Reports of the Public-Private Sector Research Center 7

Climate Change Regulation: Energy Efficiency in Buildings in Europe

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Public-Private Sector Research Center - IESE Business School

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This report is part of the periodical research and analysis of the effects of regulations on markets that the Public-Private Sector Research Center conducts and publishes in order to contribute to the debate among professionals, regulators and academics.

The "Climate Change Regulation: Energy Efficiency in Buildings in Europe" Report analyses the effects that European regulation aimed at mitigating climate change and Greenhouse Gases emissions has on the market for buildings. The report first documents the progress made towards climate change mitigation and energy efficiency in Europe. It then delves into the existing European regulation intended to increase the energy efficiency of buildings. Finally, the report provides evidence of the existence of a price premium for green buildings and about the effects of policies on certain construction materials.

José Luis Moraga and Sebastián Curet from the Public-Private Sector Research Center at IESE have developed this report. The ideas expressed by the authors are their own and do not represent the views of the institutions for which they developed the report.

Paca Navarro, Carlota Monner and Miguel de Quinto provided outstanding collaboration in the different stages of the project and this

Este informe es parte de la investigación y el análisis periódico que el *Public-Private Sector Research Center* del IESE realiza con el objetivo de comprender los efectos de la regulación en los distintos mercados y así contribuir al debate entre profesionales, legisladores y académicos.

El informe "Regulación y Cambio Climático: Eficiencia Energética en Edificios en Europa" analiza el efecto de dicha regulación dirigida a mitigar el cambio climático y las emisiones de gases de efecto invernadero en el mercado de Edificios.

El informe primero documenta el progreso realizado por Europa en cuanto a la mitigación del cambio climático y la eficiencia energética en general, y continúa con el análisis de la regulación europea específicamente dirigida a aumentar la eficiencia energética en Edificios. Finalmente, el informe muestra evidencia empírica sobre la existencia de una prima para Edificios Verdes en el mercado y sobre el efecto que la regulación tiene en la demanda de determinados materiales de construcción.

Este informe ha sido elaborado por Sebastián Curet y José Luis Moraga, del Public-Private Sector Research Center del IESE. Los autores han reflejado libremente sus propias opiniones, las cuales no representan la visión de las instituciones para las que han desarrollado el informe.

report would not have been completed without them. Comments and insights by Giulio Federico, Lluís Torrens, Salvador Estapé, Ángel López and Jorge Paz Panizo were extremely valuable.

Finally, the support of the ALCOA Foundation and ALCOA Europe, especially from Rosa García Piñeiro and Clara Acebes, was indispensable both in terms of material resources as well as in the development of some of the questions and research issues that this report addresses.

Xavier Vives
Academic Director
Public-Private Sector Research Center
IESE Business School

Paca Navarro, Carlota Monner y Miguel de Quinto han contribuido extraordinariamente en cada etapa de este proyecto, el cual no habría podido finalizarse sin su apoyo. Los comentarios e ideas aportadas por Giulio Federico, Lluís Torrens, Salvador Estapé, Ángel López y Jorge Paz Panizo fueron de gran valor para los autores.

Finalmente, el apoyo de la Fundación ALCOA y de ALCOA Europa, especialmente Rosa García Piñeiro y Clara Acebes, fue indispensable tanto en lo referente a los recursos materiales como para el desarrollo de algunas de las ideas y temas de investigación que este informe analiza.

Xavier Vives
Director Académico
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IESE Business School

Climate Change Regulation: Energy Efficiency in Buildings in Europe

Executive Summary

Resumen Ejecutivo

Why Climate Change Mitigation?

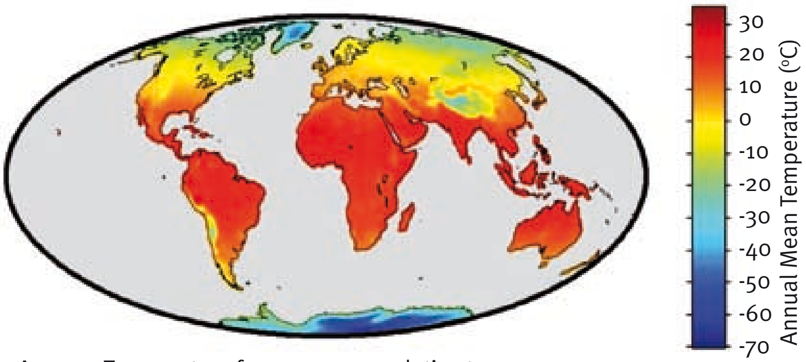
Climate change mitigation is one of the most important goals for the global economy, although not one of the most urgent ones lately. Several studies have recently confirmed definitively that the Earth is warming and that climate patterns are changing accordingly (see Charts 1 and 2; Chart 1 compares average earth temperatures in 2000-2010 to 1900-1910 and 1960-1970 respectively. An anomalous increase is evident: around 1.2 degrees since the first period, around 0.6 degrees since the 70s). Scenarios such as the complete melting of the ice cap have become more likely. These changes affect the economy in several ways and mitigation of these changes will have its own effects on the economy as well.

¿Por qué es importante mitigar el cambio climático?

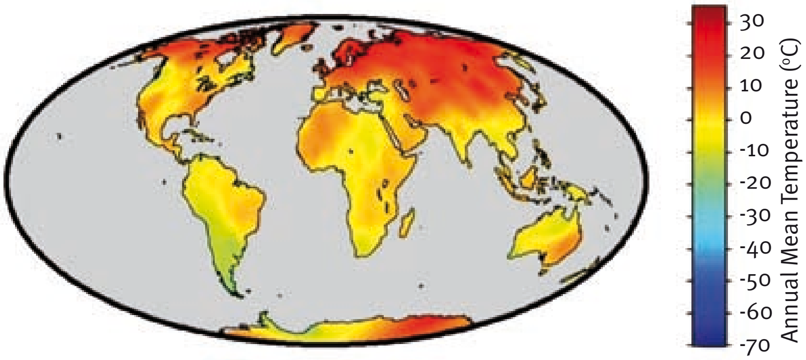
Mitigar el cambio climático es uno de los objetivos más importantes de la economía global, aunque últimamente no uno de los más urgentes. Varios estudios científicos han afirmado recientemente de forma más convincente que la Tierra está sufriendo un proceso de calentamiento progresivo y que el clima está cambiando (ver gráficos 1 y 2; el gráfico 1 compara las temperaturas medias terrestres en 2000-2010 con 1900-1910 y 1960-1970 respectivamente. Un aumento anómalo es evidente: cerca de 1.2 grados desde el primer periodo y cerca de 0.6 grados desde los años 70). Escenarios como aquél en que los polos se derriten hasta desaparecer se han vuelto más probables. Estos cambios afectan a la economía de varias maneras y los esfuerzos para ralentizar el proceso tendrán efectos económicos también.

