Bâtiment Basse Consommation) – sets the performance of new constructions as very low energy consuming buildings at an average of 50kWh/m^2 (in terms of primary energy) for space heating and cooling, domestic hot water production and lighting. The calculation method and the thermal code entail the concept of zero energy buildings as a voluntary interim goal.
GR	Article 10 of the law 38851, issued in June 2010 transposes the recast Directive in to the Greek legislation. It foresees that up to 31/12/2019 all primary energy requirements in new buildings will be covered by renewable energy and/or by combined heat and power systems, district heating/cooling systems etc. Regarding public buildings this requirement should be fulfilled by 31/12/2014.
HU	An expert group was established by the Ministry of Interior in 2010 to focus on the EBPD recast. The group will start its work end January 2012.
IE	Discussions have begun between the Department of the Environment, Heritage and Local Government, the Department of Communications, Energy and Natural Resources, and the Sustainable Energy Authority of Ireland on the implementation of the recast Directive.

LV	The Ministry of Environmental Protection and Regional Development funds the first nearly Zero Energy Buildings. It is planned to implement projects for various types of buildings with joint funding of 10 million EUR in 2011 (financial support is up to 65-80%).
NL	By July 2012 the energy performance certificate is being adapted to meet recast requirements (e.g. information on costs and benefits of energy saving measures),. Legal frameworks are currently being changed in order to introduce further penalties, o. The National Energy Efficiency Action Plan is being written. The policies both for the residential and non-residential sector will be further adapted in the coming years to reach nZEB's by 2020. An implementation plan for all inspection articles is currently being developed in consultation with relevant market parties, in order to meet requirements of articles 14 to 18.
NO	The Norwegian standard NS 3700 for low energy and Passive House residential buildings contains stricter requirements than the current technical requirements (TEK 10). An analogous Norwegian standard for non-residential buildings (NS 3701) is currently being worked on. These requirements are still optional, but the aim is to make them mandatory. A plan has been proposed foreseeing energy efficiency improvements in the building sector in line with the EPBD recast,. It includes recommendations on economic instruments to support the plan, and describes the need to increase and continuously update the workforce competence and expertise. There is already a financial support offered by ENOVA for low energy houses and Passive Houses. The Zero Emission Building Research Centre (ZEB centre) is working on a national definition for nZEBs.
PL	The Energy Efficiency Law has recently been (4th March) accepted by the Sejm (Parliament). The Ministry of Infrastructure is n preparing details to implement the recast Directive. The Ministry intends to implement the relevant legal regulations later this year. The National Program of Actions to improve energy efficiency will be launched to support the implementation of the recast Directive.
PT	The Portuguese legal framework for energy efficiency is currently being revised so that all the requirements imposed by the EPBD recast can be adopted in Portugal in a near future. There are also some strategies and plans in order to achieve some of the previously mentioned requirements.
SI	The new PURES 2010 regulation is already based on the EPBD recast and, as it is already very demanding, only minor changes in RES and RUE requirements can be expected. This regulation introduces significant steps for improving the energy efficiency in buildings, and foresees at least a 25% share of RES at building level. Currently the Energy act is being revised, and it will contain the definition of nZEB.
SK	According to the existing law there is no floor area threshold for building certification. By consequence, there is no need to align the building code with the requirements of the recast Directive. For nearly Zero Energy Buildings, there are only analyses examining the possibilities of minimising the energy use for heating by increasing thermal protection properties of components etc. Planned are works on conditions for cost-optimal measures.
SE	A strategy to promote low energy is under development, and programmes to promote RES are under consideration. The energy agency together with the Swedish Construction Federation has started a program for promoting low energy buildings.
UK	In 2006, the requirement for zero carbon homes from 2016 was announced. However, the definition of zero carbon is not yet finalised. As a step towards the 2016 standard, the government is proposing to introduce a minimum FEE from 2013. The Scottish Government will consult publicly on recast-proposals in the middle of 2011. In Northern Ireland there is no obvious indication about the steps being taken to implement the recast Directive.

BUILDING CODES

Incorporating energy-related requirements during the design or retrofit phase of a building is a key driver for implementing energy efficiency measures which in turn highlights the role of building energy codes in reducing CO_2 emissions and reaching the energy saving potential of buildings. Several Member States introduced building code requirements (prescriptive criteria) associated with the thermal performance of buildings following the oil price increases in the 1970s while requirements in some Scandinavian countries have been in place since the mid-1940s.

The Energy Performance of Buildings Directive (EPBD, 2002/91/EC) was the first major attempt requiring all Member States to introduce a general framework for setting building energy code requirements based on a "whole building" approach (so called performance-based approach). Although subsidiarity applies to implementation of the EPBD, Member States were required to introduce a methodology at the national or regional level to calculate the energy performance of buildings based upon this framework and apply minimum requirements on the energy performance of new buildings and large existing buildings subject to major renovation.

Following the EPBD in 2002, requirements have gradually started shifting from prescriptive to a performance-based approach which is regarded as a major change in the building code trends.

Major changes are also expected through the application of the cost optimality concept in the energy performance requirements as introduced by the recast of the EPBD in 2010 (2010/31/EU). Member States are required to set their national requirements in accordance with cost optimal levels by applying a harmonised calculation methodology (Article 5 and annex III of EPBD recast). This is currently being reviewed by the European Commission. The introduction of cost optimality in building regulations is likely to have a significant impact in many countries, with requirements being improved and further strengthened. Cost optimal levels should also gradually converge to nearly zero energy standards which would comprise a requirement for new buildings from 2020 onwards.

Due to these foreseen changes, building codes are anticipated to be in a dynamic phase in the next decade. Understanding building codes however requires specific technical expertise which makes monitoring and evaluating the progress of what is happening from the political level difficult. Given the environmental and climatic impacts of building codes, it is crucial to keep track of all the key transformations happening in the field of building energy codes in a simple, understandable way.

Through its survey, BPIE has collected country-by-country information, making the first attempt to provide an overall picture of what is happening in Europe in the area of building codes. A summary of the key performance-based requirements and prescriptive criteria adopted by different countries is presented in Table 2B6. With the exception of a few countries, all countries have now embedded building regulations for both new and renovated buildings. These regulations are discussed in more detail on the next page.

Table 2B6 – Summary of building energy code requirements and prescriptive criteria

Source: BPIE survey

	Building code requirements		Performance based requirements[1]		Prescriptive/element-based criteria in building codes					
	New build	Renovations	New build	Renovations	Thermal insulation	Air permeability	Ventilation requirements	Boiler/AC system efficiency	Lighting efficiency	Other requirements
AT	Y	Y	Y	Y	Y	Y	Y	Y	N	Summer comfort requirements
BE-Wl	Y	Y	Y	N	Y	N	Y	N	N	Overheating indicator should not exceed 17,500kh. T_{in} must be under 26oC for 90% of year in RE. K-values on global thermal insulation of entire building. Thermal bridges
BE-Br	Y	Y	Y	N	Y	N	Y	N	N	
BE-Fl	Y	Y	Y	N	Y	N	Y	N	N	
BG	Y	Y	Y	Y	Y	Y	N	Y	N	
CH	Y	Y	Y	Y	Y	N	N	Y	NRE	Thermal bridges, solar shading, max 80% of demand for heating & DHW covered by non-RES
CY	Y	Y	Y	Y	Y	N	N	N	N	Solar collectors in new RE
CZ	Y	Y	Y	Y	Y	Y	N	BO	N	T_{in} of 20oC in winter and 27oC summer
DE	Y	Y	Y	N	Y	Y	Y	Y	NRE	T_{in} (20-26oC), humidity, air change rate & air velocity requirements
DK	Y	Y	Y	N	Y	Y	Y	Y	NRE	Max T_{in} 26oC. Thermal bridges requirements
EE	Y	Y	Y	Y	Y	Y	Y	Y	NRE	RE & office temperature requirements
ES	Y	Y	Y	Y	Y	Y	Y	Y	NRE	Thermal comfort, T_{in} 21oC (winter), 26oC (summer), mandatory RES use (solar collectors/PVs)
FI	Y	P	Y	P[2]	Y	Y	Y	BO	Y	Max T_{in} applies (typically 25oC). Max CO_2 concentration in indoor air.
FR	Y	Y	Y	Y	Y	Y	Y	Y	NRE	Max T_{in} applies based on a number of factors
GR	Y	Y	Y	Y	Y	Y	Y	Y	N	
HU	Y	Y	Y	Y	Y	N	N	N	N	
IE	Y	Y	Y	N	Y	Y		Y		Thermal bridges
IT	Y	Y	Y	Y	Y	Y	Y	Y	N	
LT	Y	Y	Y	Y	Y	Y	Y	Y	N	
LV	Y	Y	N	N	Y	Y	Y	N	N	Orientation, window size, air temperature, air humidity & air velocity, specific heat losses of whole building & per m^2
MT	Y	N	N	N	Y	N	N	Y	NRE	Window size, glazing
NL	Y	Y	Y	N	Y	Y	Y		NRE	Daylight
NO	Y	Y	Y	Y	Y	Y	Y	Y	N	Window size, thermal bridges, ventilation fan power, heat recovery, summer/winter T_{in}
PL	Y	Y	Y	Y	Y	N	Y	Y	Y	Solar shading, window area
PT	Y	Y	Y	Y	Y	Y	NRE	Y	N	Max g-value,thermal bridge, solar collectors,cooling, DHW reqs apply
RO	Y	N	N	N	Y	N	N	N	N	Overall thermal coefficient g-value
SE	Y	Y	Y	Y	Y	Y	Y	Y	N	
SI	Y	Y	Y	Y[3]	Y	Y	Y	Y	N	Solar shading, max T_{in}
SK	Y	Y	Y	Y	Y	Y	Y	Y	N	Max T_{in}, humidity & air velocity apply.
UK	Y	Y	Y	Y	Y	Y	Y	Y	Y	

IMPORTANT NOTE

The elements in the prescriptive criteria can act as supplementary demands or as an alternative approach for setting requirements. In some cases they represent embedded elements in the performance-based methodology.

OTHER NOTES

[1] In some cases this may cover only heating demands, and in others it may also include DHW, electricity and other end uses;2 The Finnish legislation allows authorities to decide whether the building regulations will be applied to the renovation or not. New EE requirements will be in place in 2012; 3 Slovenian requirements will be in place from end 2014/beg 2015.

LEGEND

RE: Residential
NRE: Non-residential
Tin: Indoor temperature
DHW: Domestic hot water
AC: Airconditioning system
BO: Boiler
P: Partly
Y: Yes
N: No

Performance based requirements for new buildings

For many countries the EPBD was the means of introducing new elements in their building codes prior to which there were no energy performance requirements concerning the building as a whole or specific elements. Nearly all countries have now adopted a national methodology which sets performance-based requirements for new buildings. For countries in which prescriptive requirements existed before 2002 (e.g. Czech Republic, Belgium, Estonia, Bulgaria, Hungary, Ireland, Poland), there was a shift towards a holistic-based (i.e. whole building) approach whereby existing single element requirements in many cases were tightened. Table 2B6 gives an overview of the current requirements in place. In some cases, the single element requirements are just supplementary demands to the energy performance requirements ensuring the efficiency of individual parts of a building is sufficient (e.g. Denmark). In others, they act as alternative methods where the two approaches exist in parallel (e.g. Norway, Spain, Poland, Switzerland); the first based on the performance of single elements and the second on the overall performance of a building. In Switzerland, for example, the holistic approach is used mainly for new buildings and the single element approach for shallow or deep renovations while in deep renovation cases, the holistic approach is sometimes chosen. In countries where the performance-based approach is the main form of requirement, most of the elements listed in the prescriptive criteria of Table 2B1 are already integral parts of the methodology,while additional elements such as RES (solar collectors, PV, heat pumps), summer comfort, indoor climate are embedded in the methodology.

While no country has directly and fully applied the CEN standards in their methodology procedures, many countries have adopted an approach which is broadly compatible with the CEN methodology[31] [32]. A variety of reasons were cited for not using the CEN standards, including difficulty of converting into practical procedures, timing and copyright issues. Most national procedures are applied as software programmes and many countries (but by no means all) have adopted a CEN based methodology (EN 15603: Energy Performance of Buildings) and/or are using the EN 13790 monthly calculation procedure, as the basis for the calculation "engine" for simple building. Others allow proprietary dynamic simulation (for more complex buildings), whilst others have developed their own national methods. The assessment of existing buildings (for building code or Certification purposes) is often based on a reduced data-set model.

A detailed assessment of the energy performance requirements is provided in Table 2B7. It can be seen that many different approaches have been applied and no two countries have adopted the same approach. It is important not to attempt to compare the performance requirements set by Member States, given the variety of calculation methods used to measure compliance and major differences in definitions (e.g. definitions of primary and final energy, heated floor area, carbon conversion factors,

[31] Concerted Action Implementing the Energy Performance of Buildings Directive April 2011 www.epbd-ca.eu
[32] CENSE –Towards effective support of the EPBD implementation & acceleration in EU Member States www.iee-cense.eu

regulated energy and total energy requirement etc.). The setting of building code requirements with legally binding performance targets, is normally based on either an absolute (i.e. not to exceed) value, generally expressed in kWh/m^2a, or on a percentage improvement requirement based on a reference building of the same type, size, shape and orientation. Some countries (e.g. Belgium) express the performance requirement as having to meet a defined "E value" on a 0 to 100 scale, or on an A+ to G scale (e.g. Italy and Cyprus).

Most methodology procedures are applied as software programmes. Software quality assurance accreditation is undertaken in only about half of the countries, a finding which has been drawn by the Concerted Action 2010 Report. About 50% of Member States have already introduced changes to their methodology procedures to either to tighten requirements, achieve greater conformity with CEN standards, and include additional technologies and/or to correct weaknesses/gaps in earlier EPBD methodology procedures.

There is a growing interest in the harmonisation of methodology procedures. This is likely to become an increasingly important issue in the context of the EPBD RECAST Article 2.2 and Article 9 requirements associated with nearly Zero Energy Buildings (nZEB) and cost optimality (EPBD RECAST Article 5) since the Commission will need to demonstrate that all Member States are delivering equivalent outcomes. A harmonised approach to setting and measuring nZEB targets and cost-optimality implies that a broadly equivalent methodology will be required. Table 2B8 provides a summary of the certification method used for new buildings.

Table 2B7 –Performance-based requirements for new buildings

Source: BPIE survey

	Single family houses	Apartment Blocks	Offices	Educational Buildings	Hospitals	Hotels & Restaurants	Sports facilities	Wholesale & retail trade
AT	H: 66 kWh/m^2a	H: 66 kh/m^2a	H:22.75 kWh/m^3a	H:22.75 kWh/m^3a C: 1kWh/m^3a	H:22.75 kWh/m^3a C: 1kWh/m^3a	H:22.75 kWh/m^3a C: 1kWh/m^3a	H:22.75 kWh/m^3a C: 1kWh/m^3a	H:22.75 kWh/m^3a C: 1kWh/m^3a
BE - Br	E70		E75	E75				E75 (services)
BE - Wl	E<100, Espec <170kWh/m^2a , Overheating <17500 kh/an	E<100	E<100	E<100				
BE - Fl	From 2012, E70 From 2014, E60	From 2012, E70 From 2014, E60	From 2012, E70 From 2014, E60	From 2012, E70 From 2014, E60				
BG	F:122-146 H&C: 82.5-102.5 kWh/m^2a	F: 90-146 H&C: 50.0-102.5 kWh/m^2a	F: 80-132 H&C:40.0-82 kWh/m^2a	: 56-98 H&C: 40-82.0 kWh/m^2a	F: 180-242 H&C: 50-102.5 kWh/m^2a	F: 176-230 H&C: 50-102.5 kWh/m^2a	F: 90-134 H&C: 40-82 kWh/m^2a	F: 90-134 H&C: 40-82 kWh/m^2a
CH	Space heating demand (effective energy): 5 litre heating oil equivalent per m^2 (based on MuKEn 2008)							
	H: 54 kWh/m^2a	H: 42 kWh/m^2a	H: 46 kWh/m^2a	H: 43 kWh/m^2a	H: 44 kWh/m^2a	H: 58 kWh/m^2a	H: 40 kWh/m^2a	H: 36 kWh/m^2a
CY	A or B category on the EPC scale							
CZ	F: 142 kWh/m^2a	F: 120 kWh/m^2a	F: 179 kWh/m^2a	F: 130 kWh/m^2a	F: 310 kWh/m^2a	F: 294 kWh/m^2a	F: 145 kWh/m^2a	F: 183 kWh/m^2a
DE	New buildings must not exceed a defined primary energy demand for heating, hot water, ventilation, cooling and lighting installations (lighting installations only for commercial) based on of a reference building of the same geometry, net floor space, alignment and utilisation.							
DK	P: 52.5+1650/A kWh/m^2a	P: 52.5+1650/A kWh/m^2a	P: 71.3+1650/A kWh/m^2a	P: 71.3+1650/A kWh/m^2a	P: 71.3+1650/A kWh/m^2a	P: 71.3+1650/A kWh/m^2a	P: 71.3+1650/A kWh/m^2a	P: 71.3+1650/A kWh/m^2a
EE	P: 180 kWh/m^2a	P: 150 kWh/m^2a	P: 220 kWh/m^2a	P: 300 kWh/m^2a	P: 400 kWh/m^2a	P: 300 kWh/m^2a	P: 300 kWh/m^2a	P: 300 kWh/m^2a
EL	The Primary energy requirement for new and renovated building in Greece is = 0.33 – 2.73 x Reference Building energy performance							
ES	The energy performance requirements is not expressed in units of kWh/m^2a							
FI	This is based on thermal transmittance (heat loss) measured in units of W/K. For a single family house, a typical value is 134 W/K							
FR-H1	P_{FF}: 130kWh/m^2a P_{ESH}: 250kWh/m^2a	P_{FF}: 130kWh/m^2a P_{ESH}: 250kWh/m^2a	n/a	n/a	n/a	n/a	n/a	n/a
FR -H2	$P_{FF:}$ 110kWh/m^2a P_{ESH}: 190kWh/m^2a	P_{FF}: 110kWh/m^2a P_{ESH}: 190kWh/m^2a	n/a	n/a	n/a	n/a	n/a	n/a
FR -H3	P_{FF}: 80kWh/m^2a P_{ESH}: 130kWh/m^2a	P_{FF}: 80kWh/m^2a P_{ESH}: 130kWh/m^2a	n/a	n/a	n/a	n/a	n/a	n/a
HU	P: 110-230 kWh/m^2a	P: 110-230 kWh/m^2a	P: 132-260 kWh/m^2a	P: 90-254 kWh/m^2a				
IE	MPEPC = 0.6 & MPCPC = 0.69	MPEPC = 0.6 & MPCPC = 0.69	MPEPC & MPCPC should not exceed 1	MPEPC & MPCPC should not exceed 1				
IT	Regulations for new buildings are based on a set limit for heating, DHW, cooling and lighting. Only Class A+ to C buildings comply with requirements for new buildings							

