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. 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 of the energy performance in Europe’s buildings. The 27 Member States have set an energy saving target of 20% by 2020, mainly through energy efficiency measures, while the EU carbon reduction roadmap seeks to achieve some 80-95% carbon reductions in the buildings sector by 2050. Buildings represent almost 40% of total final energy consumption and, therefore, can make a crucial contribution to both targets.

Reducing the energy consumption has another particular importance in improving the security of supply and reducing the import dependency. The EU-27 dependency on energy imports increased from less than 40% of gross energy consumption in the 1980s to 55% by 2008, with the highest dependency rates for crude oil (84%) and natural gas (62%).

Yet the challenge is immense. 500 million inhabitants spread over 27 countries spanning many different climate zones, landscapes and cultures inhabit and work in a wide array of building types with an equally wide range of thermal qualities in a constantly expanding building stock. If the building sector is to significantly contribute to the 80-95% carbon reduction objective for 2050, each and every building within the EU will have to slash its energy use on average by a factor four or five, at the same time as energy supplies are decarbonised.

While individual Member States have implemented various measures to improve the energy performance of their building stock, in some cases going back 50 years or more, the European policy framework for buildings has been evolving since the early 1990s, with an array of measures to actively promote better energy performance of buildings. After 2002 the matter gained further impetus when the Energy Performance of Buildings Directive (EPBD) was adopted. The EPBD was recast in 2010 to make goals more ambitious and step up the implementation.

In order to create a sound basis for political debate and policy making at EU and MS level, the Buildings Performance Institute Europe (BPIE) undertook a major one-year study, published in October 2011, in order to get a vital picture of the European building stock, understand the reasons why renovation is not happening at a sufficient rate, and derive a set of scenarios and policy options whereby Europe’s buildings could undergo full renovation by 2050. This paper sets out the main findings, analysis and conclusions of the BPIE study.

**BUILDING TYPOLOGY**

For the countries covered by this study, there are 25 billion m$^2$ of useful floor space, a figure which is increasing at a rate of around 1% per year. To illustrate what this figure means in comparative terms, the gross floor area is nearly equivalent to the size of Belgium.
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, as illustrated in Figure-1. 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 48, 90 and 26 m$^2$, respectively. The general tendency is to seek larger floor spaces over time especially under favourable economic conditions. With increasing trends of floor space, the energy demand associated with our buildings also increases, which in turn highlights the need for improving the energy efficiency of our current stock.

<table>
<thead>
<tr>
<th></th>
<th>Population (million)</th>
<th>Land area (million km$^2$)</th>
<th>Building Floor Space (billion m$^2$)</th>
<th>Floor space per capita (m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27</td>
<td>501</td>
<td>4.3</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>US</td>
<td>309</td>
<td>9.8</td>
<td>28</td>
<td>90</td>
</tr>
<tr>
<td>CHINA</td>
<td>1,338</td>
<td>9.6</td>
<td>35</td>
<td>26</td>
</tr>
</tbody>
</table>

Table-1. Land and Building Area Comparison of EU, US and China$^1$

The floor space distribution per country is also shown in Figure-2. The 5 countries with the largest floor space (France, Germany, Italy, Spain and the UK) account for approximately 65% of the total floor space. This comes with no surprise as the corresponding share of population in these countries is equal to 61% of the total.

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The residential stock is the biggest segment, accounting for three quarters of the total floor area. Within the residential sector, 64% of the floor area is associated with single family houses and 36% with apartments.

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 sport centres. Figure-3 reveals the split between these categories at the European level. The retail and wholesale buildings comprise the largest portion of the stock.

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2 Data cover 29 countries - EU27 + Norway & Switzerland
ENERGY PERFORMANCE

Understanding the energy consumption in buildings requires an insight into the energy levels consumed over the years and the mix of fuels used. Figure-4 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 of oil and solid fuels by 27% and 75%, respectively. Overall, the energy use in buildings is at 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 to improve our buildings’ performance is taken.
In terms of CO\(_2\) emissions, buildings are responsible for around 36% in Europe\(^4\). The average specific CO\(_2\) emission\(^5\) 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-5. 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 due to the dependence on hydroelectricity and nuclear energy, respectively.

\(^3\) source: Eurostat
\(^4\) Based on information published at the European Commission’s site on energy efficiency in buildings http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm
\(^5\) 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.
Residential buildings comprise the biggest segment of Europe’s building stock and are responsible for the majority of the sector’s energy consumption - 68% of the total final energy use\(^6\). Energy in households is consumed in heating, cooling, hot water, cooking, appliances and other end uses. The final consumption of these end uses is shown in Figure-6 divided between all fuels and electricity. The strong correlation between heating degree-days and fuel consumption emphasises the importance of energy use for heating. The significant increase in use of appliances in households is also evident through the steady increase in electricity consumption - 38% growth over the last 20 years.