Chart 1. Global Annual Mean Temperatures

Gráfico 1. Temperaturas medias globales anuales



Average Temperature for 2000-2010 relative to 1900-1910



Average Temperature for 2000-2010 relative to 1960-1970

Source: Berkeley Earth Surface Temperature Project (2011). The graph shows anomalies in temperature in Europe and Antarctica

Fuente: Berkeley Earth Surface Temperature Project (2011). El gráfico muestra anomalías en la temperatura en Europa y la Antártida

Mitigating climate change potential factors produced by mankind, such as Greenhouse Gases emissions, becomes essential in this new setting. Governments and supranational entities are thus creating new tools for mitigating climate change. Several of these tools are intended to change the economic incentives of consumers and producers.

Mitigar los factores producidos por el ser humano que pueden contribuir al cambio climático, tales como las emisiones de gases de efecto invernadero (GEI, por sus siglas en inglés), es esencial en este nuevo escenario. Para alcanzar este objetivo, los Gobiernos nacionales y los entes supranacionales crean nuevos instrumentos regulatorios, los cuales pretenden cambiar los incentivos económicos de productores y consumidores.

The European Commission (EC) has enacted regulation in order to react and mitigate climate change in the region, setting targets for the reduction of Greenhouse emissions by member states (MS) for 2020. These targets, known as 20-20-20, aim at contributing to the European Union (EU) effort towards the Kyoto Protocol goals. Even though several climate change conferences have been held since Kyoto, these targets remain the main point of reference towards climate change mitigation.

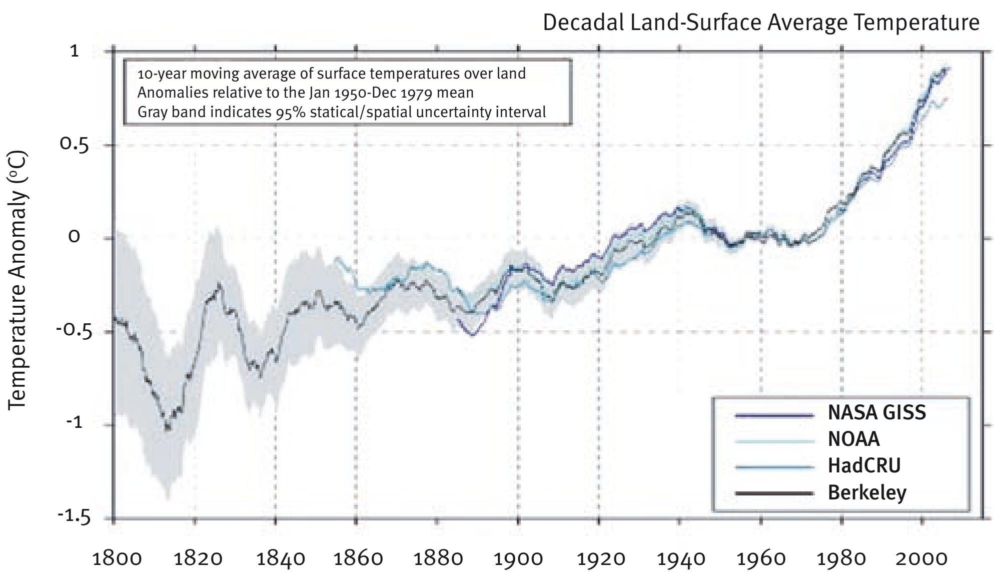
As we will see below, the analysis of Greenhouse Gases emissions (GHGs) in the continent shows that Europe will have a hard time reaching the 2020 target levels set in the Lisbon Treaty.

En este sentido, la Comisión Europea (CE) ha promulgado nuevas regulaciones con el fin de mitigar el cambio climático en la región, fijando objetivos de reducción de las emisiones de gases de efecto invernadero de los Estados miembros para 2020. Estos objetivos, conocidos como 20-20-20, tienen la intención de contribuir al cumplimiento de los objetivos del Protocolo de Kioto, que siguen siendo una referencia mundial aun luego de las reuniones de Copenhague y Cancún.

Como veremos a continuación, un análisis detallado de las emisiones de gases de efecto invernadero (GEI) en el continente demuestra que Europa no tendrá fácil la tarea de alcanzar los niveles de reducción de emisiones fijados en el Tratado de Lisboa.

Chart 2. Trend in Global Average Temperatures

Gráfico 2. Tendencia de las temperaturas medias globales



Source: Berkeley Earth Surface Temperature Project (2011). The graph shows how the ten-year moving average land-surface temperatures upward trend has intensified since the 1960s

Fuente: Berkeley Earth Surface Temperature Project (2011). El gráfico muestra la intensificación de la tendencia al alza de la media móvil a diez años de las temperaturas en la superficie de la Tierra desde la década de los 60

How Have GHG Emissions Evolved in Europe?