LT	Min Class C buildings: 80 kWh/m^{2}a for buildings over 3,000 m^2, 100 kWh/m^{2}a for buildings between 501 and 3,000 m^2, 115 kWh/m^{2}a for buildings up to 500 m^2.							
LV	No performance requirements are set							
MT	No performance requirements are set							
NL	P: 68388-68552 MJ/a	P: 35595-36855 MJ/a						
NO	N: 120-173 kWh/m^{2}a	N: 115 kWh/m^{2}a	N: 150 kWh/m^{2}a	N: 120-160 kWh/m^{2}a	N: 300-335 kWh/m^{2}a	N: 220 kWh/m^{2}a	N: 170 kWh/m^{2}a	N: 210 kWh/m^{2}a
PL	F: 142 kWh/m^{2}a H&C: 108kWh/m^{2}a	F: 123 kWh/m^{2}a H&C: 99 kWh/m^{2}a	F: 174kWh/m^{2}a H&C: 183 kWh/m^{2}a	Requirements for other non-residential buildings apply				
PT	P: 203 kWh/m^{2}a F: 80 kWh/m^{2}a	P: 203 kWh/m^{2}a F: 80 kWh/m^{2}a	P:407kWh/m^{2}a F:122kWh/m^{2}a	P:174 kWh/m^{2}a F: 52 F kWh/m^{2}a	P:465 kWh/m^{2}a F:140 kWh/m^{2}a	P:523/1395 kWh/m^{2}a F: 157/419 kWh/m^{2}a	P:233 F:70 kWh/m^{2}a	P:1279 F: 384 kWh/m^{2}a
RO	No performance-based requirements are set							
SE	FE: 55-95 FNE 110-150 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a	FE: 55-95 FNE 100-140 kWh/m^{2}a
SI	P: 170-200 H&C: 50 kWh/m^{2}a	P: 170-200 H&C: 50 kWh/m^{2}a	P: 163-180 kWh/m^{2}a for social housing, for non-residential H&C: 30-50 kWh/m^{2}a, for non-residential (public investment) H&C: 20-40 kWh/m^{2}a					
SK	P: 80-160 H&C 42-86 kWh/m^{2}a	P: 63-126 H&C: 27-53 kWh/m^{2}a	P: 120-240 H&C: 16-56 kWh/m2a	T: 42-84 H&C: 28-56 kWh/m^{2}a	T: 101-201 H&C: 27-70 kWh/m^{2}a	T: 94-187 H&C: 14-71 kWh/m^{2}a	T: 48-95 H&C: 28-56 kWh/m^{2}a	T: 81-161 H&C: 27-70 kWh/m^{2}a
UK	17-20 kgCO_2	16-18 kgCO_2	Other TER (Target carbon dioxide Emission Rate) values apply for non-domestic buildings					

NOTES

AT Based on gross floor area and gross building volume
BG Based on assumption of DD=2100, A/V=0.2 for SFH, A/V=0.8 other, 32% share of glazing for upper limit and DD=330, A/V=1.2, 32% glazing for lower limit
CH Effective space heating demand for a typical building shape calculated on the basis of the SIA-norm 380/1:2009
DK A denotes the gross heated floor area in the Danish formulate, example 73.1 P @80 m^2 58 P @300 m^2
EE Heated floor area
FI For a single family house with building volume 522 m^3, gross floor area 163 m^2, and height between floors 3m.
FR H1, H2 and H3 represent the three main climatic regions in France
IE MPEPC and MPCPC denote the Maximum Permitted Energy Performance and Maximum Permitted Carbon Performance Coefficients used in the Ireland scheme
NO In Small houses, calculated overall net energy demand is limited to 120+1600/m^2 heated floor area.
PL Based on formula EPH+W=73+ΔEP for A/Ve<0.2; EPH+W=55+90 A/Ve+ ΔEP for 0.2< A/Ve<1.05; EPH+W=149.5++ΔEP for A/Ve>1.05 for residential buildings
PT Electricity production efficiency is approx. 0.30. For a 120 m^2 building, max energy needs (in kWh/m^{2}a) are 52-117 for heating, 198 for cooling, 38.9 for DHW
SI Requirements by 31.12.2014
SK Based on assumptions for shape factor, internal air temperature, floor to floor height, air change rate, degree days, etc.
UK The UK requirements are based on achieving a % reduction in CO_2 emissions over a notional building of the same size/shape.
SE Electric heated buildings divided in three climatic zones: 95, 75, 55 kWh/m^{2}a

LEGEND

P: Primary Energy
F: Final
N: Overall Net energy demand limit (includes all electricity for lighting and appliances)
T: Total delivered energy
H: Heating
C: Cooling
H&C: Heating and cooling
MPEPC: Irish Maximum Permitted Energy Performance Coefficient
MPCPC: Irish Maximum Permitted Carbon Performance Coefficient
ESH (subscript): Space heating provided by electricity (incl. heat pumps)
FF (subscript): Space heating provided by Fossil Fuels
E (subscript): Electrically heated building
NE (subscript): Non-electrically heated building
BE – Br: Belgium – Brussels region
BE – Wl: Belgium – Walloon region
BE – Fl: Belgium – Flemish region

Table 2B8 – Key Elements considered in the certification methodology adopted by Member States

Source: BPIE survey

	Thermal characteristics	Heating installation and hot water supply	Air-conditioning installations	Natural and mechanical ventilation	Built-in lighting installation	Design, position & orientation of building	Passive solar systems and solar protection	Indoor & outdoor climatic conditions	Air-tightness	Thermal bridging
AT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BE	Y	Y	Y	Y	Y	Y	Y	Y	Y	P
BG	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CH	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CY	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CZ	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
DE	Y	Y	Y	P	Y	N	N	Y	Y	Y
DK	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
EE	Y	Y	Y	Y	Y	P	Y	Y	P	Y
EL	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
ES	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FI	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FR	Y	Y	Y	Y	Y	P	Y	Y	P	Y
HU	Y	Y	Y	N	P	N	N	N	Y	Y
IE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
IT	Y	Y	Y	Y	N	Y	Y	Y	N	Y
LI	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
LV	Y	N	N	Y	N	Y	N	Y	Y	Y
MT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
NL	Y	Y	P	P	P	Y	Y	Y	Y	Y
NO	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
PL	Y	Y	Y	Y	P	Y	Y	Y	Y	Y
PT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SI	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SK	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
UK	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

LEGEND

Y: Yes
N: No
P: Partly

Prescriptive-based requirements for new buildings

Member States have different prescriptive, element-based requirements associated with building energy codes such as maximum U values, minimum/maximum indoor temperatures, requirements for minimum ventilation rates and boiler and/or air conditioning plant efficiency. Some of the prescriptive criteria associated with the key requirements presented in Table 2B6 are further analysed below.

i. Insulation

Limiting the thermal conductivity of major construction elements is the most common thermal performance requirement for buildings. These are based upon U value requirements (expressed in W/m^2K) for the main building envelope construction elements. These U values are worst acceptable standards which as a stand-alone measure would not necessarily mean that a building meets the overall performance-based requirements in the respective country.

Country by country data on "maximum" U value requirements for roof, wall, floor, window and doors collected through the BPIE survey are shown in Figure 2B7. These are presented against the relevant heating degree days per country or region. Given the diversity in climatic conditions, maximum U value requirements vary widely across different countries where Spain, France, Greece, Italy and Portugal have multiple maximum U values due to the considerable variation in climatic conditions within each country. In some countries, variations also apply for different types of buildings (e.g. Latvia) and type of heating (e.g. Sweden). A comparison between the collected data and the cost optimal U values published by EURIMA/Ecofys[33] in 2007 (see Figure 2B7, blue line) confirm that Member State maximum U values are still higher than the cost-optimal requirements, suggesting that U value requirements in most Member States should be made more demanding. This was also one of the key findings of the IEA information paper on building codes[34] where it was shown that existing U value requirements for building components did not reflect the economic optimum. From Figure 2B7, it can be deducted that this is especially true for countries of mild or warm climates reflecting the equivalent magnitude of effort that is required in those countries. This comes as no surprise as countries in cold climatic zones have had longer traditions in thermal building regulations and therefore stricter requirements.

ii. Air tightness/permeability and ventilation requirements

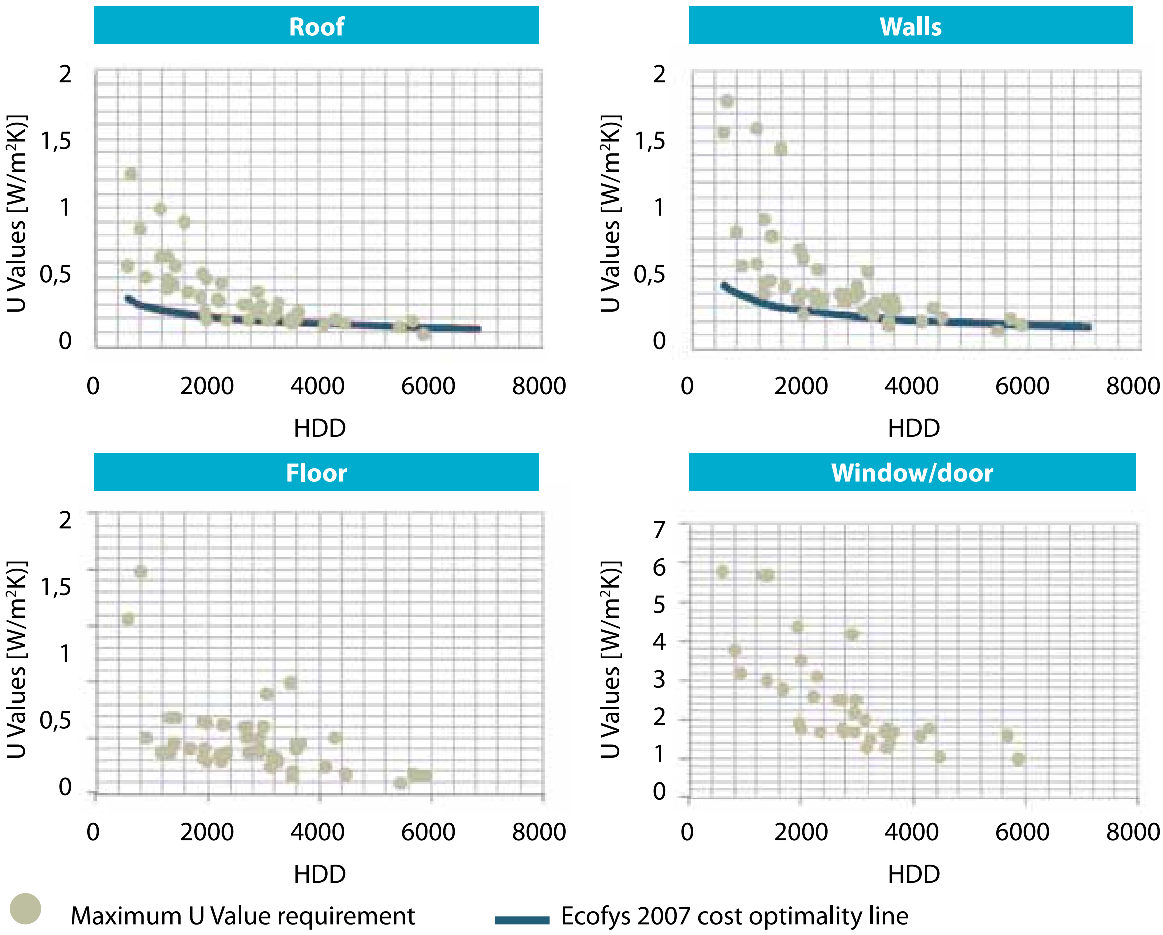
Most countries have introduced requirements to ensure minimum levels of ventilation within buildings. These are generally based upon metabolic rates and activity within the building. The requirements associated with ventilation relate principally to health, comfort and productivity; however they do have direct impact on energy requirements. The thermal performance of buildings is directly related to airtightness and the requirements for ventilation. Excessive ventilation as a consequence of poor construction detailing, can lead to considerable energy wastage and for this reason a number of countries have introduced requirements to limit the air permeability of buildings. Air permeability is normally measured using a pressure test, typically at 50Pa (4Pa in France and 10Pa in The Netherlands) to determine the air leakage rate. The requirement is typically expressed in $m^3/h.m^2$ (where m^2 is the external envelope area) or in the case of Denmark in $l/s.m^2$ (where m^2 is the floor area). Table 2B9 provides a summary of key requirements for Member States which have adopted airtightness requirements.

[33] U –Values for better energy performance of buildings EURIMA 2007 www.eurima.org/uploads/ModuleXtender/Documents/88/documents/EURIMA-ECOFYS_VII_report_p1-65.pdf

[34] Energy efficiency requirements in building codes, energy efficiency policies for new buildings, Jens Laustsen, International Energy Agency, March 2008

Figure 2B7 – Building envelope insulation requirements

Source : BPIE survey. Cost optimality line is based on the analysis undertaken by Ecofys in the study on U-Values for Better Energy Performance of Buildings, 2007



	MT	CY	PT	EL	ES	IT	LV [1]	FR	BG	BE	NL	IE	HU	SI
HDD [5]	560	782	1282	1663	1842	1907	1970	2483	2686	2872	2902	2906	2922	3053
Roof	0.59	0.85	0.9-1.25	0.35-0.5	0.45-0.65	0.32-0.65	0.2κ-0.35κ	0.2-0.25	0.3	0.3	0.4	0.25	0.25	0.2
Walls	1.57	0.85	1.45-1.8	0.4-0.6	0.57-0.94	0.33-0.62	0.25κ-0.5κ	0.36-0.40	0.35	0.4	0.4	0.37	0.45	0.28
Floor	1.57	2		0.45-0.5	0.62-0.69	0.29-0.38	0.2κ-0.35κ	0.37-0.40	0.5	0.6	0.4	0.37	0.45	0.9
Window/ Door	5.8	3.8		2.6-3.2	3.1-5.7	1.3-3.7	1.8κ-2.4κ	1.7-1.9	1.8	2.5	4.2	2.2	1.6	1.1 -1.6

	UK [3]	RO	DE	SK	CH [2]	DK	CZ	AT	PL	LT	EE	SE [4]	NO	FI
HDD	3115	3129	3239	3453	3482	3503	3571	3573	3616	4094	4444	5444	5646	5850
Roof	0.2	0.2	0.24	0.19	0.17 or 0.2	0.2	0.24	0.2	0.25	0.16	0.15-0.2		0.18	0.09
Walls	0.3	0.56	0.24	0.32	0.17 or 0.2	0.3	0.3	0.35	0.3	0.2	0.2-0.25		0.22	0.17
Floor	0.25	0.35	0.3		0.17 or 0.2	0.2	0.45	0.4	0.45	0.25	0.15-0.2	0.4-0.6	0.18	0.16
Window/ Door	2	1.3		1.7	1.3	1.8	1.7	1.4	1.7	1.6	0.7-1.4		1.6	1.0

NOTES

(1) Depending on type of building (residential, public, industrial etc.) where κ is a temperature factor, κ = 19/(Tin-Tout), Tin and Tout denote indoor and outdoor temperatures, respectively.
(2) Depending on evidence of thermal bridges
(3) For England & Wales
(4) Depending on type of building (residential and non residential) & type of heating (electric and non electric). These represent overall U values
(5) Mean HDD values for period 1980-2004 based on Eurostat data

LEGEND
HDD: Heating degree days.

iii. Other requirements
A number of countries (e.g. Austria, Denmark, France, Estonia and Poland) have introduced minimum requirements for specific fan power (generally expressed in W/l.s or kW/m^3.s.). Given the increasing use of mechanical ventilation system, the fan power requirement in low energy buildings is becoming an important issue. Additionally most countries have requirements associated with the minimum performance of boilers and airconditioning systems. Most building codes require minimum levels of daylight to be achieved within buildings, whilst ensuring that solar gains do not result in significant overheating and/or the requirement for air conditioning. Building requirements associated with limiting solar gains vary from simple approaches (e.g. limiting window areas on building aspects exposed to solar gains) through to requirements for complex modelling and simulation to demonstrate that effective measures have been adopted to provide solar protection. The Concerted Action report 1 recommended that much greater attention should be given to the issue of estimating the impact of summertime overheating in the methodology in order to reduce the rapid increase in demand for air conditioning.

In addition to specifying maximum U values, several countries have also set limits for maximum permissible thermal bridging. This is generally expressed in W/mK. Thermal bridges can significantly increase the building energy demand for heating and cooling and in nearly Zero Energy Buildings thermal bridging can account for a significant proportion of the total heat loss or gain. Thermal bridging is specific to the design and specification and can be complex and time consuming to calculate. For this reason, some countries allow a default thermal bridging value to be used, based upon a percentage (typically 15%) of the overall heat loss calculation. However, if a detailed thermal bridging calculation has been undertaken, which demonstrates that thermal bridges have been reduced or eliminated, this value can be used instead of the default. ASIEPI estimate that "a third of EU Member States have no real 'good-practice' guidance on thermal bridges in the framework of their building energy regulations. The quality of guidance in the remaining States is very varied" [35].