Understanding the 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 the electricity use consumed in the European non-residential buildings has increased by a remarkable 74% as depicted in Figure-7. This is compatible with the technological advances over the decades where an increasing penetration of IT equipment, air conditioning systems etc. means that the electricity demand within this non sector is at continuous increasing trajectory (cf. absolute difference in electricity use between 1990-2009). Based on the BPIE analysis, it is estimated that the average specific energy consumption in the non-residential sector is 280 kWh/m\(^2\) (covering all end uses) which is at least 40% larger than the equivalent value for the residential sector.

\(\text{Figure-6. Trends in residential sector final energy use}\)

\(\begin{align*}
\text{MTOE} \quad &0 &50 &100 &150 &200 &250 &300 &350 &400 \\
1999 &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad \\
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2001 &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad \\
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2008 &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad \\
2009 &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad &\quad \\
\end{align*}\)

\(\text{Figure-7. Trends in final energy use in the non residential sector}\)

\(^6\)Data extracted from Eurostat: [http://epp.eurostat.ec.europa.eu](http://epp.eurostat.ec.europa.eu)
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 ranging from building managers to residents’ committees that have a say in what happens to buildings - 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.

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 acting rationally as far as investment in energy saving is concerned. Based on the feedback of experts in each of the 29 countries surveyed, figure-8 sets out the main categories of barriers affecting renovation.

![Figure-8. Classification of barriers as identified by the BPIE survey](image)

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 to better understand why consumers take action the ways they do, often defying conventional economic theory logic. The human dimension, combined with a variety of other factors that affect decisions, needs to be better understood and better 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. Figure-9 presents the range of circumstances whereby building renovation may occur, with the final column showing the most common barriers for that pathway.
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.

**EPBD MAIN PROVISIONS**

As noted earlier, the main EU policy driver affecting energy use in buildings is the EPBD. As originally formulated in 2002, the EPBD set out the following key requirements for Member States:

- a framework for an integrated methodology for calculating energy performance;
- minimum energy performance standards in new buildings and large (>1000m²) existing buildings undergoing ‘major renovation’;
- energy certification for both new and existing buildings; and
- an inspection and assessment regime for heating and air conditioning systems.

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

- From the end of 2018, all the new buildings occupied and owned by public authorities must be nearly zero-energy buildings. This requirement is extended to all new buildings from the end of 2020.
- Member States are required to draw up national plans for increasing the number of nearly zero-energy, though there are no specific targets.
- Energy performance requirements for buildings must be set at cost-optimal levels.

EPBD is an important piece of legislation which should lead to a deep transformation of the EU building sector and catalyse the introduction of very high energy performance standards for the built environment. However, the timeline for it to become fully effective is relatively long as much of the impact will only start to be delivered after 2020. The large cost-

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7According to the Directive 2010/31/EU, a nearly-zero energy building is defined as 'a building that has a very high energy performance. 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.'
effective energy and emission savings potential from the buildings sector will remain largely untapped in the next decade and this may question even the accomplishment of the 20% target by 2020.

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, in particular “deep” renovations.

SCENARIOS

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 renovation of the EU building stock by 2050, including a “business-as-usual” case, as if 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.

A renovation model has been developed which allows scenarios to be examined that illustrate the impact on energy use and CO2 emissions of different rates (i.e. percentage of buildings renovated each year) and depths of renovation (i.e. 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
- Total investment
- Energy cost savings
- Employment impact
- Cost effectiveness indicators:
  - The internal rate of return (IRR);
  - Net saving to consumers;
  - Net saving to society, including the value of externalities;
  - Carbon abatement cost

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,
- The cost of renovation, which itself varies with depth.

The results for six scenario options are presented in Table-2 overleaf, followed by a brief discussion of each scenario.
Table.2. Key Metrics for the Six Renovation Scenarios

For the Baseline scenario 0, it is assumed that the prevailing renovation rates of 1% p.a. (which are predominantly minor) continue until 2050. Unlike the other scenarios, this does not result in a full renovation of the building stock - only 40% is renovated by 2050.

In terms of costs and savings, the baseline scenario requires a total investment of €164bn to 2050, generating lifetime energy savings to consumers worth €187bn – i.e. a net saving of €23bn. Overall benefits to society, including the value of externalities, amount to €1,226bn. Energy savings of 9% by 2050. The corresponding CO2 savings are 72%, though the majority of this is as a result of energy supply decarbonisation. 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.