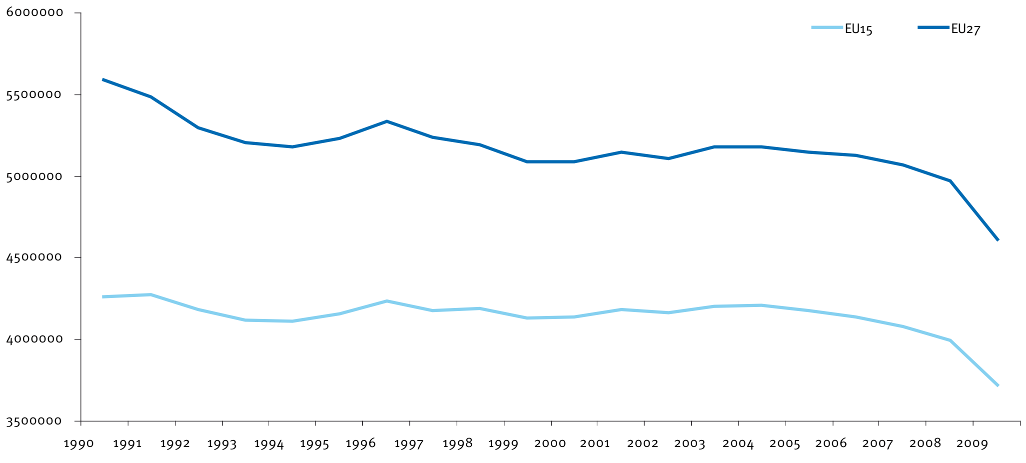
Total Greenhouse Gases emissions have not changed much in the core EU15 countries since 1990 (see Chart 3). The emissions rate has dropped slightly but it does not reflect the steep reduction that the EU is aiming for through its directives. There was only a 12.7% reduction in total GHG emissions between 1990 and 2009 despite the enactment of alternative directives and policies by the EU. This represents an average of a 0.67% drop per year. Although it may seem that the emissions target (20% below 1990 levels) is closer to being met, an increase in the pace of reductions would actually be needed.

Chart 3. Total GHG Emissions in Europe

¿Cómo han evolucionado las emisiones de gases de efecto invernadero en Europa?

Si bien la tendencia es decreciente, las emisiones de gases de efecto invernadero totales no han experimentado los cambios drásticos deseados en los países UE15 desde 1990. Dicho de otro modo, la tendencia hacia las reducciones no es tan abrupta como se pretende con las nuevas directivas y políticas aprobadas por la UE: de hecho, las emisiones de GEI solo se han reducido un 12,7% entre 1990 y 2009, lo que representa un promedio del 0,67% anual (ver gráfico 3). Aunque puede parecer que el objetivo de alcanzar niveles de emisiones un 20% inferiores a los de 1990 en el año 2020 está más cerca, es necesario aumentar el ritmo de las reducciones para alcanzarlo.

Gráfico 3. Total de emisiones de GEI en Europa



Source: Eurostat –1000 metric tons CO_2 equivalent– Total Greenhouse Gases emissions

Fuente: Eurostat –1000 toneladas métricas equivalentes de CO_2– Total de emisiones de gas de efecto invernadero

The distribution of GHG emissions across the different EU15 countries has changed over time (see Chart 4). While countries like Germany or

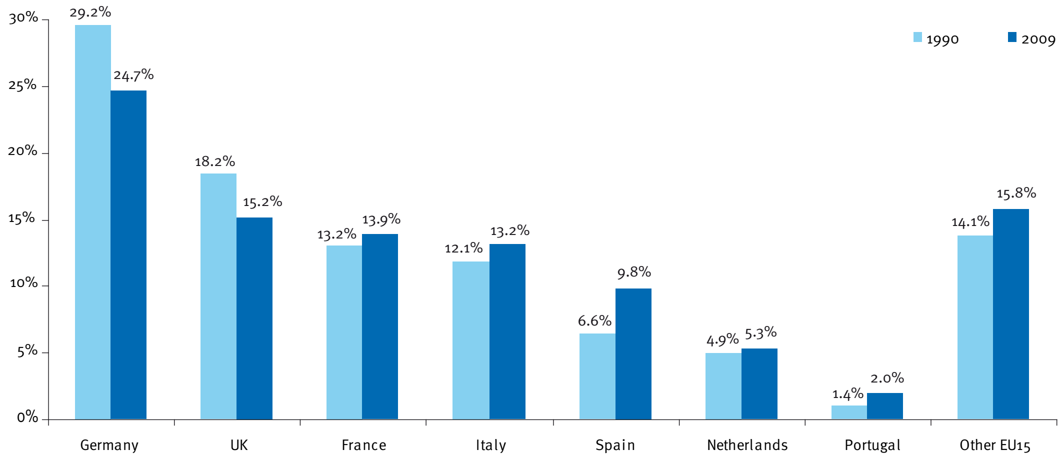
La distribución de las emisiones de GEI entre los distintos países del UE15 ha cambiado con el paso del tiempo (ver gráfico 4).

the UK have considerably reduced emissions (around 20%), others, like Spain or Portugal (around 25%), have considerably increased them. This is due to not only different growth patterns but also to varying national regulations and levels of enforcement of the European legislation.

Mientras que países como Alemania o el Reino Unido han reducido considerablemente sus emisiones (cerca de un 20%), otros como España o Portugal las han aumentado de forma considerable (cerca de un 25%). La principal causa de esta asimetría es el diferente patrón de crecimiento que los distintos países tienen, pero también contribuyen las diferencias existentes entre las regulaciones nacionales y los niveles de implementación de la normativa europea.