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[35] ASIEPI Information Papers P188 and P189 http://www.asiepi.eu/wp-4-thermal-bridges/information-papers.html

Table 2B9 – Airtightness levels in building codes

Source: BPIE survey

AT	In naturally ventilated buildings, maximum n_{50} is 3.0. In mechanically ventilated buildings, maximum n_{50} is 1.5.
BE	Default value of 12 m^3/hm^2 is used in methodology if no pressure test is available. Actual test result is used in the calculation if available.
BG	In apartments with high airtightness, n_{50}<2.0 h^{-1}, with medium airtightness n_{50}=2.0-5.0 h^{-1} and with low n_{50}>5h^{-1}. In SFH with high airtightness, n_{50}<4.0h^{-1}, with medium airtightnessn_{50}=4.0-10.0 h^{-1} and low airtightnessn_{50}>10.0 h^{-1}.
CY	Not regulated in building codes.
CZ	Recommended maximum for common buildings is 4.5 h^{-1}, low energy buildings 1.5 h^{-1} and passive houses 0.6 h^{-1}.For mechanically ventilated buildings w/o heat recovery 1.5 h^{-1}, with heat recovery 1.0 h^{-1}.
DE	For naturally ventilated buildings, n_{50} is 3.0h^{-1} and for mechanically ventilated buildings, n_{50} is 1.5h^{-1}.
DK	Airtightness must be better than 1.5 l/sm^2, tested @ 50 Pa.
ES	Air permeability of windows and doors depend on the climatic zone. For zones A and B (Class 1, 2, 3 and 4), maximum air permeability is 50 m^3/hm^2. For zones C, D and E (class 2, 3 and 4), maximum air permeability is 27 m^3/hm^2.
EL	Air penetration for the reference building, is taken equal to 5.5 m^3/hm^2 frame.
EE	For small buildings, maximum airtightness is 6 m^3/hm^2 (for new buildings) and 9 m^3/hm^2 (for existing buildings). For large buildings, maximum airtightness is 3 m^3/hm^2 (for new buildings) and 6 m^3/hm^2 (for existing buildings).
FI	n_{50} equal to 2.0 is used for reference building heat loss in Finnish Building Code. For EPC, n_{50} of 4 is considered unless the measured value is different. Air change rate in new apartments should be at least 0.5 h^{-1}.
FR	Airtightness under 4Pa of building envelope is limited to 0.8 $m^3/hm^2$for SFH, 1.2 $m^3/hm^2$for other residential buildings, offices, hotels educational and health care buildings and 2.5 m^3/hm^2 for other buildings.
HU	Not regulated in building codes.
LT	For naturally ventilated building, maximum n_{50}=3 h^{-1}, for mechanically ventilated buildings, maximum n_{50}=1.5 h^{-1}.
LV	Maximum n_{50} in dwellings is 3 m^3/hm^2, 4 m^3/hm^2 in public buildings, 6 m^3/hm^2 for industrial buildings. For ventilated buildings, maximum n_{50} is 3 m^3/hm^2.
MT	Not regulated in building codes.
NL	For residential buildings, 200 dm^3/s @10 Pa and for non-residential buildings 200 dm^3/s per 500 m^3 @10 Pa.
NO	Maximum n_{50} is 3.
PT	For residential buildings, the requirement is 0.6h^{-1}. Requirements for non residential buildings with mechanical ventilation exist depending on type of use.
SI	For naturally ventilated buildings, maximum n_{50} is 3.0, for mechanically ventilated buildings, maximum n_{50} is 2.0.
SK	For SFH with high quality windows, maximum n_{50} is 4 h^{-1} and for all other buildings is 2 h^{-1}. Other values apply for buildings with double glazed windows with seals or single glazed windows without seals.
UK	Maximum n_{50}=10 m^3/hm^2

Building code requirements for existing buildings

Despite being an EPBD requirement, not all countries have reported specific mandatory building codes associated with improving the energy performance of existing buildings. It is important to recognise that EPBD (Article 5) only applies to buildings over 1,000 m^2 and most Member States have introduced requirements for consequential improvements associated with buildings over 1,000 m^2. It should be noted that these requirements may not be applied when they are not deemed to be "technically, functionally and economically feasible".

Table 2B10 provides a summary of different approaches adopted by a number of Member States when a building undergoes major renovation. Switzerland has adopted a very progressive approach to improving the performance of existing buildings, where the thermal performance of renovated buildings must not exceed 125% of the new building limit. A number of Member States have introduced minimum component performance standards when building elements (e.g. windows, doors etc.) or energy using plant (boilers, a/c equipment etc.) are being replaced. Good examples include countries which have a performance-based requirement as well as requirements for any component that is replaced or refurbished.

Table 2B10 – Building code requirements for existing buildings

Source: BPIE survey

AT	Specific maximum heating energy demand targets for major renovation of residential and non-residential buildings. Values for renovated buildings are around 25-38% higher than new build requirements. Heat recovery must be added to ventilation systems when renewed. Maximum permitted U values for different elements in case of single measure or major renovations. Prescriptive requirements to limit summer over-heating.
BE	Maximum U values and ventilation requirements apply depending on the region.
BG	Regulations requiring performance-based standards of existing housing and other buildings after renovation. Requirements for new and renovated buildings are the same.
CH	Renovated buildings are required to use no more than 125% of the space heating demand of an equivalent new building. A single element approach may also be applicable for renovations.
CY	Minimum energy performance requirements (class A or B) for buildings over 1,000 m^2 undergoing major renovation.
CZ	Performance-based requirements when a building over 1,000 m^2 is renovated. Requirements for new and renovated buildings are the same.
DE	Conditional requirements apply in the case of renovation of components whereby requirements extend exclusively to those parts of the building surface and parts of the installation that are the subject of the measures. Alternatively, a holistic assessment can also be made where values for renovated buildings should not exceed new build requirements by more than 40%.
DK	Component level requirements when existing buildings are refurbished for all improvements or extensions regardless of building size.
EE	Performance-based requirements for all building types when buildings are major renovated. Values for renovated buildings are around 25-38% higher than new build requirements.
ES	Existing buildings over 1,000 m^2 must comply with the same minimum performance requirements as new buildings if more than 25% of the envelope is renovated.
FI	Reference transmittance/heat loss (in W/K) requirements apply. New energy performance regulations will be launched in 2012.
FR	Performance-based requirements for buildings undergoing renovation apply for residential buildings and values depend on the climate and type of heating (fossil fuel/electricity). Requirements for components also apply during building renovation. New renovation requirements for all buildings from 2013.
HU	Performance-based requirements (in terms of primary energy) apply for residential buildings, offices and educational buildings. Requirements for new and renovated buildings are the same.
LT	Buildings over 1,000 m^2 undergoing major renovation must achieve the energy performance standard of a Class D building where D corresponds to 110 kWh/m^2a for buildings > 3,000 m^2; 130 kWh/m^2a for buildings from 501 to 3,000 m^2; 145 kWh/m^2a for buildings up to 500 m^2.
LV	Requirements on different elements are applicable.
MT	U value requirements for existing renovated buildings.
NL	The Energy Performance Standard (EPN) sets requirements for the energy performance of major renovations of existing buildings (expressed as an energy performance coefficient).
NO	Building regulation requirements only apply when the purpose or use of the building is changed at renovation or if considered so extensive as to be equivalent to a new building.
PT	Special requirements for buildings over 1,000 m^2 and over a specified threshold energy cost. A mandatory energy efficiency plan must be prepared and all energy efficiency improvement measures with a payback of less than 8 years must (by law) be implemented. The threshold is based upon 40% of the worst performing buildings by typology.
SI	Minimum requirements apply to major renovations (i.e. if at least 25 % of the envelope is renovated). The requirements apply to buildings of all size (NB the 1,000 m^2 limit is not used). Min. requirements apply for the renovation of heating systems.
SK	Requirements for improving the thermal performance of apartment by at least 20% when being renovated.
UK	Specific requirements when replacing "controlled elements" such as windows, boilers and thermal elements in residential buildings. Consequential improvement requirements for buildings over 1,000 m^2 undergoing major renovation in so far as they are "technically, functionally and economically feasible".

Enforcement and Compliance
Building control requirements prior to, during and upon completion of the construction phase typically involve announcement to authority, application for permits, approval of plans, inspections by authority and completion of certificates. These requirements can be a critical step for ensuring regulation enforcement. Based on a comprehensive review of Building Control published in June 2006[36] by the Consortium of European Building Control (CEBC), building control systems in Europe have undergone significant change over the past two decades. In many countries greater market liberalisation has resulted in a move away from government-run building control functions. There are growing calls for minimum quality assurance standards to be introduced in all countries to licence, audit and regulate the activities of individuals (both public and private) involved in undertaking the building control function. This is particularly important in the context of the structural, fire protection and energy performance regulation requirements, where the issues are technically complex and specialist skills and expertise is required.

In the context of renovations, the BPIE survey has gathered information on the requirements, typical time period and main obstacles associated with obtaining a permit for carrying out renovation work. From the reported answers, it was clear that not all countries have permit requirements for renovations while, for the ones that do so, permits are typically necessary if major changes are undertaken in the façade of buildings (from modifying the roof to adding external insulation in case of France). Moreover, the time required to obtain a permit could vary substantially from one month (e.g. in Czech Republic) to several months (e.g. in Belgium) where the timeframe can be shorter if the project is supported by a renovation programme (e.g. in Germany this is the case with the KfW Programme).

In addition, many observers suggest that the compliance and enforcement of building energy codes is currently undertaken with less rigour and attention to detail, than other building regulation requirements such as structural integrity and/or fire safety. While there are few studies on compliance with building energy codes, there is a growing body of academic research suggesting that as building thermal requirements become more demanding (e.g. in the pursuit of nearly Zero Energy Buildings) there is increasing evidence of a performance gap between design intent (i.e. theoretical performance as modelled using national calculation methods) and the actual energy performance in-use. This suggests one or more of the following issues: the calculation methods are flawed, the enforcement regime is not being undertaken sufficiently rigorously or designers and builders are failing to satisfactorily deliver the outcome intended.

Closing the performance gap between design intent (and regulatory requirement) is likely to become an important issue over the next decade if countries are to deliver the climate and environmental targets related to buildings. The key findings of the PRC/Delft Univ. of Technology review of National Building Regulations[1] found that there was "little attention yet to enforcing sustainable building regulations in most of the various countries analysed". The report also suggested that, given the highly technical nature of the requirements associated with sustainability and energy, there was a serious shortage of individuals with appropriate expertise to undertake the building control function. This is resulting in poor enforcement of compliance associated with these important issues.

[36] Consortium of European Building Control BCR Report Building Control Systems in Europe June 2006 http://www.cebc.eu/files/reports/bcr_-_issue_2_-_sep_2006.pdf

C. FINANCIAL PROGRAMMES

The regulatory framework described in section 2B provides an increasingly demanding set of requirements aimed at new buildings in particular, and to a lesser extent for improving the energy performance of the existing stock. However, many potential areas of improvement to existing buildings remain outside formal legislative or regulatory requirements. To address these shortcomings, a variety of financial programmes have been introduced. Member States have used many financial instruments in various forms since the first oil crisis in the 1970s. However, financial issues are now more important as Europe strives towards increasing building energy performance. This is highlighted by Article 10 in the recast of the EPBD on financial incentives and market barriers. Article 10, paragraph 1 states:

"In view of the importance of providing appropriate financing and other instruments to catalyse the energy performance of buildings and the transition to nearly zero- energy buildings, Member States shall take appropriate steps to consider the most relevant such instruments in the light of national circumstances."

The Article goes on to state that Member States were to have drawn up by June 30th a list of "existing and, if appropriate, proposed measures and instruments including those of a financial nature, other than those required by this Directive, which promote the objectives of this Directive." This list is to be updated every three years and the Commission is to "examine the effectiveness of the listed existing and proposed measures..."

As shown throughout this report, any ambitious retrofit strategy will have to address financing in a major way.

REVIEW OF CURRENT FINANCIAL PROGRAMMES

In its survey for this study, BPIE requested information on the range of financial instruments that are being implemented in Member States. For completeness, BPIE cross checked with information available in recent studies and on-line databases (see below). Because of the wealth of material, BPIE will create a separate report available for download on its website documenting all financial instruments in Member States.

Figure 2C1 – Types of financial programmes and incentives on the energy performance of buildings

Financial programmes fall into the main categories illustrated in Figure 2C1. For the most part, schemes are funded by public authorities. These could be at the national/federal level, or regionally/locally. EU structural funds and resources from other EU and international sources are also available for renovation works, particularly in the Central and East region countries. Many of these schemes are targeted at poor quality apartment blocks constructed prior to 1990. By contrast, white certificate schemes place an obligation on third parties, typically energy companies, with the costs ultimately borne by energy consumers through an increase in energy tariffs.

A summary of the financial programmes currently operating in individual EU Member States, together with Norway and Switzerland is provided in Table 2C1.[37] This table shows how the wide range of financial instruments is used throughout Europe. BPIE has identified 333 separate schemes. It can be seen that direct financial support in the form of grants or subsidies is prevalent throughout Europe. Many countries support residential as well as non-residential buildings, both new build and existing (though not necessarily in the same programme), while others focus on renovating the existing building stock. A number only support residential buildings. There are also many schemes that target specific technologies, such as insulation, boiler scrappage, renewables, or specific building categories, such as social housing, the public sector, panel buildings. There are several schemes that provide support for new passive buildings.

Various forms of loans and tax incentives are used in many countries. These are usually available for individuals as well as businesses, thereby covering most of the building stock outside the public sector. Somewhat less popular are energy supplier obligations/white certificate schemes, audits and third party financing, used in only a handful of countries, though the use of energy supplier obligations could become mandatory across all EU Member States if the current proposal in the draft Energy Efficiency Directive is approved.

In terms of programme size, whilst it is difficult to make direct comparisons due to different funding regimes and timescales, the financial support varies considerably from around €1M/a to in excess of €1bn/a. Larger programmes tend to be support for improvements to social housing stock. These have traditionally been funded at large scale through financial transfers from central governments to local/regional authorities or public housing bodies. While the original purpose of these schemes has been to meet basic housing requirements, funds are increasingly directed towards improving the energy performance of social or public housing.

Programmes often take 3-5 years, though individual initiatives can last anything from one year to over a decade. This is a concern if a retrofit strategy is to be for the long term. The Energy Audit Programme in Finland has operated since 1992, while energy suppliers in the UK have been under some form of energy saving target obligation since 1994. It is noteworthy that a number of schemes have been terminated recently as a result of the credit crunch and consequent measures to rein in public expenditure. Table 2C2 summarises some of the identified programmes operating in different countries across Europe illustrating theirwide range and nature.

[37] It should be added that there are two on-line databases that provide updated information on financial instruments. The first is MURE which is a joint project under the Intelligent Energy for Europe Programme of the European Commission/DG Energy of all energy efficiency agencies in the EU 27, Croatia and Norway. MURE is an information platform on energy efficiency policies in Europe. See http://www.mure2.com/. The second is the International Energy Agency that has the Policies and Measures Databases offer access to information on energy-related policies and measures taken or planned to reduce GHG emissions, improve energy efficiency and support renewable energy development and deployment. See http://www.iea.org/textbase/pm/index.html.

Table 2C1 – A summary of the current financial programmes in the EU

Source: BPIE survey

	Grants, Subsidies, Funds	Loans	Tax Incentives, Levies Etc	Obligations, white certificates	Audits	3rd Party finace, ESCOs	Other
AT	All		Households			Existing bldgs	
BE	All		Households & Business	Flanders region			
BG	Existing bldgs	Residential and Public bldgs	Class A or B new build				
CZ	All	Public bldgs				Existing residential bldgs	
CY	All						
DK	Existing bldgs						
ES	Residential	Residential			Residential		
FI	All		Households		Existing non-residential		
FR	All	All	Households & Business	Existing buildings	Private sector		Feed-in tariff; training scheme
DE	All	Residential				Public buildings	Feed-in tariff
GR	Existing bldgs		Private sector				
HU	Existing bldgs		Planned				
IE	Residential		Business	Imminent			
IT	Existing bldgs	Existing bldgs	Households & Business	All		Yes	Feed-in tariff
LT	Existing bldgs						household renewable grants
LI	All						
LU	All	New homes					
MT	All						
NL	Residential	New private non-residential	Private sector				All
NO	All					All	
PL	Public sector	Existing bldgs		Planned			
PT	All		All				
RO	Residential bldgs						
SK	Existing bldgs	Existing bldgs					
SL	Private residential and Public non-residential	Private homes				Public residential	
ES	All	All	Households			Public sector	
SE	All		Households & Business				Technology procurement
CH	All		Households & Business				
UK	Existing bldgs	Residential	Households & Business	Residential		Public sector	Feed-in tariff

Table 2C2 – A summary of selected financial programmes across Europe

Source: BPIE survey

AUSTRIA - Federal promotion of extraordinary efficiency in buildings

In 2006, Austria's federal and state governments launched a programme for residential buildings to achieve a consumption level of 65kWh per square metre, falling to 25-45 kWh/m^2 by 2010, including incentives for use of renewable heating systems. The programme is expected to generate 10,000 additional jobs (Total budget: €1.78 billion).

BELGIUM - Interest free loans to stimulate retrofitting in Wallonia region

A 1-billion euro plan including energy efficiency renovations is to be adopted soon in Wallonia. The objective is to reduce energy bills and CO_2 emissions, while creating 5,000 jobs by 2014. The programme covers private dwellings and public buildings including public housing, schools and municipal buildings. The renovations will benefit from private support up to 100% financing. In the case that the owner agrees to make several renovations, the costs not covered by the premiums will be interest-free loans.

FINLAND - Energy audit programme

Finland's Energy Audit Programme (the EAP) is one of the oldest national energy efficiency grant schemes in place. EAP started as a subsidy policy in 1992 and has operated as a full-scale programme since 2004. It is a voluntary programme promoted by a 40 % to 50 % subsidy on energy audits. The total amount of subsidies during the period of 1992-2007 has been €23.1M. Since 1992 some 6 800 buildings have been audited. The cumulative savings during the whole period 1992-2007 are approximately 360 million EUR and over 11 TWh, of which industry accounts for about 70 %.

FRANCE - The sustainable development account (livret de developpement durable)

It is a savings account that pays tax-free interest of 2.5% a year for investments of up to €6000. Together with funds raised from the previous CODEVI account, total funding is expected to reach €60bn. Since January 2008, every bank must allocate at least 2 % of the total account to the improvement of the energy performance of the building. Preferential loans can be awarded to individuals, co-properties and entrepreneurs for the purchase and installation of: energy efficient boilers; thermal insulation (walls, windows, shutters); thermal regulation equipment; equipment producing energy from renewable sources; space and water heating equipment using wood or other biomass; heat pumps.

GERMANY - Loans and subsidies from the reconstruction credit institute, KfW

The government-owned banking group Kreditanstalt für Wiederaufbau (fW) plays a central role concerning promotion of energy savings and CO_2 reduction in the building sector. Between 1990 and the end of 2009 subsidies for at least 3.1 million homes were implemented. In 2009, total subsidies amounted to €16.9 billion, of which €10.6 billion was for energy efficiency and €6.3 billion for renewable energies. KfW offers subsidies and loans for new buildings as well as energy efficient renovations that meet requirements of the quality label "Effizienzhaus" (efficient building).

POLAND - Energy management in public sector

"The Green Investment Scheme – Energy management in public sector" supports implementation of thermal modernization projects in public services buildings, in particular: a. heat insulation of the buildings, b. replacement of windows and external doors, c. upgrading lighting and heating, ventilation and air-conditioning systems, d. drawing up technical documentation for the project, e. energy management systems in buildings and f. use of renewable energy sources. (Budget: PLN 555M as a subsidy (equivalent to 126M euro), PLN 1110 bn (equivalent to 250M euro) in the form of a loan extended by the National Fund).

SLOVAKIA - Energy efficiency and renewable energy finance facility

The European Bank for Reconstruction and Development (EBRD) in cooperation with the Slovak Government have financed a programme for local banks to provide loans between 20,000 EUR and 2,500,000 EUR (as well as grants of 7.5-15% of the loan amounts), together with free technical assistance, for private companies and housing associations implementing energy efficiency and renewable energy projects.

SPAIN - Plan to boost energy services contracts (PLAN 2000 ESE)

The plan articulates a set of measures to reduce energy consumption in the targeted buildings by at least 20%. Alongside reductions in CO_2 emissions and reduced energy dependence, the aim is to boost the market for ESCOs, thereby increasing stable employment. The implementation of the plan is expected to have a favourable impact, either from the point of view of the expected energy savings, reduction in CO_2 emissions, the cutback on energy dependence and the market boost of ESCOs, which will be translated into stable employment.