Scenarios 1A and 1B compare the impact of a rapid acceleration in the rate of renovation ("Fast & Shallow") with a slow but steady ramping up ("Slow & Shallow"). The fast scenario 1B has a higher level of energy cost savings, 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 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 required 90% CO2 saving.

The Central Scenario 2 adopts an intermediate path in terms of both rate of renovation and depth of renovation. Investments are greater than for the Shallow scenarios, though this is more than offset by the higher energy savings to produce larger net savings to consumers and to society. 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.

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8 All costs and savings are 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.
The Deep scenario models a rapid shift towards deep renovations during this decade. It achieves energy savings as high as 68%, with corresponding CO2 emission reductions of 90% - the target for buildings set out in the EU 2050 Roadmap. The investment required is over five times the Baseline level, though the net savings are considerably greater than for the earlier scenarios.

Finally, the 2-stage scenario is unlike the others in that it includes properties which are renovated twice. It considers the situation where properties that undergo minor or moderate renovation between 2011 and 2030 are then upgraded 20 years later to a deeper level. These second round of renovations occur in addition to first time renovations. As a result of greater experience in renovation, the costs progressively come down over time so the total investment required is less than for the Deep scenario, even though the energy and carbon savings are broadly similar. As a result, the net savings to consumers and to society are greater.

In terms of cost effectiveness to consumers, scenarios 1-3 are broadly similar in the internal rate of return, all falling into the range 11.5-12.5%. This is slightly better than the baseline scenario, at 10%, though not as good as the 2-stage scenario 4, which achieves 13.4%.

Figures 10 and 11 below compare the net savings to consumers and to society from the 6 scenario options. It can be seen that the more ambitious the scenario, the higher the net savings are.
Figure 11. Societal Benefits

Figure 12 compares the present value investment and energy savings – the difference providing the net savings to consumers.

Figure 12. Comparison of costs and savings
Finally, figure-13 shows the employment impact resulting from the investment in improving the energy performance of Europe’s building stock. 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.

![Average Employment Generated 2011-2050](image)

**Figure-13. Employment Impact**

Each of the scenarios 1-4 represent a significant ramping up in activity compared to the current situation (i.e. the Baseline). 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 match the rhetoric around tackling climate change with action on the ground. And, 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.

What is more challenging is how to persuade consumers to make the necessary investments – both a greater number than we are currently witnessing, but also a progressively deeper level of renovation. Measures 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 ways 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.

The public sector needs to take a leading role in the renovation revolution. Indeed, this is envisaged as a requirement within the draft Energy Efficiency Directive, where, from 1st 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 costs down for private households and businesses.

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CONCLUSIONS AND RECOMMENDATIONS

There are significant economic, environmental and societal benefits from undertaking a major renovation programme to improve the energy performance of Europe’s buildings, though these benefits will not be realised without considerable further effort in terms of policy and enabling infrastructure (in particular financing mechanisms), at EU as well as Member State level. The study’s main recommendations are as follows:

- At the EU level, it is necessary to strengthen the existing legislation with binding measures and eventually to establish a roadmap for the renovation of the building stock.

- Member States should prepare detailed deep renovation plans comprising regulatory, financial, informational and training measures. Renovation targets can be built according to the financial and technical national potential (effort sharing) and 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 EPBD.

- A more aggressive approach to setting minimum energy standards heating, cooling, ventilation and lighting equipment needs to be adopted.

- Ambitious renovation strategies are cost-effective when considering the full life cycle but they also require significant up-front investments. In order to boost the deep renovation of the EU building stock, specific financing instruments such as a Deep Renovation Fund (possibly via the European Investment Bank) should be established.

- EU expenditure that can be used for the renovation of the building stock (e.g. Structural and Regional Development Funds) should also introduce the conditionality of low-energy standards on a cost-optimality basis.

- In addition, the European Commission may 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 even for implementing common measures and harmonised regulatory measures for deep renovation.

- There is a need to increase the skills in the construction industry in Europe to improve resource efficiency and environmental performances of construction enterprises, and promote skills, innovation and technological development to meet new societal needs and climate risks. The upcoming strategy for the sustainable competitiveness of the construction sector announced to be realised later in 2011 by the European Commission may provide a strong foundation for improving the knowledge level and the practice in renovation activities.

- Governments should eliminate market barriers and administrative bottlenecks for the renovation of the housing stock.

- A better implementation of the buildings energy certification and audit schemes is needed as these schemes are important information and awareness tools which can stimulate the real-estate market towards green investments.

- Energy services companies (ESCOs) may in future be developed to 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 for the ESCOs may facilitate a faster and better development of the renovation programmes.

- The scope for Energy Savings Obligations or White Certificate Schemes to deliver deep renovation needs to be fully exploited.

- Data collection processes and sharing of knowledge within and between Member States are needed to help the diffusion of best practice.