Chart 4. Share of GHG Emissions in EU15

Gráfico 4. Tasa de emisiones de GEI en UE15



Source: Eurostat – 1000 metric tons CO_2 equivalent; % of Total GHG Emissions

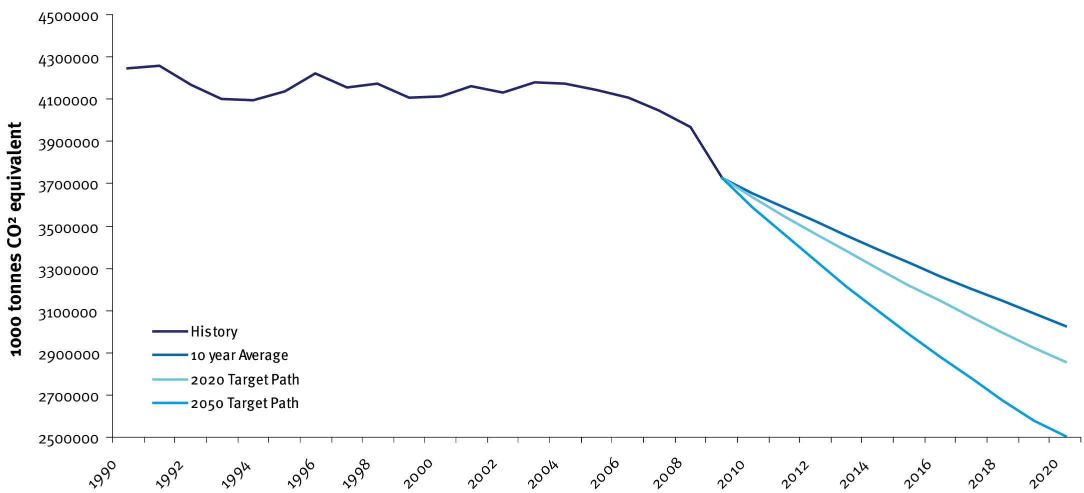
Fuente: Eurostat – 1000 toneladas métricas equivalentes de CO_2; % del total de emisiones de GEI

As we observe in Chart 5, a projection of the historic reduction of GHG emissions in the EU15 over the next decade allows us to state that additional efforts are needed to reach both the 2020 and 2050 targets.

Como se aprecia en el gráfico 5, si la reducción de emisiones de GEI sigue durante la próxima década la tendencia de los últimos diez años, se necesitarán esfuerzos adicionales para alcanzar los objetivos marcados para 2020 y 2050.

Chart 5. Scenario Simulation for Total GHG Emissions in EU15 (2020)

Gráfico 5. Escenario de simulación para el total de emisiones de GEI en UE15 (2020)



Source: authors' own elaboration

Fuente: elaborado por los autores

How have Building GHG emissions evolved in Europe?

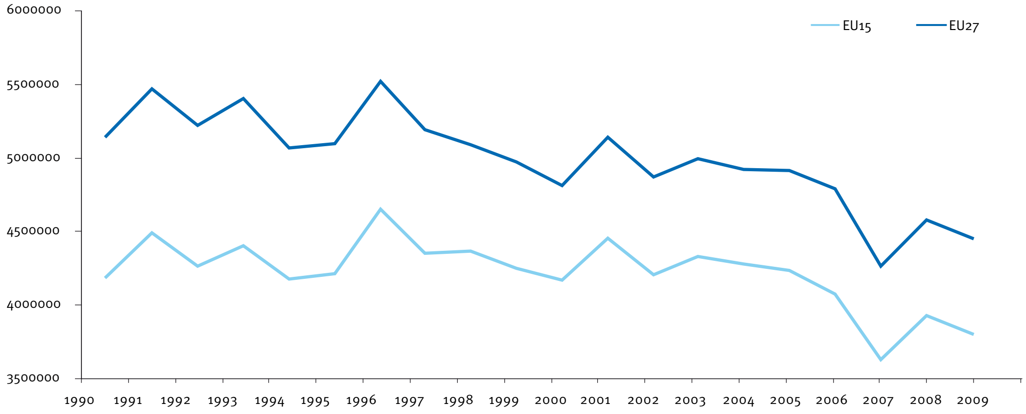
A crucial contributor to GHG emissions in Europe is the dwelling stock (see Chart 6). The Building sector, which comprises both residential, government and commercial buildings plus other services, and the construction sector as a whole, represents around 40% of final energy consumption and between 25% and 36% of GHG emissions in Europe, depending on the reporting standard. Hence, an increase in energy efficiency in the residential sector would imply a significant reduction in GHG emissions in Europe (see Chart 7, which shows the parallelism between residential and total GHG emissions).

¿Cómo han evolucionado las emisiones de GEI de los Edificios en Europa?

El inventario de viviendas contribuye de forma significativa a las emisiones de gases de efecto invernadero en Europa (ver gráfico 6). El sector económico de los "Edificios", que incluye las viviendas residenciales, edificios públicos y comerciales, así como el sector de la construcción, representa cerca del 40% del consumo final de energía y entre el 25% y el 36% de las emisiones de GEI en Europa, dependiendo del estándar de medida utilizado. Por ende, un aumento de la eficiencia energética en el sector residencial reduciría considerablemente las emisiones totales de GEI en Europa (ver gráfico 7, que muestra la alta correlación entre el total de las emisiones de GEI y el correspondiente a la categoría de viviendas residenciales).

Chart 6. GHG emissions by the Residential sector in Europe (Tg million tonnes)

Gráfico 6. Emisiones de GEI del sector residencial en Europa (TG millones de toneladas)

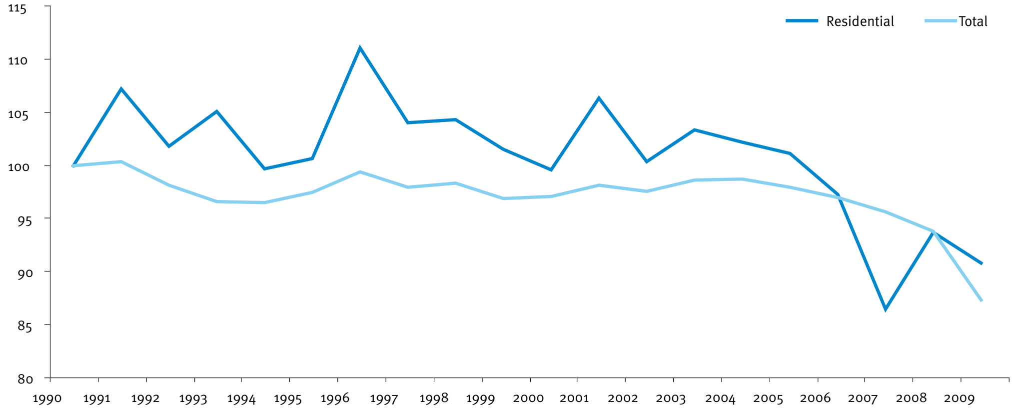


Source: EEA

Fuente: EEA

Chart 7. Compared Evolution of Total and Residential GHG Emissions in Europe

Gráfico 7. Evolución comparada de las emisiones de GEI totales y residenciales en Europa