SWITZERLAND - National building support programme of the climate cent foundation

The Climate Cent Foundation (now the Buildings Programme) is funded by a charge levied on all petrol and diesel imports at a rate of 1.5 cent per litre. Support is for energy renovation of existing buildings envelopes, i.e. roofs, walls and windows. By October 2010, 6750 projects had been completed and 118 million Swiss Francs had been paid out. Over the period 2008 to 2012, contracted projects will reduce 240000 tonnes of CO_2 emissions at an average price of 790 Swiss Francs per tonne of CO_2.

UK - Energy supplier obligations

In force since 1994, they initially applied to monopoly electricity suppliers in England and Wales, but were soon extended to cover suppliers in Scotland and N. Ireland, and then, from 2000, gas suppliers throughout the UK. The scheme has also evolved from a levy-based approach, where particular levels of expenditure per supplier were mandated, into one where, since competition was introduced into the retail sector in 1998-99, the obligation has shifted to meeting a carbon reduction target, without specifying the level of expenditure. Initially applicable to households and small-medium businesses, the scheme has applied to the residential sector only since 2000.

IMPACT OF FINANCIAL PROGRAMMES

The key concern is the level of ambition that can be attained from financial programmes to motivate consumers to invest in deep renovation. Some of the schemes identified with the most ambitious objectives in terms of potential energy savings achieved were:

1. In Austria, under the 'Federal Promotion of Very High Efficiency Buildings', an initial standard of 65 kWh/m^2 in 2007, going to 25 kWh/m^2 in 2010 was required in order to qualify for state funding.
2. In the Flemish region of Belgium, under the energy savings investments in dwellings rented by social renting companies, 100% of the costs are reimbursed for roof insulation, high efficiency windows and condensing boilers.
3. The Czech Republic's PANEL programme provides for total retrofitting (insulating buildings, improving heating systems, distribution pipes and sources of heat and hot water and use of renewable energy).
4. In Estonia, the Green Investment Scheme requires at least 20% energy savings. The Renovation Loan for apartment buildings also requires at least 20% energy savings.
5. In France subsidies are available for low consumption buildings and retrofits (AAP PREBAT).
6. In Germany, in its 'Housing Modernisation Scheme', investors receive a long-term low-interest loan of up to €100,000 with a fixed interest rate for 5 to 10 years and redemption-free grace years. While there is no target, the amount available should lead to very ambitious improvements.
7. In Romania, the 'Multiannual National Programme' for increasing the energy performance of apartment blocks/houses requires a decrease in energy consumption from 180-240 kWh/m^2 to below 100 kWh/m^2.
8. In Spain, the 'Support for Energy Efficiency in Buildings', encourages buildings to attain a high energy rating of A or B. Separately, PLAN 2000 ESE, which promotes energy service contracts, requires energy savings of at least 20%. The Activation Plan, using ESCOs, also requires a reduction of 20% for state buildings.

The results of the selected measures described above are encouraging, but many of them are only modest in their ambition. Achieving a 20% reduction may sound impressive, but much more is needed and possible.A study published by EuroACE in 2010 illustrated the cost effectiveness[38] of such programmes to governments which has been estimated to be around €20-25/tonne of mitigated carbon emissions, a figure which is lower than virtually all alternative non-traded carbon abatement measures. However, being cost effective does not reflect the level of ambition. The schemes identified above show a reasonable level of ambition to save energy but a 20% energy savings is not enough if Europe is to achieve an 80-95 % reduction in GHG emissions reductions by 2050.

One major concern is that the use of financial instruments today is only achieving the business-as-usual case in Europe with very few financial instruments providing enough funding for deep renovations. If the goal is to significantly increase the number of deep renovations to meet 2050 aspirations, it will require more innovative approaches than what is seen today. There are steps underway to improve the availability of new financing instruments. Innovative approaches include Energy Supplier Obligations, energy service companies, the use of EU structural funds more effectively and possible targets to renovate specific building sub-sectors (e.g. the proposal in the draft Energy Efficiency Directive to Member States to renovate a certain percentage of public buildings annually) which will require Member States to "unlock" funding for such renovations.

The recast of the EPBD requires Member States to outline the current and proposed financial instruments for the buildings sector. Most Member States are doing this through their submission of National Energy Efficiency Action Plans due June 2011.[39] That provides an opportunity for Member States to reflect on how financial instruments can be used more ambitiously and an opportunity for the European Commission to monitor whether Member States are taking ambitious enough steps.

[38] Klinckenberg Consultants, Making Money Work for Buildings, Financial and Fiscal Instruments for Energy Efficiency in Buildings, EuroACE, September 2010. Cost-effectiveness was calculated on the basis of the cost of the programme (typically to government) per ton of CO_2 emission avoided, over an impact period of up to 30 years (and shorter for investments with a shorter lifespan) For more information, go to: http://www.euroace.org/MediaPublications/PublicationsReports.aspx

[39] Updates of the national submissions are available at: http://ec.europa.eu/energy/efficiency/end-use_en.htm. As of August 26, 19 Member States had submitted their plans.

D. OTHER PROGRAMMES

The BPIE 2011 survey did not directly survey other policy instruments beyond the regulatory building codes and financial programmes. Primarily, the measures concern various aspects of information: awareness programmes, training, specialised publications, networks and information exchange. There are also research and development programmes at both the national, EU and international levels.

Information

Appropriate information to consumers, decision makers, the energy service sector, architects, distributors and others in the energy efficiency field ensures that more of the cost-effective potential is achieved. There is a wide range of information programmes throughout the region and the number of programmes has expanded significantly in recent years. Information programmes cover a large spectrum from mass media campaigns, information centres, training, technical manuals and brochures, labelling and energy audits. They can be used for awareness creation or for providing detailed information to various actors: consumers, equipment operators/technicians, managers of building complexes, engineers, architects and decision makers.

Awareness creation is often considered key because many consumers have little understanding of the cost-effective potential for improvements for energy efficiency or of the techniques to make such improvements. Awareness creation is also important for service providers (e.g. auditors) to show the market potential available. All Member States are active in awareness creation.

One rather recent addition to help in information sharing is the European portal for energy efficiency in buildings, BUILD UP (www.buildup.eu) funded by the European Commission. It is for buildings professionals, local authorities and citizens. The BUILD UP web portal brings together new practitioners and professional associations while motivating them to exchange best working practices and knowledge and to transfer tools and resources.

Training

When first introduced in 2002 the EPBD recognised that new approaches to buildings performance were going to be needed. The recast of the EPBD, approved in 2010, increased the need for new approaches that would require improving the capacity of a wide range of people. For new buildings, architects and designers would need to learn to integrate latest thinking to maximise performance. This is particularly true for the nearly Zero Energy Buildings that will be required by December 31, 2018 for public buildings and December 31, 2020 for all buildings – residential and non-residential. Strategies need to be developed by Member States and these have to be submitted to the Commission in early 2012.

The recast Directive makes several references to the importance of training. Furthermore, the Energy Efficiency Plan published by the Commission in March 2011 states:

There is a clear lack of appropriate training (e.g. for architects, engineers, auditors, craftsmen, technicians and installers). Energy efficient building solutions are often technically demanding and put high knowledge requirements on the parties involved. Today, about 1.1 million qualified workers are available, while 2.5 million will be needed by 2015 in order to improve the energy efficiency of buildings and better integrate renewable energy technologies. The lack of a qualified workforce leads to sub-optimal renovation or installation of appliances – hence it is essential that the right skills are available; major training and qualification efforts will be required.

The European Commission, through its Intelligent Energy Europe programme, is providing support for training programmes.

R&D

The European Union supports R&D through Framework Programme 7. This includes funding for energy efficient buildings. Currently, much of the focus is on public-private partnerships for energy-efficient buildings and the demonstration of zero carbon building renovations for cities and regions.

The European Commission and many Member States also participate in technology programmes of the International Energy Agency, based in Paris. Participation is through the use of Implementing Agreements of the IEA that allow participating countries to share research efforts. For buildings there are separate implementing agreements on buildings and community systems, district heating and cooling, energy storage, heat pumping technologies and efficient electrical end-use equipment. The IEA recently published a report outlining the effectiveness of their implementing agreements and the strategies for the future.[40] EU countries are very active. For example, for the agreement on buildings and community systems, 15 Member States participate as well as Norway and Switzerland. Many of these implementing agreements have been operating since the 1980s.

[40] IEA, Energy Technology Initiatives, Implementation Through Multi-lateral Co-operation, IEA/OECD, 2010.
For more information on the buildings-related implementing agreements go to http://www.iea.org/techno/technologies/enduse.asp.

PART 3

RENOVATING WITH PURPOSE – FINDING A ROADMAP TOWARDS 2050

"Designing a roadmap for the systematic renovation of the European building stock is not only key to reach the European climate targets, but would also leverage urgently needed economic and social benefits."

The previous chapters so far have given a detailed overview of the buildings sector, from the physical qualities of the sector to the policies that are driving improvements in energy savings. Our assessment reveals a very heterogeneous European building stock and varied and unbalanced policies which are not properly addressing the cost-effective potential. Consequently, the energy performance of the European building stock should be significantly improved in order to realise the ambitious targets for improving energy efficiency by 2020 and the even more ambitious targets for GHG emissions reductions by 2050.

However the energy savings targets are not binding and this affects the effectiveness of the implementing measures. Recent policy pronouncements from the EU show that Europe is not going to achieve the 2020 energy savings target without new policies and without better implementation of current policies. One of the major weaknesses of the 2010 recast of the Energy Performance in Buildings Directive has been on existing buildings. While a cost-optimality calculation is being developed and while there is a definition for major renovations, there are no effective instruments to drive the market to increase the rate of renovation (for more energy savings) and to increase the rate of "deep" renovations.

One of the aims of this report is to identify the measures, policies, actions and solutions to barriers that need to be taken in order to put Europe onto a path that can achieve the complete renovation of the existing building stock by 2050. The Commission's analysis from the low carbon road map shows that emissions in the building sector must be reduced by as much as 90% by 2050 if the climate change goals are to be met. As this report argues, the most effective way of achieving that target is through a combination of cutting energy demand in buildings through increased energy efficiency and wider deployment of renewable technologies on and in buildings together with decarbonising energy supplies. Reducing energy consumption has another particular importance in improving security of supply and reducing import dependency. The EU 27 dependency on energy imports increased from less than 40% of gross energy consumption in the 1980s to 54.8% by 2008, with the highest dependency rates for crude oil (84.2%) and for natural gas (62.3%)[41].

In order to define the necessary effort for fostering the improvement of the actual building stock and to reach the overall aims of energy and emissions reduction, BPIE has developed a number of possible scenarios for the renovation of the EU building stock by 2050, including a "business-as-usual" case, assuming that the current rate and ambition of renovation continues. The other scenarios give plausible and feasible options for significantly ramping up renovation activity, depending in large part on the policy framework that can be developed. After giving an overview of the model, this section will describe and compare the scenarios and provide some conclusions on the future way forward for Europe.

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[41] Eurostat: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Energy_production_and_imports

A. ECONOMIC PERSPECTIVES

It is generally recognised that energy efficiency is the cheapest way of reducing carbon emissions. The EPBD Impact Assessment[42] concluded that the potential for cost-effective energy savings in the EU building stock is about 30% in the period to 2020. Opportunities to improve the energy performance of buildings include:

- Improving the thermal performance of the building fabric through insulation of walls, floors and roofs, and replacement and tightening of windows and doors.
- Improving the energy performance of heating, ventilation, air conditioning (HVAC) and lighting systems.
- Installation of renewable technologies such as photovoltaic panels, solar thermal collectors, biomass boilers, or heat pumps.
- Installation of building elements to manage solar heat gains.

Each individual improvement measure has a cost and a saving associated with it that are specific to a particular building, as well as ancillary benefits:

- Costs can vary depending on whether measures are installed individually or as a package, and also whether improvements are being undertaken at the same time as maintenance, repair or building upgrade/modernisation. For example, if HVAC equipment is at the end of its useful life, the cost of the energy efficient option would be the marginal extra cost over a standard efficiency replacement.
- Savings will depend on the previous level of energy consumption, energy sources used, the price of energy, the lifetime of the measure and also future movements in energy prices. Some of the savings may be offset mainly when energy efficiency measures address fuel poverty, but overall this rebound effect may be partially compensated by other above mentioned factors (e.g. by the increase of energy prices or even by behavioural measures).
- New windows and efficient HVAC systems are known to increase the value of a property. The value of high levels of insulation and buildings integrated renewable technologies have yet to be fully appreciated by consumers, though this will change over time as the benefits of low energy consumption, a good energy rating (A-B) and a low carbon footprint become more recognised and accepted across society.
- Additional user benefits include lower noise levels and improved comfort from insulation and glazing, better indoor air quality and temperature control from new HVAC equipment, less operational maintenance or increased energy security and protection against price fluctuations through deployment of renewable energy resources that are not dependent on conventional distribution systems.
- Societal benefits range from reduced GHG emissions, improved energy security and alleviation of fuel poverty.
- Socio-economic benefits through development of new green businesses and employment opportunities.

While the ancillary benefits are of real value and can often be the main factor in determining whether a particular investment is made (for example to increase comfort or reduce draughts), the case for investing in improved energy performance is often made purely on economic grounds. This is unlike the case for other comparable investments in a property. For example, in a residential context, consumers will often spend large sums of money on renovating kitchens and bathrooms for aesthetic reasons, without undertaking a cost-benefit analysis.

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[42] Impact assessment, accompanying document to the proposal for a recast of the energy performance of buildings directive (2002/91/ec), 2008. http://ec.europa.eu/energy/strategies/2008/doc/2008_11_ser2/buildings_impact_assesment.pdf

Even when viewed purely in economic terms, investments in energy saving typically need to meet a higher hurdle rate than other investments. For example, an energy saving measure costing €10,000 that saves €2,000 each year has a simple payback of 5 years. Many consumers or businesses would be reluctant to make this kind of investment seeing it as not being sufficiently attractive. Yet if the life of the measure is as little as ten years, the investment would generate an internal rate of return (IRR) of 15%, assuming no change in energy prices (with a measure life of over 20 years, the IRR is nearly 20%). This is a highly attractive return on investment and such an energy saving project is clearly profitable.

Notwithstanding the above, the case for a renovation roadmap argued within this report is made largely on its economic merits.

There are 25 billion m^2 of buildings in the EU27 together with Switzerland and Norway ranging from homes, offices and retail premises to hospitals and leisure centres. As highlighted in Part 1 of this report, this building stock exhibits a multiplicity of different shapes, sizes, styles, ages, fuels used, occupancy and location. Each of these factors has an impact on the energy and cost savings achievable.

An added dimension to the issue of building renovation is the decision-making process. Each building has an owner and an occupier – in some cases this will be the same person or organisation, while in others they will be different. Indeed, large and complex commercial buildings are often characterised by multiple levels of ownership. Decisions on whether to renovate a building could be taken by either the owner or the occupier, or indeed jointly, making it difficult to identify the responsible party. Likewise, the costs will be affected if multiple parties are involved in the process. This is a classical barrier for deciding on the renovation of a building, also known in literature as the tenant-landlord dilemma (or the so called split incentive barrier).

It is clear from the above that there is a very wide range of possible costs and savings for an almost endless permutation of improvement measures across the European building stock. In some cases, an improvement might be the result of a single measure like an upgrade of the HVAC equipment, while in others it could comprise a holistic solution to an entire complex of buildings, with a package of measures. In order to rationalise these variables, it is necessary to develop a standard metric for determining and reporting the costs of measures. The simplest approach is to relate the total cost of a renovation (whether it be for a single measure or an entire building) to the building floor area, i.e. €/m^2.

To date, there has been no systematic attempt to garner comprehensive data on energy saving renovation costs at European level. Moreover, the renovation costs vary greatly among EU regions and countries, being influenced by many factors such as market development, prices of materials, financing cost, labour market costs and the existence of specific support programmes and policies. While the difficulty of collating such data is recognised, this is a major shortcoming that needs to be addressed, given the importance of energy savings measures in the existing building stock to the EU's climate and energy security targets.

That said, a number of national or regional studies have quantified the costs of achieving different levels of energy performance improvement across a range of building types. Most typically, these relate to residential properties, for which the improvements can more readily be analysed and indeed replicated over a number of similar dwellings.

In what is perhaps the most comprehensive analysis of renovation measures for residential properties, ARGE[43] calculated the costs and savings for achieving six different levels of energy performance across three typical German dwelling types, assuming three starting positions – modernised, part-modernised

[43] http://www.bdb-bfh.de/bdb/downloads/ARGE_Kiel_-_Wohnungsbau_in_Deutschland_2011.pdf

and un-modernised. Compared to the original energy consumption, energy savings varied from around 20% to over 90% for the highest level of performance, with corresponding costs in the range €100-800/m^2. Another study[44] based on Hungarian buildings derived much lower costs for a similar range of savings: from €50/m^2 to €300/m^2.

These figures should also be seen in the context of current and evolving practice in renovation across Europe. While there is a great deal of experience on implementing single measures (e.g. window/boiler replacement, or insulation of walls/roofs), the experience of holistic "whole building" solutions is much more limited. Achievement of very high levels of energy saving, such that the building approaches nearly zero energy levels, requires deployment of buildings-integrated renewable technologies, and various energy efficiency measures which have a high cost improvement potential. This suggests that the cost of achieving high levels of energy saving will come down more rapidly over time than for the more established measures which deliver more modest savings. It is also important to note that different national priorities will dictate to a significant extent the costs of different types of renovation.

For example, a programme offering incentives for particular technologies would typically help to stimulate demand and over time, reduce the cost of the technology compared to another country without the programme or with a different energy price structure. In addition, long term renovation programmes generate consistent benefits in both construction and supply chain industries, with a significant job creation potential and a constant improvement of workers' qualification and skills.

Renovation databases have been established in the UK[45] and France[46]. At present, these hold limited amounts of data, but provide a good example of the kind of knowledge base that needs to be built up in order to provide a more complete picture of the range of renovation activities, including building types, costs, savings and lessons learnt.

These studies and data sources, together with information provided by experts located in 29 countries across Europe and an extensive literature search, have provided the first attempt to quantify renovation investment costs at European level. After allowing for differences in costs between higher cost and lower cost countries[47], average costs for different levels of renovation have been derived in Table 3C1.

Defining renovation levels and associated costs

The term "renovation"[48] has been used by different commentators to describe a wide variety of improvements to an existing building or group of buildings. In the context of this report, "renovation" is taken to mean an upgrade to the energy performance, unless otherwise specified.

Qualitatively, it can be seen that a renovation to a building facade (i.e. walls and windows) will provide a different level of energy saving than one addressing all of the building envelope and its energy systems (HVAC, lighting etc.) as well as the installation of renewable technologies. There is therefore a need to categorise different levels of renovation.