Source: Indexes based on EEA data (base: 1990), show annual change in GHG emissions

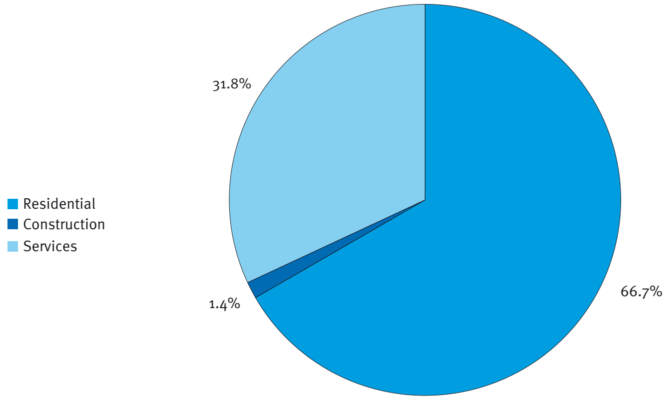
Fuente: Indices basados en datos de EEA (base:1990), muestran el cambio anual en las emisiones GEI

The dwelling stock share of final energy consumption by buildings in Europe is almost 67% in both the EU15 and EU27 (see Chart 8). The increase of energy usage in this sector reached 12.68% in the EU15 and 8% in the EU27. This implies that the residential sector has increased energy usage since the implementation of the mitigation targets and in spite of them.

Como vemos en el gráfico 8, el inventario de viviendas representa el 67% del consumo final de energía del conjunto de los edificios, tanto en UE15 como en UE27. El aumento del consumo de energía en este sector alcanzó el 12,68% en UE15 y el 8% en UE27, lo que implica que este sector aumentó su consumo de energía aun cuando se promulgó regulación orientada a la eficiencia energética.

Chart 8. Building Sector Shares (EU27)

Gráfico 8. Distribución del sector edificios (UE27)



Source: Eurostat

Fuente: Eurostat

However, over the 1990-2008 period, driven by the existence of more efficient buildings, space heating technologies and electrical appliances, energy efficiency in the household sector increased by 19% in EU27 countries, or 1.1% per year. This effect was counterbalanced by an increase of 13%, at an annual average rate of 0.7%, in final energy consumption of households. Hence, we can see that mainly two opposite drivers influence household energy consumption. Efficiency improvements in space heating and large electrical appliances reduced consumption while the size of dwellings increased. At the same time increased use of electrical appliances and central heating contributed to a raise in

Sin embargo, en el periodo 1990-2008, la eficiencia energética del sector residencial aumentó un 19% en UE27 (un 1,1% al año) debido a la construcción de edificios más eficientes y a mejoras en la tecnología de calefacción y en los aparatos eléctricos. Este efecto se vio contrarrestado por un aumento del 13% en el consumo de energía, a un promedio anual del 0,7%. Así pues, se aprecian dos factores opuestos que influyen en el consumo residencial de energía. La mayor eficiencia en calefacción y grandes equipos eléctricos reduce el consumo, pero el mayor tamaño de las viviendas y el correspondiente incremento en el uso de los mismos contribuyen al aumento del consumo, anulando parte de los beneficios de la eficiencia energética. En consumption, which offsets part of the energy efficiency benefits. CO_2 emissions per dwelling were 24% below their 1990 level in 2008, mainly because of CO_2 savings resulting from the switch to fuels with lower CO_2 content.

su conjunto, las emisiones de CO_2 por vivienda fueron en 2008 un 24% inferiores a las de 1990 debido a esta mayor eficiencia, la cual también vino acompañada de la utilización de combustibles con un menor contenido de CO_2.

How Would Building Energy Efficiency Contribute to Reductions in GHG Emissions in Europe?

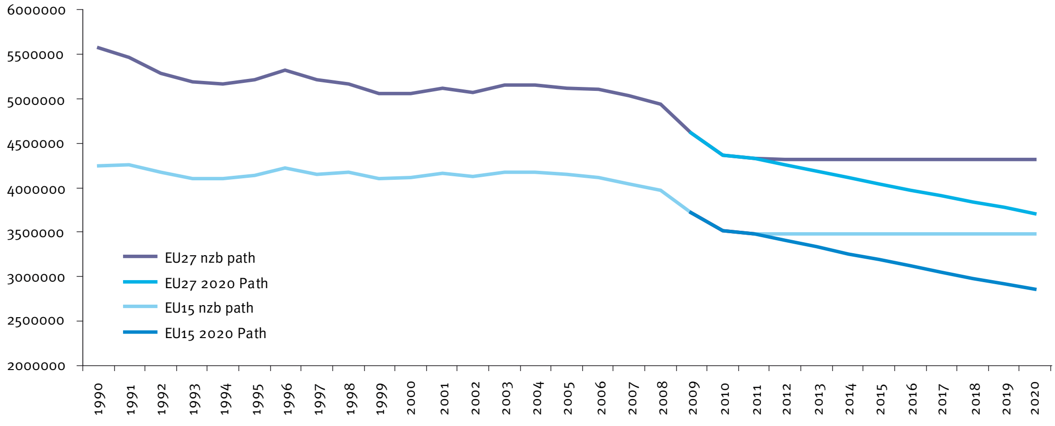
If we analyze these trends assuming that higher energy efficiency will result in lower energy consumption, for instance, through the achievement of Net Zero Buildings in the Residential sector, and assuming all else is constant, we can see how total GHG emissions would be impacted by this reduction. A Residential sector that is more energy efficient would result in much lower GHG emissions for Europe (see Chart 9).