At its most basic, the energy performance of a building can be improved by the implementation of a single measure, such as a new boiler plant or the insulation of the roof space. Normally, these types of measures might be termed "energy efficiency retrofit", though for the purposes of this report, the term "minor renovation" is proposed. Typically, energy savings of up to 30% might be expected by the application of one to three low cost/easy to implement measures.

[44] "Employment Impacts of a Large-Scale Deep Building Energy Renovate Programme in Hungary" - Ürge-Vorsatz et al, Central European University
[45] http://www.rethinkingrefurbishment.com/portal/
[46] http://www.effinergie.org/site/Effinergie/70-ProjetsRealisations
[47] Eurostat purchasing power data were used to normalise costs
[48] "Retrofit" and "refurbishment" are often also used to describe essentially the same process.

At the other end of the scale, renovation might involve the wholesale replacement or upgrade of all elements which have a bearing on energy use, as well as the installation of renewable energy technologies in order to reduce energy consumption and carbon emission levels to close to zero, or, in the case of an "energy positive" building, to less than zero (i.e. a building that produces more energy from renewable sources than it consumes over an annual cycle). The reduction of the energy needs towards very low energy levels (i.e. passive house standards, below 15kWh/m^2 and year) will lead to the avoidance of a traditional heating system. This is considered to be a break point where the ratio of the benefits (i.e. energy cost savings) to investment costs reaches a maximum. We propose calling these renovations nearly Zero Energy Building (nZEB).

In between these two examples are renovations involving a number of upgrades. These can be subdivided into "Moderate", involving 3-5 improvements resulting in energy reductions the range 30-60%, and "Deep" (60-90%). A deep renovation typically adopts a holistic approach, viewing the renovation as a package of measures working together.

Table 3A1 summarises the 4 categories of renovation, together with average total project costs for energy efficiency measures, expressed in €/m^2 floor area. The costs reflect the total installed costs of measures, i.e. materials, labour and professional fees, but do not include any costs not directly related to improving the energy performance of buildings.

Table 3A1 – Renovation type and cost estimates

Source: BPIE model

Description (renovation type)	Final energy saving (% reduction)	Indicative saving (for modelling purposes)	Average total project cost (€/m^2)
Minor	0-30%	15%	60
Moderate	30-60%	45%	140
Deep	60-90%	75%	330
nZEB	90% +	95%	580

Renovation Rate

In addition to a lack of comprehensive information on the costs and savings of building renovations, there is little data on the numbers of renovations being undertaken, their depth, or indeed trends in renovation rates. Most estimates of renovation rates (other than those relating to single energy saving measures) are mainly between around 0.5% and 2.5% of the building stock per year. These rates typically reflect the activity of the past few years which in some cases are linked to special circumstances during those years (e.g. the existence of a renovation programme) and therefore may not be of normal practice. In this work, it is assumed that the current prevailing renovation rate across Europe is 1%[49]. The available results from a number of sources are provided in Table 3A2.

[49] This is in line with the study carried out for the European Commission led by Fraunhofer Institute on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries (2009). In this report, refurbishment rates of 1.2%, 0.9% and 0.5% per year were assumed for North-Western Europe, Southern Europe and New Member States respectively.

Table 3A2 – Renovation rates across different Member States (annual % of building stock renovated)

Source: BPIE survey

Country	Residential	Non-residential	Unspecified	Comment
AT			1.20%	
CY			0.9%	Average rate 1980-2009
CZ	2.4% (single family); 3.6% (multi-family)			Estimated by SEVEn
FI			1-1.5%	
DE			0.7%	
HU	1.30%			
IT			1.20%	
LT	0.36%	2.75%		Average rate for 2005-10
NL	3.5%	1.6% (offices)		
NO	1.5%	1.5%		
PL	2.5% (multi-family buildings)			
PO			1.5%	
SL			2%	
CH			0.8-1%	
Other sources*				
Novikova (2008)			1%	
Janssen (2010)			1.2-1.4%	
Petersdorrf (2004)			1.80%	EU 15
Lechtenböhmer (2009)			1%	EU 27

* as quoted in "Employment Impacts of a Large-Scale Deep Building Energy Renovate Programme in Hungary"- Urge-Vorsatz et al, Central European University"

Prioritising the building stock that can deliver most energy savings

Countries within Europe have been grouped into three broad regions according to climatic, building typology factors and market similarities as explained in Part 1. Moreover, each region has been further subdivided into four age bands, corresponding approximately with the time periods when major changes in building codes occurred.

Generally, countries in Northern and Western Europe implemented insulation standards from around the 1960s, (though some predate this time period), and this trend received a major boost in response to the oil crises of the 1970s. With the onset of concerns over climate change, a further period of tightening can be witnessed from around the 1990s.

New Member States from Central and Eastern Europe were somewhat insulated from global events by the easier and cheaper access to Russian gas and oil, but the impetus for change resulted from the fall of the Berlin Wall and a shift toward market economies from 1989 onwards. Meanwhile, in parts of Southern Europe with little demand for heating, building codes were generally introduced much later and were much less stringent than in colder climates. On the other hand, the energy consumption for cooling is significantly higher than in the other European regions and here is an important savings potential.

The key dynamic of the buildings sector across the EU and in the neighbouring countries (including European Free Trade Association members[50], applicant countries such as Croatia and Eastern European signatories of the Energy Community Treaty) is now the EPBD. For some countries based in Southern Europe, it was the driver for introducing their first ever thermal requirements in new buildings, though it also resulted in a tightening of thermal insulation requirements in countries which already had code requirements.

New constructions from 2010 onwards will increasingly be subject to the cost-optimality requirements set out in the EPBD recast, which will require tougher standards in every country, though some Member States have already set out more demanding codes for some or all of their building stock. The final change on the horizon are the nearly Zero Energy Buildings (nZEB) requirements, resulting in the radical reduction of the need for fossil fuels and associated imports (averaged over an annual cycle) for heating, cooling, hot water and fixed lighting (the so-called "regulated" energy requirements) after 2020.

Table 3A3 demonstrates the impact of geographic location, geo-political issues, building typology and changing energy performance requirements over the years on the average energy consumption of residential buildings in the three major European zones.

Table 3A3 – Regulated final energy for residential properties (GWh per annum)

Source: BPIE model

Regulated Energy (GWh)		North & West	South	Central & East	Total
Old	Pre 1960	1,193,504	228,933	183,937	1,606,374
Modern	1961-1990	506,461	198,250	266,647	971,358
Recent	1991-2010	136,319	41,581	52,551	230,452
New	2011-2020	28,390	11,718	11,394	51,501

The implications for renovation policies are clear – the biggest energy savings can generally be achieved in the older building stock. This is reflected in the scenarios, where the majority of renovation activity is assumed to occur in the pre-1960 stock up to around 2030. From 2031 onwards the emphasis shifts to the "Modern" age band, while it is assumed that buildings constructed in the current decade will not undergo renovation until 2040 onwards.

Job Creation

A comprehensive review of the employment impact of energy saving building renovation spanning Europe and North America was undertaken by the Centre for Climate Change and Sustainable Energy Policy at the Central European University in Hungary[51]. On average, the studies show that 17 new jobs were created for every €1 million of expenditure at today's prices. That average is used in the modelling.

[50] Liechtenstein, Iceland, Norway, and Switzerland

[51] http://3csep.ceu.hu/sites/default/files/field_attachment/project/node-6234/employment-impactsofenergyefficiencyretrofits.pdf

B. OVERVIEW OF THE RENOVATION MODEL

A renovation model has been developed which allows scenarios to be examined that illustrate the impact on energy use and CO_2 emissions of different rates (percentage of buildings renovated each year) and depths of renovation (extent of measures applied and size of resulting energy and emissions reduction) in the residential and non-residential building sectors up to 2050.

A number of scenarios have been modelled to illustrate the financial, economic, environmental, employment and energy use impacts of different rates of uptake and depth of building renovation. In particular, the scenarios assess the following outcomes, both annually and in total:

- Energy saved – the total energy savings over the lifetime of the measures installed
- CO_2 saved – the total CO_2 savings over the lifetime of the measures installed. The CO_2 savings in a given year are calculated by multiplying the energy saved by the weighted average CO_2 emission factor for that year
- Total investment required - the total cost of the installed renovation measures, including materials, labour and professional costs
- Energy cost savings – the cumulative value of the lifetime energy saving. Savings in a given year are calculated by multiplying that year's energy saving by the weighted average energy price
- Employment impact – the number of full time equivalent jobs created over the 40-year period (2011-2050), based on employment factor (no. of jobs per €1 million investment) times the average annual investment
- Cost-effectiveness indicators:
  - > The internal rate of return (IRR) - based on the net saving each year (i.e. cost saving less investment required in a given year)
  - > Net saving to consumers - the difference between the lifetime energy cost savings and the lifetime investment. Both figures are discounted by the weighted average consumer discount rate. A negative figure indicates a net COST to consumers
  - > Net saving to society, including the value of externalities - the sum of the lifetime energy cost savings and value of externalities, less the lifetime investment. Both figures are discounted by the societal discount rate. A negative figure indicates a net COST to society
  - > Carbon abatement cost – net lifetime societal savings divided by the lifetime carbon savings. A negative figure indicates a net benefit per tonne of CO_2 saved

The development of the model is therefore split into two parts:

(I) Assessing the practical limit (of floor area to be renovated and the energy use associated with this building floor area); and

(II) Examining scenarios.

Determining the practical limit for the renovation of the EU building stock

The first step in the modelling process was to assess the practical limit of buildings that can undergo low energy renovation in the residential and non-residential building sectors in the 2011 to 2050 timeframe.

The practical limit to renovation up to 2050 will be affected by a number of considerations:

- **Demolitions:** Some buildings will be demolished and therefore leave the stock. These buildings are likely to suffer from structural problems or be in areas where supply exceeds demand, and therefore are unlikely candidates for renovation to improve their energy performance.
- **Heritage Buildings:** Many buildings have historical, aesthetic and/or cultural value. As a consequence, planning authorities and other bodies may restrict the extent and type of renovation that can be undertaken. In practice, these buildings are not excluded because there will always be some energy efficiency measures that can be applied, even if it is not a total renovation. Minor and moderate measures may often be feasible in the case of heritage buildings.
- **Recent Renovations:** Some buildings may have undergone renovation in the recent past and this may make future renovation economically less attractive. It is contended that the number of buildings renovated to a level that would prevent the application of further energy savings measures is very small, of the order of 1% of the existing stock.
- **New Buildings:** New buildings constructed between 2011 and 2020 will probably be subject to renovation in the period up to 2050, even if only to replace HVAC equipment. Also, as energy standards for renovation are tightened and new technologies become more widely available and affordable, these will increasingly be deployed on buildings constructed this decade. This will add to the volume of the building stock that comprises the practical limit.

Beyond 2020 it is assumed that nZEB requirements under the recast of the EPBD will result in buildings achieving a level of energy performance that will not require further renovation (other than equipment replacement) to 2050.

The building stock floor area has therefore been adjusted to arrive at the 2050 practical limit by applying the percentage reductions and increases shown in Table 3B1 to the current floor area for residential and non-residential buildings in the EU27, Norway and Switzerland.

Table 3B1 – Adjustments to current building stock to determine the 2050 practical limit

Source: BPIE model

Adjustment	Calculation	Percentage increase or reduction
Demolitions from 2011 to 2050	40 years at 0.2% of the building stock each year	-8%
Heritage buildings	Assumed not to prevent renovation at some level	0%
Recent Renovations	Assumed to be very few that would prevent the addition of further energy efficiency measures	-1%
New Buildings from 2011-2020	10 years at 0.5% of the building stock each year	+5%
Total Adjustment	(note simple rather than compound addition)	-4%

Input data

For modelling purposes, the following information derived from section 1 of this report has been used, together with a number of assumptions:

- The main target building stock for renovation is the practical limit, based on the existing stock of buildings, less an allowance for demolitions and buildings already renovated. From 2040 onwards, there will also be a small contribution from renovation of buildings constructed in the current decade (2011-2020)
- Current rates of activity will be taken as a baseline figure for the year 2010:
  - > Prevailing renovation rates are 1% as the EU average; and
  - > Prevailing renovation depths are predominantly minor.
- Energy prices are taken from Eurostat[52] and include all taxes, as these form part of the savings consumers make when reducing their energy imports.
- Energy price forecasts are derived from EU Energy Trends to 2030[53].
- When valuing societal benefits, externalities associated with energy use are included[54].
- Two rates of decarbonisation of energy supplies are modelled. The slow rate of decarbonisation is based on that witnessed since 1990 – approx. 0.5% p.a. and reflects a continuation of current activity, i.e. no change to the recent underlying level of decarbonisation.
- The fast one takes the decarbonisation rate needed to achieve the levels of carbon reduction assumed in the EU 2050 Roadmap, i.e. approx. 5% p.a. for electricity and 2% for other fuels, where the latter reflects fuel switching from higher to lower carbon sources (including renewables).
- The following discount rates have been be applied:
  - > Households 10%
  - > Business 10%
  - > Public Sector 5%
  - > Societal 3%
- Cost reduction factors are applied, reflecting the impact of increasing renovation activity over the period to 2050. Higher factors are applied to the deeper renovation profiles, given that there is a steeper learning curve as the volume of activity increases, and the cost of buildings-integrated renewable technologies in particular come down with increasing market maturity. The impact is illustrated in Figure 3B1, with cost reductions ranging from 1% p.a. for minor renovations to 4% p.a. for nZEB renovations.

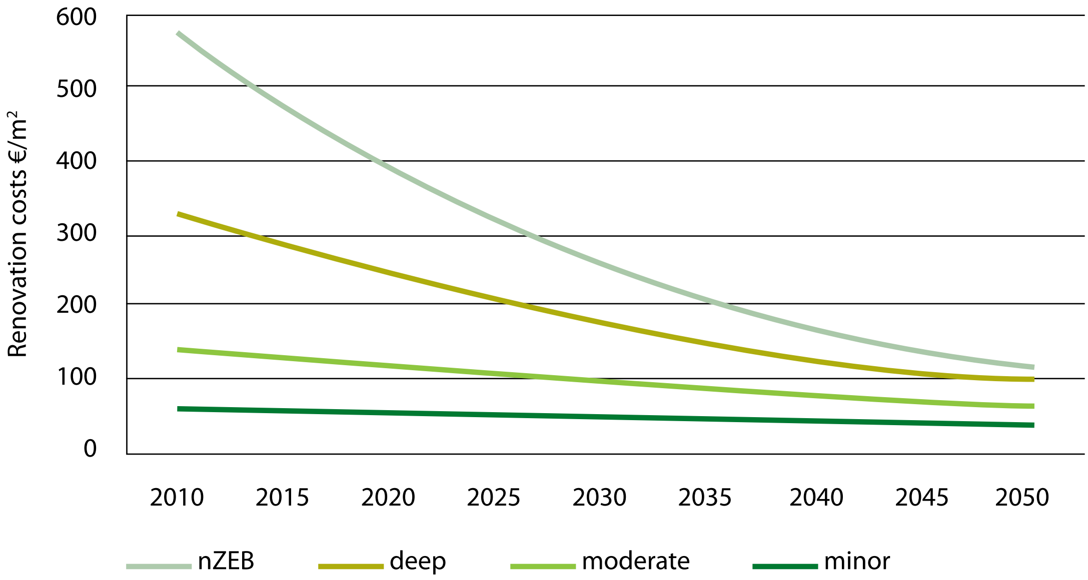
[52] http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database

[53] http://ec.europa.eu/energy/observatory/trends_2030/doc/trends_to_2030_update_2009.pdf

[54] Externalities, or external costs, reflect the environmental and human health damages arising from energy use. These negative impacts include climate change damage costs associated with emissions of CO2 and other GHGs, as well as impacts on health, agriculture etc. caused by other air pollutants such as NOx, SO2, and particulates associated with energy production and consumption. The damage caused, by and large, is not included in the price we pay for energy and so represents an external cost. For this study, an external cost of €00.4/kWh of electricity production has been used – this is the average of the high and low figures used by the European Environment Agency.

Figure 3B1 – Cost reductions for different levels of renovation over time

Source: BPIE model



Renovation variables

The three main variables that influence the pathways for building renovation are:

- the rate of renovation, expressed as a % of the building stock in a given year;
- the depth of renovation, according to the four previously described levels: minor, moderate, deep and nZEB; and
- the cost of renovation, which itself varies with depth.

The costs of each renovation depth assumed in our modelling are the ones from Table 3A1.
The assumptions for the evolution of the renovation rates as well as for the depth of renovation are presented in the following paragraphs.

Rate of renovation

Our ambition is to see all EU buildings renovated between now and 2050. It can be seen that, in order to achieve 100% renovation within 40 years, an average renovation rate of 2.5% p.a. needs to be attained. However, with current rates as low as 1%, levels of activity need to more than double to achieve the required annual rate.

The main variables concerning renovation rates and considered by this model are the speed at which renovation activity ramps up, and the potential peak renovation rate (or saturation value).

Taking into account the above-mentioned assumptions and considering at the same time the practical limits of the renovation rate, this model proposes three main growth patterns: SLOW, MEDIUM and FAST. These three growth patterns are benchmarked against a BASELINE which assumes that the current renovation rate remains unchanged over time.

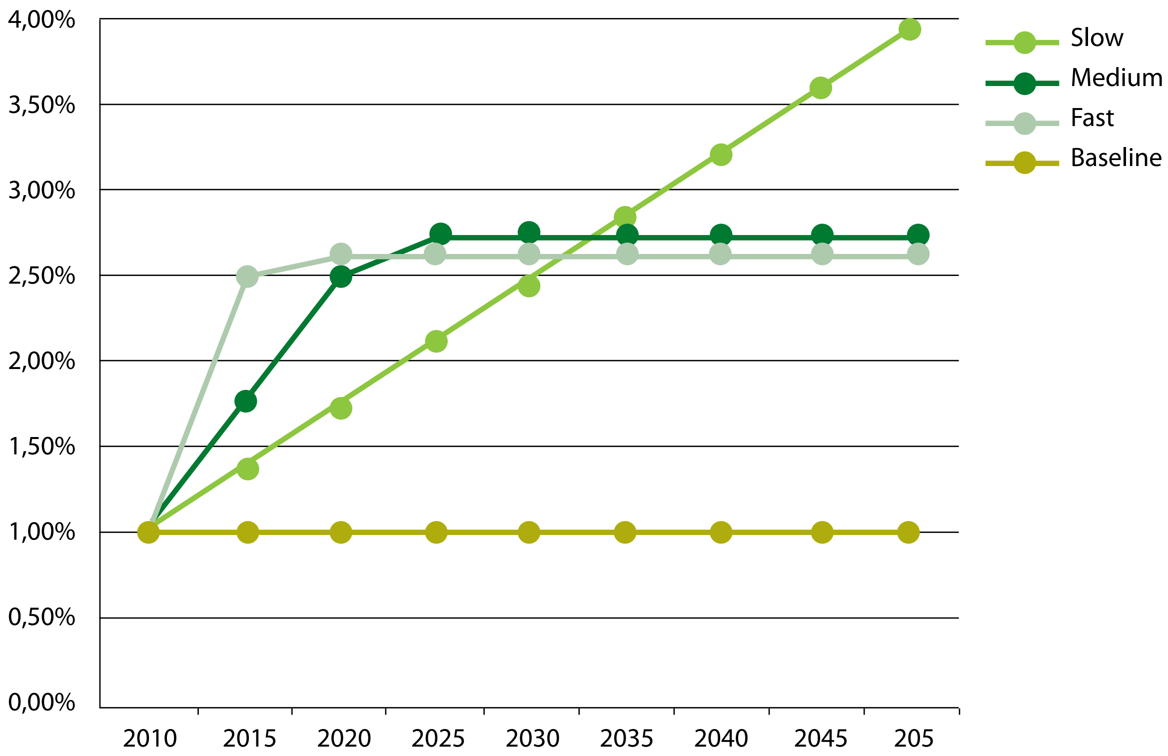
The impact on the rate of growth of renovation activity is illustrated in Figure 3B2. It can be seen that an aggressive pathway (labelled "FAST" in the graph) would require a rapid increase in the rate of renovations over the next 5 years, to 2016, followed by a constant renovation rate of just under 2.6% for the remainder of the period to 2050, a total of 34 years[35]. Conversely, under the slowest rate of growth (labelled "SLOW"), renovation activity grows slowly but steadily year on year from 2011, achieving just under 4% p.a. in the year 2050.

Also illustrated is the MEDIUM pathway in between these two levels. This pathway grows steadily over the next decade to reach a constant rate of around 2.7% p.a. by 2022. This renovation rate is then maintained for 28 years, until 2050.

Each of the illustrated pathways, other than the baseline, results in the same overall outcome in 2050 in terms of floor area of buildings renovated – the only variable is the timing. In any case, each pathway will put significant requirements on the actors in the building renovation value chain (i.e. not only the construction industry, but also planners, architects, financial service industry etc.) to service the growing renovation demand. To sustain these renovation rates also requires respective regulatory and incentive schemes.

Figure 3B2 – Profiles of renovation rates considered herein

Source: BPIE model



Depth of renovation

The other key variable in terms of activity is the renovation depth, by which we mean the proportion of energy savings[56] achieved in a renovation.

Whilst it is not possible to say with certainty what the current depth of renovation is being undertaken within Europe, the available evidence points to a picture where the overwhelming majority of activity is in the minor category. Deep renovations, where they do occur, are frequently pilots or demonstration

[55] In reality, it is to be expected that renovation activity, under all scenarios, would tail off in the last few years as the market becomes saturated with fully renovated buildings. However, this is a minor effect that has not been modelled as it does not have a significant bearing on the full period between now and 2050, which is the main focus of this report

[56] based on regulated energy use:- heating, hot water, cooling and lighting

projects to assess the viability of achieving energy savings of 60% or more and to provide a learning opportunity.

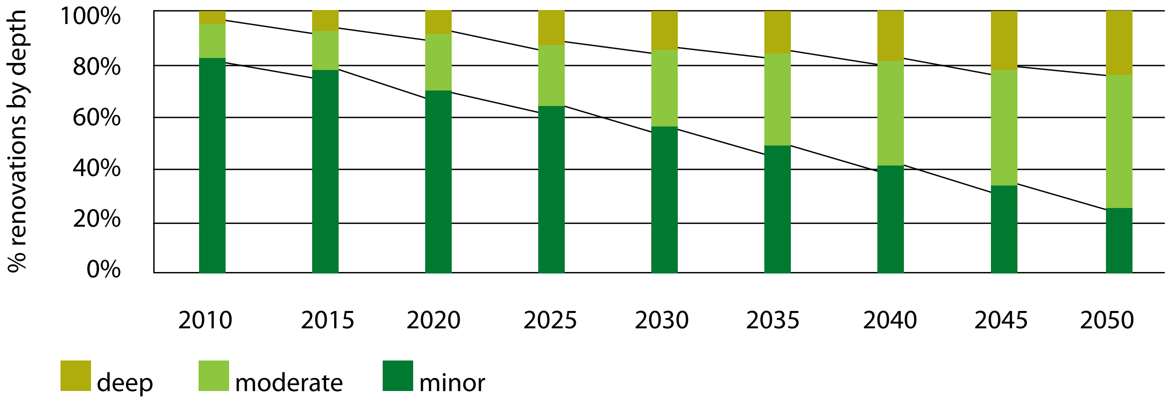
In the absence of accurate figures for depths of renovations currently being undertaken, we have assumed the following split as being the starting point of the scenarios:

- **Minor** 85% of total renovations
- **Moderate** 10% of total renovations
- **Deep** 5% of total renovations
- **nZEB** negligible

Shallow renovation path
In this option, the minor renovations continue to represent most activity over the next two decades, and still account for 25% of activity by the middle of the century. Moderate renovations grow steadily over the period, reaching 50% of total activity in 2050 respectively, while deep renovations grow more modestly, achieving only 25% of total activity in 2050. nZEB activity continues to be negligible.

Figure 3B3 – Shallow renovation path

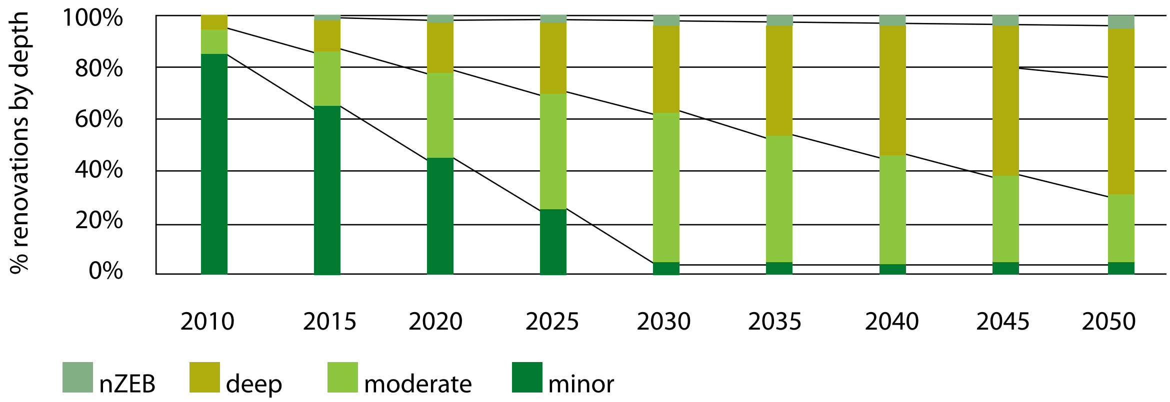
Source: BPIE model



Intermediate renovation path
In the intermediate path, minor renovations continue to be most common for the next decade, but fall away such that, by 2030, they reach just 5% of the total, continuing at that level thereafter[57]. Deep renovations grow to 65% of activity by 2050, while nZEB renovations are introduced, reaching 5% of renovations by 2050. The balance is made up of moderate renovations.

Figure 3B4 – Intermediate renovation path

Source: BPIE model



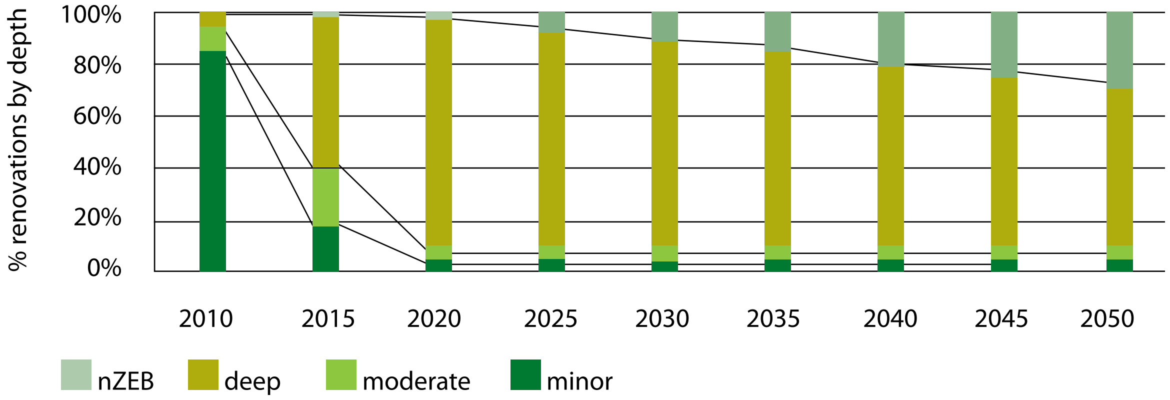
[57] In all scenarios, 5% is the minimum level for minor renovations, to reflect situations where the only improvement in energy performance is due to replacement of equipment at the end of its life e.g. HVAC equipment, or for some building types (e.g. heritage buildings) where the options to renovate are limited

Deep renovation path

By the end of this decade, deep renovations become the dominant activity and remain so until 2050. nZEB renovations accelerate from 2020 onwards, such that they account for 30% of the total by 2050, by which time both minor and moderate each account for just 5% of the total.

Figure 3B5 – Deep renovation path

Source: BPIE model

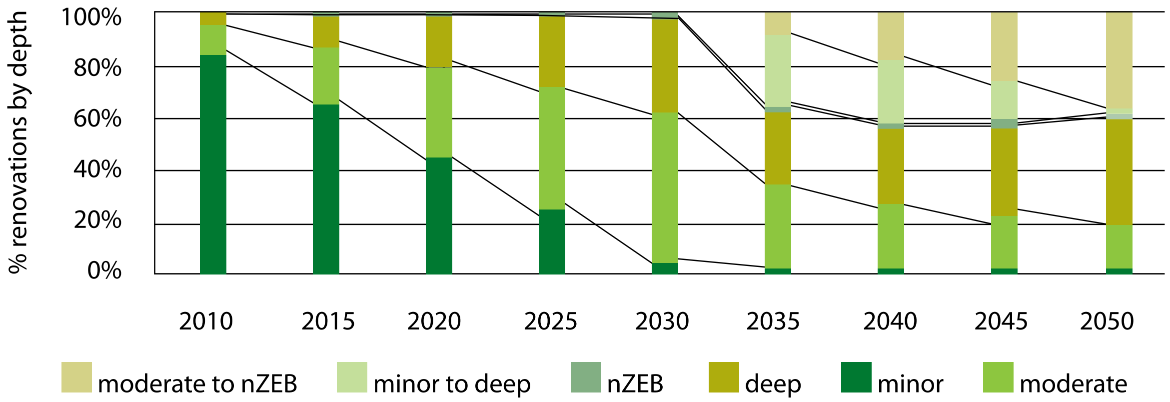


Two-stage renovation path

A fourth renovation path depicts the case in which some properties are renovated twice, though with different measures. Properties that undergo minor or moderate renovation between 2011 and 2030, with e.g. new windows and heating systems, are then upgraded 20 years later, to deep and nZEB standards respectively. These second round of renovations occur in addition to first time renovations, which follow the Medium scenario – therefore, the two-stage and Medium scenarios are identical to 2030.

Figure 3B6 – Two-stage renovation path

Source: BPIE model



C. SETTING THE SCENE

This section explores six scenarios under which the renovation of the European building stock might evolve over the next 40 years. These scenarios are derived from combinations of the renovation rate and renovation depth pathways as well as the two decarbonisation rates described earlier.

One difference between the baseline and the other five scenarios is the age profile of the residential stock being renovated. Except for the baseline scenario, the profile of homes renovated is weighted more heavily towards the older stock in the period 2011-2030, giving a higher energy saving per € of investment during this period. The reason for applying this weighting is on the basis that policies to increase renovation rates would favour older properties where greater energy (and hence carbon) savings can be achieved.

Scenario 0 – Baseline (Business As Usual)

For the baseline scenario, it is assumed that the prevailing renovation rates (which are predominantly minor) continue until 2050. Unlike the other scenarios, this does not result in a full renovation of the building stock. In fact, at the prevailing renovation rate of just 1% p.a., only 40% of the stock is renovated by 2050.

In terms of costs and savings[58], the baseline scenario requires a total investment of €164 billion to 2050, generating lifetime energy savings to consumers worth €187 billion – i.e. a net saving of €23 billion. Overall benefits to society, including the value of externalities, amount to €1,226 billion.

Compared to today's regulated energy use (heating, ventilation, hot water, cooling and lighting), energy savings of 2% are achieved by 2020, rising to just over 9% by 2050. The corresponding CO_2 savings in 2050 are 18% to 72% (the lower figure is calculated at the low decarbonisation rate; the higher at the fast decarbonisation rate). It can be seen that the baseline scenario falls far short of the level of ambition required to deliver the carbon savings envisaged in the EU 2050 Roadmap.

The results in saved energy are minor compared to today, which means that the high CO_2 reductions by 2050 (72%) occur mainly due to a decarbonisation of the energy supply when a 5% annual decarbonisation rate is applied.

The table below summarises the key results for 2020 and 2050.

Table 3C1 – Key results of scenario 0

Source: BPIE model

Scenario	Results in year...	% energy saved	% CO_2 saved[59]	Investment (€bn)	Energy cost saving (€bn)	Net saving to consumers (€bn)	Net saving to society (€bn)
0 - Baseline	2020	2%	5-28%	107	94	-13	277
0 - Baseline	2050	9%	18-72%	164	187	23	1226

[58] All costs and savings are at present value. Consumer savings (i.e. those arising to end-users – households, businesses and public sector bodies) are discounted by the weighted average consumer discount rate, but do not include externalities. Societal savings are discounted at 3% and include externalities.

[59] For the percentage of CO_2 saved, the lower figure reflects the slow decarbonisation rate, while the higher figure reflects the higher decarbonisation rate.

Scenarios 1a (Slow & shallow) and 1b (Fast & shallow)

These two scenarios both take the shallow renovation path. They compare the impact of a rapid acceleration in the rate of renovation ("Fast & shallow") with a slow but steady ramping up ("Slow & shallow"). These scenarios are shown in order to illustrate the consequences of focusing mainly on shallow renovation measures which may be perceived as the "cheaper and more pragmatic solution".

As might be expected, the energy savings to 2020 are greater under the fast scenario (7%) where the renovation rate rapidly rises to 2.6% of the building stock p.a. The slow scenario achieves a renovation rate of just 1.4% by 2020, delivering 4% energy savings. However, this position is reversed by 2050 as more buildings are renovated to a greater depth under the slow scenario. The corresponding figures for 2050 are:

Table 3C2 – Key results of scenarios 1a and 1b

Source: BPIE model

Scenario	Results in year...	% energy saved	% CO_2 saved	Investment (€bn)	Energy cost saving (€bn)	Net saving to consumers (€bn)	Net saving to society (€bn)
1a - Slow & shallow	2020	4%	7-29%	161	163	2	532
1a - Slow & shallow	2050	34%	40-79%	343	530	187	4884
1b - Fast & shallow	2020	7%	9-31%	255	260	5	853
1b - Fast & shallow	2050	32%	38-79%	451	611	160	4461

The fast scenario has a higher level of energy cost savings, due to savings arising earlier, but suffers the penalty of a too rapid ramping up of activity before the impact of cost reductions through greater experience (the "learning curve") helps to bring the price of the moderate and deep renovations down. The investment required for scenario 1b to 2050 is therefore greater and the net savings to consumers, and to society, lower as a result.

Both scenarios suffer from the fact that the depth of renovation does not increase sufficiently to achieve the 90% CO_2 saving aimed for in the EU roadmap 2050. Most of the CO_2 savings witnessed are due to the decarbonising of energy supply. With the assumption of a more conservative decarbonisation rate of 0.5% per year, CO_2 reduction per year is only 7% and 9% respectively by 2020, and 40% and 38% respectively in 2050. This means that both scenarios miss the EU's CO_2 reduction targets by a clear margin.

Higher CO_2 reductions are achieved with a high decarbonisation factor. These reductions, however, are not achieved in the building sector but mainly in the power supply sector.

Employment generation can be observed in both scenarios, mainly due to the increase in renovation rates, but not necessarily due to the increase in the renovation depths. A slow but constant increase in the renovation rates would generate on average 0.4 million jobs annually by 2020, a fast ramping up would lead to an average 0.6 million jobs each year.

An initially slow growth in the annual renovation rate, as modelled in scenario 1a has a significant impact on the required renovation rate in the years from 2035 onwards. As can be seen in Figure 3B2, the renovation rate will have to grow continuously during the decades and reach a level of over 3% annually beyond 2035, climbing to almost 4% by 2050. This requires a continuous growth of investment by the building sector.

Further, a fast ramping up of the renovation activities as modelled in scenario 1b may also overburden the supply side, both in terms of materials and services provided. The actors in the building renovation value chain would have to make significant and fast investments to satisfy the growing market demand. There are, however, recent examples of other sectors delivering significant growth rates, such as the European renewable energy industry where turnover grew by a factor of 7 between 2005 and 2010[60]. The EU policy framework to support renewable energy systems played a crucial role in achieving this growth.

Scenario 2 - Medium

The Medium scenario combines the intermediate renovation path with the medium rate of growth.

Despite having a lower rate of growth than scenario 1b (fast & shallow), the energy savings in 2020 for scenario 1b and 2 are comparable due to the higher proportion of moderate and deep renovations under the medium scenario. By 2050, the impact of the deeper renovation profile can be seen, with energy savings of nearly 50%, comfortably exceeding the 32-34% achieved in scenarios 1a and 1b.

CO_2 reduction results for 2020 do not show a significant difference to scenarios 1a and 1b, whether under a high or a low decarbonisation rate of the energy supply. Clear differences are only visible over the longer term until 2050, due to the fact that the share of minor renovations decreases significantly over the decades compared to scenarios 1a and 1b.

Results for 2050 show a clearer distinction regarding CO_2 reduction. With a fast energy supply decarbonisation, CO_2 emissions will be reduced by 84%, however, with a slow energy supply decarbonisation the reduction will only be 53%, compared to 2010.

Looking at the economic effects of this scenario, it becomes clear that the net savings for consumers are the highest (together with scenario 4) of all scenarios for the years to 2020, with a level of 13 billion Euros. Societal savings including externalities amount to €902 billion the second highest saving of all scenarios by 2020. The internal rate of return is equally high delivering a 10% return by 2020.

By 2050, the internal rate of return increases to 12.5%. At this point in time net savings for consumers will accumulate to €300 billion, and the internal rate of return will be at 12%. Furthermore, 700,000 jobs per year on average will have been created for the period to 2050.