¿Cómo contribuirá la mayor eficiencia energética de los edificios a la reducción de la emisiones de GEI en Europa?

Si analizamos las tendencias actuales y suponemos que una mayor eficiencia energética implicará un menor consumo energético, por ejemplo consiguiendo «Edificios de Consumo Neto de Energía Nulo» en el sector residencial, (y asumiendo que todo lo demás permanece constante) podemos evaluar cómo afectaría tal reducción a las emisiones totales de GEI. El gráfico 9 muestra como la construcción de hogares con una mayor eficiencia energética reduciría significativamente las emisiones de GEI en Europa.

Chart 9. Scenario Simulation for Net Zero Residential GHG Emissions with 2020 Path

Gráfico 9. Escenario de simulación para emisiones de GEI en viviendas residenciales con energía neta nula con la Hoja de ruta 2020



Source: own elaboration-1000 metric tons CO_2 equivalent

Fuente: elaboración propia-1000 ton. métricas equivalentes de CO_2

Net Zero buildings would account for 6.4% reduction in total GHG emissions for EU27 and 6.7% reduction in total GHG emissions for EU15. Even though 2020 targets are not reached with Net Zero Buildings, almost 85% of the targets would be reached thanks to this policy.

Los edificios de energía cero, representarían una reducción del 6,4% en las emisiones totales de GEI para UE27 y del 6,7% para UE15. Aun cuando esta reducción no significa alcanzar las metas de 2020, casi se llegaría al 85% de los objetivos marcados.

What European Policies are Important in this Context?

Analyzing the structure of European regulation intended to create incentives for climate change mitigation provides us with useful information (see Chart 10). First, from the amount of policies and regulations that have been enacted and re-enacted by the EU since Kyoto we understand that the policy activity has been intense. Moreover, the process of enactment, enforcement and reform of regulations helps us determine whether the initial regulations had the intended effects or if they fell short of their objectives. We find that the EU has been successful in that the MSs have enacted legislation concerning the EPBD; however, the implementation is slow and nonuniform across MSs. It will probably be necessary to introduce sanctions in case of imperfect of incomplete implementation.

Second, we are able to understand where European regulations focus regarding climate change mitigation. Economic policies aiming at incentives towards energy efficiency are the tools currently being stressed most in the EU. Some of these energy efficiency policies target very specific sectors, such as the European Performance of Buildings Directive, which aims towards climate change mitigation through a better use of the European dwelling stock.

Finally, as the European Union usually leads the way for the rest of the world in matters

¿Qué políticas europeas son importantes en este contexto?

Al analizar la estructura de la regulación que tiene como objetivo la creación de incentivos para mitigar el cambio climático encontramos directrices útiles (ver gráfico 10). Primero, dada la cantidad de políticas y normativas que la UE ha aprobado desde Kioto, percibimos que la actividad reguladora ha sido muy intensa. Además, el proceso de aprobación, aplicación y reforma de esas políticas nos ayuda a comprender cuáles fueron los efectos iniciales de estas regulaciones y si han logrado sus objetivos. Encontramos que la UE ha logrado que los estados miembros aprueben la legislación que regula la EPBD, aunque todavía no ha tenido éxito en promover la implementación de la misma. Probablemente sea necesario que la UE implemente nuevos mecanismos de sanción en caso de incumplimiento.

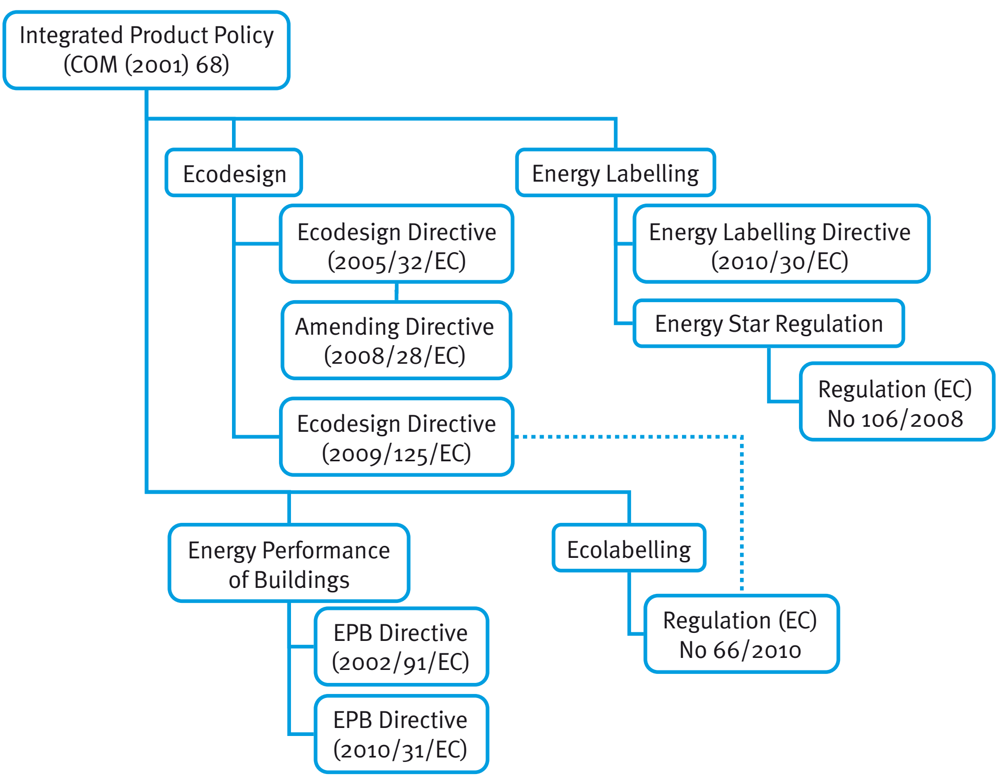
En segundo lugar, entendemos cuáles son los intereses principales actuales de la regulación europea sobre el cambio climático. Las políticas económicas que buscan crear incentivos hacia la eficiencia energética son los instrumentos en los que más énfasis se hace desde la UE. Algunas de estas políticas tienen como objetivo sectores muy específicos, tales como la Directiva Europea de Eficiencia Energética en Edificios, cuyo objetivo es mitigar el cambio climático a partir de un uso más racional del inventario de viviendas de Europa.

Finalmente, como la Unión Europea suele liderar al resto del mundo en lo que respecta a related to regulation, and specifically climate change mitigation regulation, this analysis helps us understand what instruments are likely to be mimicked by other countries. In this sense, it also allows us to understand what effects the regulation will have on markets in new countries and regions.

regulación y, concretamente, a la regulación específica sobre el cambio climático, este análisis nos permite comprender qué instrumentos pueden ser imitados por otros países y comparar los diversos instrumentos reguladores. Asimismo, podemos conocer los efectos que tendrá la regulación en los mercados de distintos países y regiones.

Chart 10. Map of European Climate Change Mitigation Regulation

Gráfico 10. Mapa de la legislación para la mitigación del cambio climático en Europa



Source: own elaboration

Fuente: elaboración propia

As we have seen, the European Union is not yet close to its proclaimed targets on GHG emissions and energy consumption. Even

Tal como hemos mencionado antes, la UE está todavía lejos de alcanzar los objetivos sobre las emisiones de GEI y el consumo energético para though the economic and financial crisis has "helped" to take the EU closer to its goal by significantly reducing economic activity in the region, the annual pace of emissions reduction would need to be increased for both the EU27 and the EU15 in order to meet the 2020 targets. Furthermore, if the EU were to extend its target reduction on GHG emissions to 30% by 2020, reforms would need to accelerate.

As mentioned above, Buildings are key to achieving these targets. GHG emissions from buildings in the EU account for 36% of total emissions. Likewise, Buildings consume 40% of the energy in Europe. Hence, several EU directives are pointed towards the goal of boosting energy efficiency in buildings. The European Performance of Buildings Directive— which has been recast in 2010 in order to help achieve the goal of energy efficiency in buildings—is a primary tool for clarifying this scene.

The European Performance of Buildings Directive (EPBD)

This directive was passed in 2002 and reformed in 2010. Its main provisions were to make it mandatory for constructors to display labels showing energy impact per year and to set minimum energy requirements for construction materials.

Recent changes to this directive include switching from Member State Benchmarking Method Development to EU Commission Development, which implies that from now on MS will have to apply EU Commission designed measurement standards, not their own.

However, the main point of the reform concerns the standard to be set for public procurement

2020. Aun cuando la crisis económica y financiera actual ha «ayudado» en este sentido al reducir la actividad económica de la región, el ritmo anual de las reducciones deberá acelerarse para alcanzar los objetivos de UE27 y UE15 en 2020. Además, si la UE decidiera finalmente extender su objetivo a un 30% de reducción de las emisiones de GEI para el año 2020, las reformas deberían acelerarse aún más.

Los edificios son clave para alcanzar estos objetivos, tal como hemos visto. Las emisiones de GEI de los edificios representan el 36% del total y, su consumo de energía, el 40% del consumo final en Europa. Por ende, varias directivas europeas apuntan a una mayor eficiencia energética en edificios. Una de ellas es central: la "Directiva europea de eficiencia energética de los edificios", que ha sido reformada en 2010.

La Directiva europea relativa a la eficiencia energética de los edificios (EPBD, por sus siglas en inglés)

Esta directiva se promulgó en 2002 y se reformó en 2010. Entre sus provisiones más importantes está la obligatoriedad para los constructores de exhibir certificados de impacto energético e incluir ciertos requisitos mínimos para los materiales de construcción.

Entre los cambios recientes a esta directiva se incluye la reducción en el protagonismo de los Estados miembros en favor de la Comisión Europea, lo cual implica que los Estados miembros finalmente convergerán hacia estándares definidos por la CE.

Sin embargo, el punto más importante de la reforma tiene que ver con el estándar de adquisición regarding buildings: the reformed directive establishes a voluntary goal of "near zero" to be applied to new public buildings. This "near zero" goal is criticized as not ambitious enough: some aspire towards a "net zero energy" goal. Two main reasons for this criticism are the need for a clear-cut goal for all MSs and the problem of what is considered to be "near zero" by each Member State. On the other hand, some claim that a "net zero" goal would be unattainable because of its costs while a "near zero" goal would be effective and affordable for a Member States.

Notwithstanding this, the main provisions of the new EPBD are not supposed to be implemented supra-nationally but by the Member States individually. Two of the most important aspects for this study are first, the "labeling" of buildings through the implementation of energy efficiency certificates (as the Energy Performance Certificate) that aim to affect the demand for buildings through a differentiation of products, and second, the implementation of minimum standards for building elements.

Hence, these policies affect the market for buildings by imposing labels and near zero targets on buildings, which influences demand for greener construction materials. The regulation will have two potential impacts on the markets, one through European consumers' willingness to pay for greener products and the other through requirements imposed on construction materials. These effects will depend on the *Velocity of Adoption* and *Convergence* of the National Energy Efficiency Action Plans (NEEAPs) to the 2010 EPBD recast.

pública: se permitirá establecer voluntariamente un criterio para que los edificios públicos se puedan calificar como «Edificios con Consumo de Energía casi Cero». Esta meta, de todas formas, ha recibido críticas por ser poco ambiciosa, y hay quien sugiere que la meta real debería ser crear edificios con un consumo de energía neto igual a cero. Se ha dejado abierto al criterio de cada Estado miembro la definición de los objetivos y lo que cada uno estima «casi cero». Al mismo tiempo, hay quien considera inalcanzable la meta de energía cero neta y considera la «casi cero» más eficaz y barata para los Estados miembros.

A pesar de ello, las provisiones de la nueva EPBD no se implementarán de forma supranacional sino individualmente por cada Estado miembro. Dos aspectos centrales para este estudio son, en primer lugar, la certificación de edificios mediante certificados de eficiencia energética que intentan influir en la demanda de viviendas a través de la diferenciación de productos; y, en segundo lugar, la implementación de requisitos mínimos para los materiales de construcción.