Table 3C3 – Key results of scenario 2

Source: BPIE model

Scenario	Results in year...	% energy saved	% CO_2 saved	Investment (€bn)	Energy cost saving (€bn)	Net saving to consumers (€bn)	Net saving to society (€bn)
2 - Medium	2020	7%	10-31%	252	265	13	902
2 - Medium	2050	48%	53-84%	551	851	300	7015

[60] See http://www.erec.org/statistics/turnover.html, accessed 21/9/2011

Scenario 3 - Deep

The Deep scenario combines the deep renovation path with the medium rate of renovation growth. By virtue of the rapid shift towards deep renovations, and the growing share of nearly Zero Energy Buildings towards the middle of the century, this scenario achieves energy savings as high as 68%, with corresponding CO_2 emissions reductions of 90% (under the fast decarbonisation option) - the target for buildings set out in the EU 2050 Roadmap.

While the investment required for the deep scenario is considerably greater than for the earlier scenarios, so are the savings, as demonstrated in the table below.

By 2020, societal savings will amount to €1,656 billion including externalities. This figure represents almost a doubling compared to scenario 2. On the other hand, investment costs until 2020 are also highest of all scenarios, amounting to €477 billion which is due to the fact that deep renovation measures are introduced quickly and on a large scale, leading to large energy savings but also requiring larger investments. Compared to all other scenarios, this is equivalent to an almost doubling of the investment costs in the period to 2020, or nearly a five-fold increase compared to the baseline. As a result, the internal rate of return of 9% is slightly lower than in the previous scenario. However, the savings at present value are still higher than the investment costs, delivering a net saving for consumers of €10 billion.

Looking ahead to 2050, the internal rate of return increases to 11.8%, however, it is only the fourth highest of all scenarios. This can be explained by the fact that the total amount of initial costs for deep renovation measures are relatively higher due to their fast introduction in the first half of the scenario period. This prevents the learning effects to have a full impact on cost reduction of deep measures.

As in the case to 2020, the investment costs of this scenario are the highest also in the years to 2050, amounting to €937 billion. However, savings are also the highest at €1,318 billion, resulting in a net saving for consumers of €381 billion.

The impact on employment creation is the highest of all scenarios. Triggered by the relatively fast increase in the renovation rate and by applying deep renovation measures, this scenario leads to the creation of 1.1 million direct jobs per year on average for 40 years. This is more or less equivalent to employing 1.1 million people for their full working life time.

Table 3C4 – Key results of scenario 3

Source: BPIE model

Scenario	Results in year...	% energy saved	% CO_2 saved	Investment (€bn)	Energy cost saving (€bn)	Net saving to consumers (€bn)	Net saving to society (€bn)
3 – Deep	2020	13%	16-35%	477	487	10	1656
3 - Deep	2050	68%	71-90%	937	1,318	381	9,767

To summarize, this scenario delivers high energy and CO_2 savings, while also delivering the highest employment effects. However, it also requires a steep increase in investments in this decade which would represent a step change compared to the current reality of renovation practices in Europe.

Scenario 4 – Two-stage renovation

The fourth scenario deviates from the assumption in the previous scenarios that buildings will be renovated once between 2010 and 2050. In this scenario, from 2031 onwards the "second stage" renovations commence, occurring in addition to the first time renovations.

As a result of the learning curve cost reductions, particularly for the deeper renovations, the cost of achieving a deep or nZEB renovation is now substantially less than if it had been undertaken 20 years earlier. The overall investment is therefore considerably lower than for the Deep scenario. In present value terms, a cost reduction of nearly 40% is achieved, despite achieving slightly higher levels of energy and CO_2 savings in 2050. Correspondingly, the net savings, both to consumers and to society at large, are significantly greater than for the Deep scenario.

The achieved energy saving is the highest of all scenarios, leading to a 71% saving in 2050. CO_2 emissions decrease by 73% to 91%, depending on the decarbonisation rate as described earlier.

The renovation rate of this scenario follows the same path as the medium scenario until 2030, requiring an intermediate growth rate during the first two decades. However, renovation activities will have to significantly increase after 2030 to deliver on the second stage of renovation which comes on top of the now continuous renovation rate of scenario 2 (c.f. Table 3C5). This requires strategic planning ahead by the supply chain, which in turn needs to be enabled and supported by a reliable and clear policy framework.

Table 3C5 – Key results of scenario 4

Source: BPIE model

Scenario	Results in year...	% energy saved	% CO_2 saved	Investment (€bn)	Energy cost saving (€bn)	Net saving to consumers (€bn)	Net saving to society (€bn)
4 - 2 stage	2020	7%	10-31%	252	265	13	902
4 - 2 stage	2050	71%	73-91%	584	1,058	474	10,680

The scenarios in direct comparison

Tables 3C6 and 3C7 present the full set of results of the five scenarios, to 2020 and 2050 respectively. This overview provides an opportunity to compare the relevant indicators which should inform decision making.

Table 3C6 – Overall results to 2020

Source: BPIE model

Scenario		0	1A	1B	2	3	4
Description		Baseline	Slow & Shallow	Fast & Shallow	Medium	Deep	Two- stage
Annual energy saving in 2020	TWh/a	94	169	271	283	527	283
2020 saving as % of today	%	2%	4%	7%	7%	13%	7%
Investment costs (present value)	€bn	107	161	255	252	477	252
Savings (present value)	€bn	94	163	260	265	487	265
Net saving (cost) to consumers	€bn	-13	2	5	13	10	13
Net saving (cost) to society - without externality	€bn	238	462	742	787	1,441	787
Net saving (cost) to society - including externality	€bn	277	532	853	902	1,656	902
Internal Rate of Return	IRR	8%	9%	9%	10%	9%	10%
Fast decarbonisation							
Annual CO_2 saving in 2020	$MtCO_2/a$	286	300	319	321	367	321
2020 CO_2 saved (% of 2010)	%	28%	29%	31%	31%	35%	31%
CO_2 abatement cost	€/t CO_2	-4	-9	-14	-14	-26	-14
Slow decarbonisation							
Annual CO_2 saving in 2020	$MtCO_2/a$	54	73	98	101	161	101
2020 CO_2 saved (% of 2010)	%	5%	7%	9%	10%	16%	10%
CO_2 abatement cost	€/tCO_2	-26	-46	-66	-70	-105	-70
Average annual net jobs generated	M	0.3	0.4	0.6	0.6	1.2	0.6

Table 3C7 – Overall results to 2050

Source: BPIE model

Scenario		0	1A	1B	2	3	4
Description		Baseline	Slow & Shallow	Fast & Shallow	Medium	Deep	Two- stage
Annual energy saving in 2050	TWh/a	365	1,373	1,286	1,975	2,795	2,896
2050 saving as % of today	%	9%	34%	32%	48%	68%	71%
Investment costs (present value)	€bn	164	343	451	551	937	584
Savings (present value)	€bn	187	530	611	851	1,318	1,058
Net saving (cost) to consumers	€bn	23	187	160	300	381	474
Net saving (cost) to society - without externality	€bn	1,116	4,512	4,081	6,451	8,939	9,908
Net saving (cost) to society - including externality	€bn	1,226	4,884	4,461	7,015	9,767	10,680
Internal Rate of Return	IRR	10.1%	12.4%	11.5%	12.5%	11.8%	13.4%
Fast decarbonisation							
Annual CO_2 saving in 2050	$MtCO_2/a$	742	821	814	868	932	939
2050 CO_2 saved (% of 2010)	%	71.7%	79.3%	78.6%	83.8%	89.9%	90.7%
CO_2 abatement cost	€/tCO_2	-20	-74	-68	-103	-136	-151
Slow decarbonisation							
Annual CO_2 saving in 2050	$MtCO_2/a$	182	410	391	547	732	755
2050 CO_2 saved (% of 2010)	%	18%	40%	38%	53%	71%	73%
CO_2 abatement cost	€/tCO_2	-89	-196	-185	-221	-238	-255
Average annual net jobs generated	M	0.2	0.5	0.5	0.7	1.1	0.8

It is clear that only two of the scenarios achieve the ambitious European CO_2 reduction targets as described by the European Commission in its Roadmap 2050 paper. Scenarios 3 and 4, the deep and the two-stage scenario, achieve a CO_2 reduction of around 90%, but only under the assumption that the power supply sector undergoes a fast decarbonisation as well. Nevertheless, in both scenarios the majority of CO_2 savings are achieved through energy savings measures on the demand side.

In terms of cost-effectiveness to consumers, scenarios 1-3 are broadly similar in terms of the Internal Rate of Return when considered over the period to 2050, all falling into the range 11.5-12.5%. This is slightly better than the baseline scenario of 10%, though not as good as scenario 4, which achieves 13.4%

The following set of graphs present and compare the overall results of the scenarios to 2050.

Figures 3C1 and 3C2 below compare the net savings to consumers and to society from the six scenario options. It can be seen that the more ambitious the scenario, the higher the net savings are.

Figure 3C1 – Lifetime net savings to consumers (present value)

Source: BPIE model

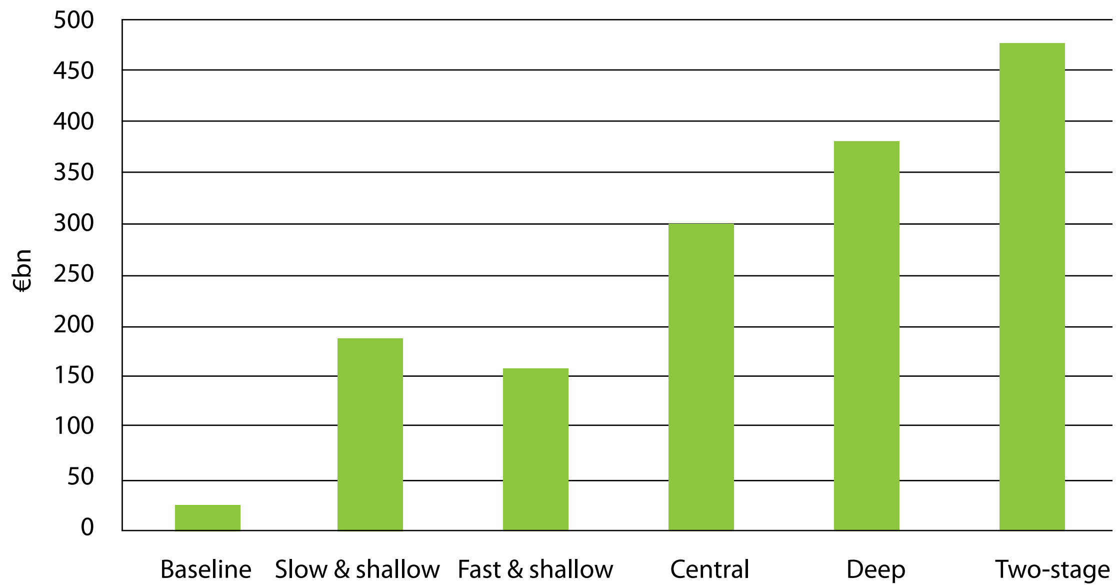


Figure 3C2 – Lifetime net savings to society (present value)

Source: BPIE model

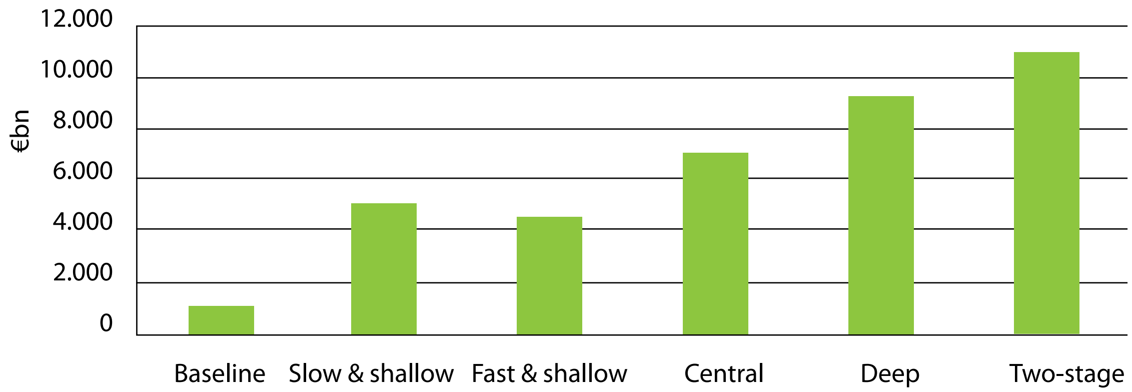
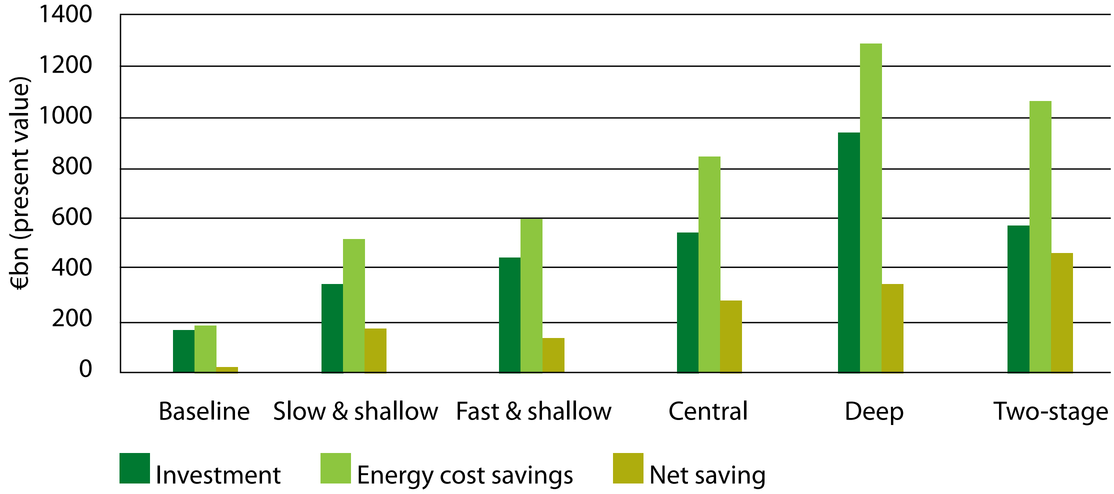


Figure 3C3 below compares the present value investment and energy savings – the difference providing the net savings to consumers. While both the deep and the two-stage scenario achieve broadly the same level of CO_2 reduction, the deep scenario requires a significantly higher absolute investment level. In return, it also generates higher energy cost savings; however, the net savings are smaller than in the two-stage scenario. The high investment needs of the deep scenario are caused by a fast increase in deep renovation measures in the first decade.

The two-stage scenario requires a lower investment due to a slower increase in the number of deep renovations while benefiting from a longer learning period which leads to cost reductions.

Figure 3C3 – Lifetime financial impact for consumers (present value)

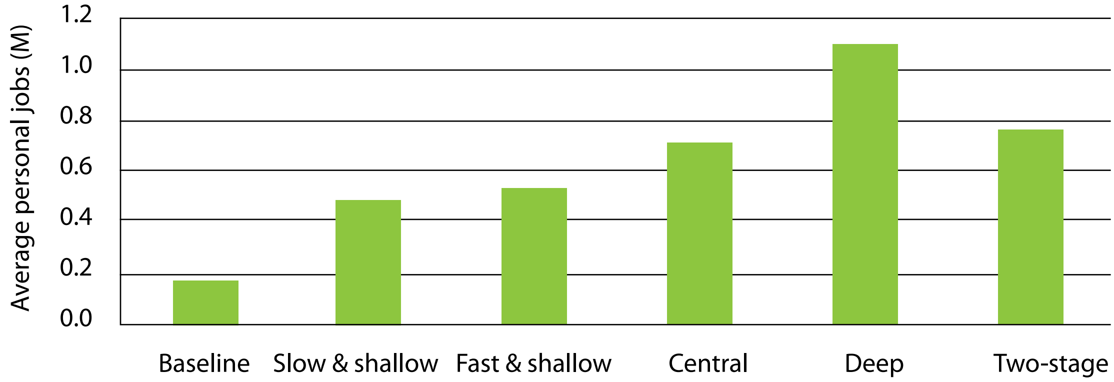
Source: BPIE model



Figures 3C4 shows the employment impact resulting from the investment in improving the energy performance of Europe's building stock, as an average over the period. It can be seen that, while continuing with business-as-usual would employ under 200,000 people over the next 40 years, the accelerated renovation scenarios would generate between 500,000 and over 1 million jobs.

Figure 3C4 – Average employment generated in 2011-2050

Source: BPIE model



In all the scenarios, the estimated CO_2 emission reduction by 2050 is determined by the energy savings but also by the decarbonisation of the energy supply sector. It is interesting to note that in the deep and two-stage scenarios there is a 71-73% CO_2 emission reduction even under the slow decarbonisation assumption, a figure which is close to the CO_2 emission reduction for the slow and shallow scenario under the fast decarbonisation assumption. This highlights the role of renovation measures in the decarbonisation strategy. The decarbonisation of the energy supply sector is significantly eased by decreasing the energy demand of buildings and is importantly more sustainable. Moreover, the costs for decarbonising the energy generation system will be significantly less if the consumption patterns of the building sector will dramatically reduce.

Each of the scenarios 1-4 represent a significant ramping up in renovation activity compared to the current situation (i.e. the baseline scenario 0). When looked at purely in terms of the investment required, these range from around double the baseline level for scenario 1a, through to over five times the baseline level for the deep scenario 3. These are significant increases, but certainly achievable if governments across the EU were to agree and implement respective policies and market stimulation mechanisms. The current practice, as shown in Part 2 of this report, is clearly not sufficient to trigger a renovation wave across Europe which would deliver the societal, economic and environmental benefits possible. At a time of rising unemployment and increased energy dependency, the employment and energy-saving benefits to consumers from an accelerated renovation programme would provide a welcome boost to many countries continuing to suffer economic difficulties following the credit crunch.

Taking into consideration the three most relevant factors, i.e. achievement of CO_2 reduction targets, investment considerations and positive employment effects, it seems that the results of the two- stage scenario provide the best balance of these factors, comparing all scenarios. The two-stage scenario therefore illustrates a pathway which should influence policy choices to stimulate the renovation of the European building stock.

FINAL REMARKS AND POLICY RECOMMENDATIONS

Improving energy efficiency of buildings has important macro-economic benefits and can substantially contribute to all three priorities of the Europe 2020 Strategy[61], as well as to the EU 2050 roadmap targets. Society as a whole will be better off as a result of investments in energy savings measures for buildings, even before the climate benefits are taken into account. Energy saving renovation programmes developed in countries such as Germany, the UK and Austria have already proved the positive impact in terms of employment and private capital triggered. There are varied estimations about the positive employment effects of energy saving renovation measures, stimulating direct employment in the construction and related industries from the materials supply chain. Energy saving activities in buildings have a great potential for catalysing the creation of indirect and induced jobs in education, research & innovation, energy services companies, waste management etc.

The political decision is the key factor in creating a favourable framework for private investors. Strong commitments with clear targets and offering long term predictability are necessary to trigger a step change in renovation practices. EU Member States show significant differences in terms of commitments, financial potential and market conditions.

Furthermore, there are significant market frictions at Member State level: the landlord-tenant dilemma, multiple stakeholders and decision makers, conditionality in renovation of certain buildings (i.e. historical buildings etc.), difficulties to access financing or unattractive interest rates, harmful subsidies for energy production and heating energy prices in some countries are just some of the barriers.

Energy savings and efficiency in buildings represents an evolving market and despite the cost-effectiveness of most measures, the transaction costs can be high and pay-back periods are not always attractive for the private residential sector. This may also raise issues of equity, as certain measures will arguably not be affordable by poorer households. Immediate measures are necessary to eliminate these barriers both at the EU level, by creating an appropriate framework, and Member States level, by implementing best practice policies that can overcome the barriers on all relevant fronts.

The substantial renovation of the EU27 building stock is insufficiently covered by the existing legislation and hence the sectorial potential for creating cost-effective energy savings, jobs, welfare and economic growth is not properly exploited. To attract more private capital it is necessary to develop long-term renovation programmes with clear targets and monitoring, providing appropriate financial instruments and public financial leverage. This is critical for the establishment of a long term market. Therefore, to have long term programmes and associated financing is a must for transforming deep renovation strategies into common practice.

It is necessary to create a stable, clear and simple legal framework in order to ease the administrative burdens for both private investors and house owners.

Despite the fact that significant developments have happened in recent years, current EU legislation only partially covers the field of buildings renovation. More targeted measures are required for fostering the

[61] COM(2010) 2020 . EUROPE 2020 A strategy for smart, sustainable and inclusive growth. Brussels, 3.3.2010.

deep renovation of the existing building stock. The Energy Performance of Buildings Directive stipulates the implementation of energy saving measures only in case of deep renovation of the building and without asking for a certain depth of renovation measures. Establishing cost-optimal levels for buildings renovation should represent an important step forward in establishing minimum requirements for the renovation depths. The EPBD recast also asked EU Member States to draw up by the end of June 2011 (and to update it every three years) a list of existing and proposed measures and instruments, including financial ones, which promote the EPBD's objectives. However this requirement refers to the objectives of the EPBD recast which are not clearly specifying the need for a certain renovation speed or depth of the existing building stock. It is therefore a strategic prerequisite that EU Member States implement the EPBD recast in a way that stimulates deep renovation of the existing building stock.

As discussed in a previous chapter, at Member States level there are several ongoing programmes that directly address the energy saving renovation of the building stock with more or less ambitious aims, comprising a large range of financial instruments. None of them are demanding enough for delivering the cost-optimal potential and a lot of additional efforts are required.

Consequently, in order to address the challenge of renovating the existing building stock and to keep pace with the ambitious aims of the European Union for reducing and decarbonising the energy consumption and production, further improvements of the EU and national frameworks are needed. Some suggestions are presented on the next page.

Key recommendations at EU level

Policy measures:

- At EU level, it is necessary to strengthen the existing legislation with binding measures and to establish a roadmap for the renovation of the EU27 building stock. The renovation roadmap has to be built on a long term basis with binding targets for energy efficient retrofit of the EU27 building stock by 2050. A renovation roadmap must have a clear monitoring and reporting plan with interim targets indicating the renovation rates and the renovation depths to be reached gradually by 2020 and by 2030. The renovation targets may be integrated in the National Energy Efficiency Action Plans (NEEAPs) under the End-use Energy Efficiency and Energy Services Directive (ESD, Directive (2006/32/EC), currently under recast into an Energy Efficiency Directive (EED)[62].
- The EU legislation should call upon Member States to prepare detailed deep renovation plans comprising regulatory, financial, informational and training measures. Having a predictable long-term deep renovation roadmap will provide confidence to the business sector and will avoid the risk of falling short after 2020 and creating unwanted economic problems (such as employment distortions, additional costs etc.). To increase the cost-effectiveness of the renovation roadmap, renovation targets can be built according to the financial and technical national potential and support potential cooperation mechanisms between Member States. The holistic renovation approach must be encouraged in order to increase the cost-effectiveness of the measures and to be in line with the provision of the Energy Performance of Buildings Directive. Tailor-made roadmaps can define different phases which move from voluntary to binding measures. The measures should be continuously evaluated and improved whereby the renovation requirements should be eventually tightened to meet nZEB standards.
- The process of adopting minimum energy saving regulations and energy labelling for heating and cooling equipment and construction materials under the Energy Labelling and Eco-design of the energy related products Framework Directives has to be strengthened and supported.

[62] Com(2011)370 final. Proposal for a Directive on energy efficiency repealing Directives 2006/32/EC and 2004/8/EC.

- Finally, the EU should support the harmonisation of national data collection systems concerning the energy performance of buildings, ensuring sufficient high quality data availability and closing the gap in existing systems which were shown through this study (c.f. Part 1). These data are needed to design and implement properly working policies and incentive schemes that drive the necessary change in the building sector.

Financing:
- Ambitious renovation strategies are cost-effective when considering the full life cycle but they also require significant up front investments. For boosting the deep renovation of the EU building stock the establishment of specific financing instruments, i.e. an EU Deep Renovation Fund (possibly via the European Investment Bank and designed for different building types) could be considered which complements the national financing schemes and shares the risks. The financing should be given only for deep level renovations leading to very low energy standards. Such a fund will offer more financial flexibility and additional confidence to private investors.
- EU expenditure for the renovation of the building stock (i.e. by Structural and Regional Development Funds) should introduce the minimum requirement for implementing measures at cost-optimal levels (as will be defined under the EPBD recast). This would be in line with the requirement to "climate-proof the future EU multi-annual financial framework 2014-2020" (a budget for Europe 2020) and to deliver on the principle that "through its operational programmes throughout the EU, cohesion policy has a crucial role to play in stepping up efforts to reach the 20% energy efficiency target[63]".
- In addition, the European Commission could facilitate the development of innovative financial instruments at Member State level by elaborating guidelines for financing, by promoting best practice and by stimulating the cooperation between Member States for sharing experience and for implementing common measures and harmonised regulatory measures for deep renovation. Innovative financing schemes should be designed to trigger increased private investment.

Training and education:
There is a strong need to increase the skills in the construction industry in Europe to ensure appropriate framework conditions for the Internal Market of construction products and services, improve resource efficiency and environmental performances of construction enterprises, and promote skills, innovation and technological development to meet new societal needs and to mitigate climate risks. Hence the upcoming strategy for the sustainable competitiveness of the construction sector, which was planned to be realised this year by the European Commission[64], may provide a strong foundation for improving the knowledge level and the practice in renovation activities.

Key recommendations at the National level

Policy measures:
- National Governments should eliminate market barriers and administrative bottlenecks for the renovation of the housing stock. Improving the energy efficiency of buildings will generate significant economic benefits for society, including an important impact in terms of employment in the construction industry, the sector most affected by the economic downturn. Improving the energy performance of buildings should be seen as a positive force for economic recovery.
- In order to foster the deep renovation of the building stock, Member States should develop long-term comprehensive regulatory, financial, educational and promotional packages addressing all the macro-

[63] http://ec.europa.eu/budget/library/biblio/documents/fin_fwk1420/MFF_COM-2011-500_Part_II_en.pdf .
[64] COM(2010) 614, An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage.

economic benefits. Important components of these programmes should be the faster identification and adoption of ambitious and yet cost-effective renovation levels, the gradual strengthening/introduction of related building code requirements and effective quality control and verification systems.

- Enforcing compliance with building codes and standards will be key to countering the perception that energy saving renovation measures come with a price premium. Proper monitoring of compliance, enforcement and quality control the process through a qualified workforce should be part of any policy package to foster deep renovation. The relatively low compliance level in almost all the EU Member States is a significant barrier in reaching the estimated energy savings potential.
- The confidence of consumers and investors into the quality level of renovation measures must be (re-) established, so that the readiness to make the necessary investment increases. Guarantee systems for the performance of efficiency measures should be developed.
- A better implementation of the buildings energy certification and audit schemes is needed as these schemes are important information and awareness tools which can increase the value of efficient buildings and can stimulate the real estate market towards green investments.
- The public sector has to take a leading role in the renovation revolution. Indeed, this is envisaged as a requirement within the draft Energy Efficiency Directive, where, from 1 January 2014, public bodies would be required to renovate at least 3% of their floor area each year to achieve at least the Member State's prevailing minimum energy performance requirements. Such a measure would kick start the market for renovation and help to bring down costs for private households and businesses.
- Energy services companies (ESCOs) can play an important role in fostering deep renovation programmes by providing the necessary technical and financial expertise and by triggering third party financing. Hence, removing the market barriers facing ESCOs may facilitate a faster and better development of the renovation programmes. Regulatory frameworks should encourage the set-up and development of a well-functioning energy services market, not limited to commercial buildings.
- Energy supply (and distribution) companies in a number of European countries have specific obligations for delivering energy savings through their customers' efficiency, the so called Energy Savings Obligations or White certificates. The proposed Energy Efficiency Directive (EED), if adopted, intends to oblige all Member States to develop energy savings obligations for the energy companies. These schemes are expected to also include building renovation measures. However, it will be necessary to establish minimum performance requirements for the renovation measures to be implemented under energy saving obligation schemes. Otherwise there is a risk of increasing the renovation speed but at shallow levels mainly and to endangering the sustainability of the savings.
- National regulation should be periodically discussed and reinforced and all the main stakeholders should be involved in this process in the framework of a national consultation platform.
- To persuade consumers to make the necessary investments – both a greater number than currently witnessed, but also a progressively deeper level of renovation, additional measures should be considered. Initiatives such as requiring the least efficient stock to be brought up to a higher energy performance level before a property can be sold would certainly begin to stimulate the market, but would need to be coupled with easy forms of financing. In the UK, the Energy Bill 2011 proposes that from April 2018 all private rented properties must be brought up to a minimum energy efficiency rating of 'E'. This provision will make it unlawful to rent out a home or business premise that does not reach this minimum standard – effectively banning the least efficient 'F' and 'G' properties[65].

[65] http://www.decc.gov.uk/assets/decc/legislation/energybill/1001-energy-bill-2011-brief-private-rented-sector.pdf

- A reliable and continuous data collection process of the main characteristics of the building stock is a necessary prerequisite for reliable policy making. As this survey has shown the levels of data availability and quality show drastic differences between the EU Member States. In order to improve the knowledge level and to be able to take effective measures to improve the energy performance of buildings, Member States should collaborate to implement a harmonised standard for collecting relevant data about the European building stock.

Financing:

- The success of deep renovation programmes will depend on the creation of appropriate financing schemes, addressing all the categories of private and commercial real estate owners as well as introducing measures using appropriate subsidies, low-interest and longer term loan schemes and other financial incentive schemes.
- Financing packages should propose appropriate market instruments tailored to different needs and able to overcome the main market barriers. In addition, the renovation programmes should be based on a preliminary macro-economic analysis in order to ensure the sustainability and durability of the measure by integrating all the benefits, by minimizing the costs, by securing the programme budget and by proposing the most suitable market instruments. Moreover, the incentives should be offered only for a low-energy standard of the renovation, preferably based on ex-ante and ex-post evaluation of the energy performance of the building.
- A proper public financing approach may leverage considerable private capital as has been proven by several successful programmes developed in some European countries. Attracting private capital to invest in building renovation is a key issue of any financing programme that aims to stimulate the economy and to transform energy efficiency measures into a sustainable business activity. Governments should draw up a balance sheet which calculates the costs of effective deep renovation incentive schemes against the increased tax revenue from a significant growth of the construction industry (e.g. through VAT, income tax, corporate tax, etc.).
- Relevant national stakeholder need to improve their knowledge about the use of the EU Structural and Regional Funds and the EIB financing lines for improving the energy performance of the buildings stock. Investing in buildings means investing in the development of society.

Training and promotional activities:

- For implementing effective and good quality deep renovation it is necessary to improve the skills of the building professionals at the level of both basic professional education and long-life learning activities. Therefore, training and educational activities should be developed both in the construction sector and in the supply chain industries.
- Promotional and dissemination activities must be an important part of the deep building renovation programmes. The German KfW experience indicates that an important success factor is the creation of an energy efficiency brand[66], well known and perceived by the market.
- Awareness raising and promotional activities should address the psychological barriers which exist concerning deep renovation. A discussion about societal values needs to address behaviour change to support investment decisions in favour of sustainability rather than investment decisions driven by social status factors, or by short term return considerations. Soft measures need to support a shift in values which can speed up progress towards a more sustainable behaviour by all actors in the buildings value chain.

[66] G. Gumb. Supporting the energy efficient rehabilitation of the building stock – The German experience. Presentation at the BPIE's European Round-table on financing buildings retrofit, Nov. 2010

Conclusions

As this report shows, the building sector can contribute significantly to mitigating climate change while delivering many other societal benefits. Political courage and will, innovative investment tools and societal awareness are key factors for transforming the sector. Existing EU policies have to be implemented in a best practice manner to achieve the intended energy savings, while new instruments are needed to stimulate a deep renovation wave across Europe and its Member States.

Good policy making requires good knowledge about the status quo of building performance. BPIE's survey has shown that data gaps exist which make it difficult to develop targeted programmes, to monitor policy implementation and to evaluate progress. The EU and its Member States should make significant efforts to close these data gaps and to harmonize monitoring, reporting and evaluation.

All actors in the European value chain of buildings should grab the renovation opportunity to innovate products and services, to build a well-functioning energy saving renovation market, to offer attractive solutions to private and commercial customers and to use their respective ingenuity to make highly efficient buildings a common standard of the European building stock.

Essentially, what is needed is nothing less than a European energy saving renovation revolution.

DEFINITIONS

Air-conditioning system: a combination of all components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity and air cleanliness [EPBD, 2002/91/EC]

Boiler: the combined boiler body and burner-unit designed to transmit to water the heat released from combustion [EPBD, 2002/91/EC]

Building envelope: integrated elements of a building which separate its interior from the outdoor environment [IUPAC International Union of Pure and Applied Chemistry - Compendium of Chemical Terminology 2nd Edition (1997)];

Combined heat and power (CHP): the simultaneous conversion of primary fuels into mechanical or electrical and thermal energy, meeting certain quality criteria of energy efficiency [EPBD, 2002/91/EC]

Commercial building: A commercial building is a building that is used for commercial use. Types can include office buildings, warehouses, or retail (i.e. convenience stores, 'big box' stores, shopping malls, etc.)

Cost-optimal level: Cost-optimal level means the energy performance level which leads to the lowest cost during the estimated economic lifecycle [EPBD, recast, 2010/31/EC]

Derived heat: Derived heat covers the total heat production in heating plants and in combined heat and power plants. It includes the heat used by the auxiliaries of the installation which use hot fluid (space heating, liquid fuel heating, etc.) and losses in the installation/network heat exchanges. For autoproducing entities (= entities generating electricity and/or heat wholly or partially for their own use as an activity which supports their primary activity) the heat used by the undertaking for its own processes is not included. [Eurostat definition]

District heating/cooling: means the distribution of thermal energy in the form of steam, hot water or chilled liquids, from a central source of production through a network to multiple buildings or sites, for the use of space or process heating or cooling [EPBD, 2010/31/EC]

Energy audit: 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 [ESD, 2006/32/EC]

Energy consumption: The amount of energy consumed in the form in which it is acquired by the user. The term excludes electrical generation and distribution losses.

Energy performance certificate: a certificate recognised by the Member State or a legal person designated by it, which includes the energy performance of a building calculated according to a methodology based on the general framework set out in the Annex of Directive 2002/91/EC [EPBD, 2002/91/EC]

Energy performance of a building: the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use of the building, which may include, inter alia, heating, hot water heating, cooling, ventilation and lighting. This amount shall be reflected in one or more numeric indicators which have been calculated, taking into account insulation, technical and installation characteristics, design and positioning in relation to climatic aspects, solar exposure and influence of neighbouring structures, own-energy generation and other factors, including indoor climate, that influence the energy demand [EPBD, 2002/91/EC]

Energy performance requirement: minimum level of energy performance that is to be achieved to obtain a right or an advantage: e.g. right to build, lower interest rate, quality label [CEN standard - En 15217 "Energy performance of buildings – "methods for expressing energy performance and for the energy certification of buildings"]

Energy service company (ESCO): a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria [ESD, 2006/32/EC]

Final energy: Energy supplied that is available to the consumer to be converted into useful energy (e.g. electricity at the wall outlet). (Intergovernmental Panel on Climate Change, IPCC)

Gross floor area: The total area of all the floors of a building, including intermediately floored tiers, mezzanine, basements, etc., as measured from the exterior surfaces of the outside walls of the building

Heat pump: a device or installation that extracts heat at low temperature from air, water or earth and supplies the heat to the building [EPBD, 2002/91/EC]

Internal gross area: A term used in the United Kingdom, defined in the RICS Standard, for the area of a building measured to the internal face of perimeter walls at each floor level

Internal rate of return (IRR): A rate at which the accounting value of a security is equal to the present value of the future cash flow. [European Central Bank]

Living floor space/area: total area of rooms falling under the concept of rooms [OECD Glossary of statistical terms]

Nearly zero energy building: a building that has very high energy performance, as determined in accordance with Annex I of the EPBD recast. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby [EPBD recast, 2010/31/EC]

Net floor area: A term used in the ISO standard to express the Interior Gross Area less the areas of all interior walls

Net present value: The net present value (NPV) is a standard method for the financial assessment of long-term projects. It measures the excess or shortfall of cash flows, calculated at their present value at the start of the project

Payback time: the length of time required to recover the cost of an investment

Primary energy: Energy from renewable and non-renewable sources which has not undergone any conversion or transformation process

Public building: building owned or occupied by any public body

Regulated energy: energy used in the home for heating, cooling, hot water and lighting

Residential building: A structure used primarily as a dwelling for one or more households. Residential buildings include single-family houses (detached houses, semi-detached houses, terraced houses (or alternatively row houses) and multi-family houses (or apartment blocks) which includes apartments/flats

Third-party financing: a contractual arrangement involving a third party — in addition to the energy supplier and the beneficiary of the energy efficiency improvement measure — that provides the capital for that measure and charges the beneficiary a fee equivalent to a part of the energy savings achieved as a result of the energy efficiency improvement measure. That third party may or may not be an ESCO [ESD, 2006/32/EC]

U-Value: is the measure of the rate of heat loss through a material. Thus in all aspects of home design one should strive for the lowest U-Values possible because the lower the U-value – the less heat that is needlessly escaping. The calculation of U-values can be rather complex - it is measured as the amount of heat lost through a one square meter of the material for every degree difference in temperature either side of the material. It is indicated in units of Watts per meter Squared per Degree Kelvin or W/m2 [Irish Energy Centre - Funded by the Government under the national Development Plan with programmes partly financed by the European Union.]

Useful floor space/area: floor space of dwellings measured inside the outer walls, excluding cellars, non-habitable attics and, in multi-dwelling houses, common areas [OECD Glossary of statistical terms];

White certificates: certificates issued by independent certifying bodies confirming the energy savings claims of market actors as a consequence of energy efficiency improvement measures [ESD, 2006/32/EC]

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