Por ende, estas políticas afectarán al mercado de edificios al imponer certificaciones y objetivos de reducción de emisiones, las cuales influirán en la elección de materiales de construcción más «verdes». Esta regulación tendrá dos posibles consecuencias en los mercados: primero, a través de la «disposición a pagar» de los consumidores por productos «verdes»; segundo, a través de requisitos mínimos para los materiales de construcción. Estos efectos dependerán de la "*velocidad de adopción*" y de la "*capacidad de convergencia*" de los Planes de Acción Nacional de Eficiencia Energética (PANEE) hacia la EPBD de 2010.

How do the National Energy Efficiency Action Plans Adjust to the EPBD Recast? Velocity and Convergence

The Energy Performance Building Directive (Directive 2002/91/EC) introduced the compulsory energy certification of buildings in the EU in 2006 and it has played a key role in the common policy for monitoring and reducing energy consumption. The Energy Performance of Buildings Directive recast approved in 2010 sets the stage for Member States to determine the criteria for energy efficiency in buildings. In order to assess the experience gained in this field in Europe overall, and in particular against the highly diverse settings of the different European nations, we examine the extent to which the Directive has been implemented by seven EU Member States: The Netherlands, the United Kingdom, France, Germany, Italy, Portugal and Spain.

This report studies the existing National Action Plans and their intended effects on the market for buildings (demand, price, and so on), on energy efficiency and on carbon emissions.

Some countries in Europe were pioneers in the implementation of energy efficiency in buildings. As usual, countries like United Kingdom, Germany, The Netherlands and France were among the first to implement some kind of energy performance certificates (EPC) for buildings.

Our analysis will comprise two sets of issues: "speed of adoption" and "convergence in regulations." The first issue, speed of adoption, will reveal the timing differences between different EU MS. On the second issue, we will evaluate the "capacity for convergence" in regulation of the various EU MS regardless of the initial speed of adoption.

¿Cómo se han adaptado los Planes de Acción Nacionales de Eficiencia Energética a la reforma de la EPBD? Velocidad y convergencia

La EPBD (Directiva 2002/91/CE) introdujo la certificación energética obligatoria de los edificios en la UE a partir de 2006 y ha desempeñado un papel clave en la política común para controlar y reducir el consumo de energía. La reforma de 2010 determina que los Estados miembros serán los que fijen los criterios de eficiencia energética en edificios. Para sopesar la experiencia que Europa en su conjunto, y especialmente teniendo en cuenta los contextos tan diversos de las naciones europeas, ha adquirido en este sector, examinamos la implementación de la EPBD en siete Estados miembros: Alemania, España, Francia, Holanda, Italia, Portugal y Reino Unido.

Analizamos los PANEE existentes y sus efectos previstos en el mercado de edificios (demanda, precio, etc.), en la eficiencia energética y en las emisiones de GEI.

Observamos que algunos países de Europa han sido pioneros en la implementación de regulación de eficiencia energética en edificios como por ejemplo el Reino Unido, Alemania, Holanda y Francia.

Nuestro análisis comprende dos temas centrales: la «velocidad de adopción» y la «convergencia» hacia la EPBD. El primero resume las diferencias de timing de los distintos Estados miembros y su compromiso con la EPBD. El segundo evalúa la capacidad de convergencia de los Estados miembros sin importar la velocidad de adopción inicial.

Speed of Adoption

We can break down European Member States into three different groups in terms of speed of adoption: pioneers, early adopters and laggards.

The "pioneer" group comprises those countries with a longer history in terms of sustainability regulation, which have led the way in terms of implementing the original European Performance of Buildings Directive. These countries have adopted labels, minimum requirements and targets earlier than their counterparts. Our analysis determines that the United Kingdom (through its NEEAP for England and Wales), Germany and The Netherlands are the Pioneers of our group.

"Early adopters" are those countries that fall short in one of the categories mentioned, but which, despite not being the first in implementation, have also set early standards on labels, minimum requirements and targets. In our sample, France and Portugal are "early adopters."

Finally, the laggards are those countries that historically have lagged behind on all fronts in terms of NEEAP implementation. We consider the clear examples of Spain and Italy.

Velocidad de adopción

Podemos dividir a los Estados miembros en tres grupos diferentes en función de su velocidad de adopción: pioneros, de adopción temprana, y de adopción tardía.

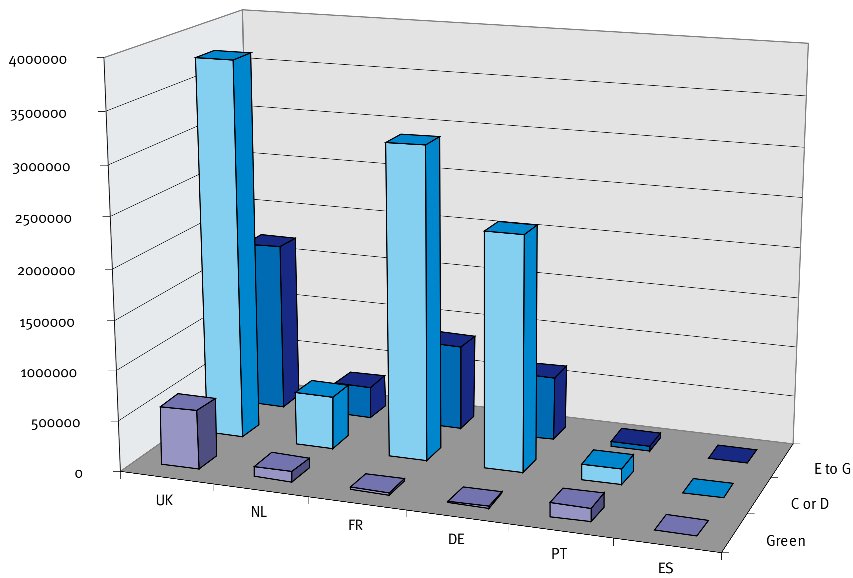
En el grupo de los «pioneros» incluimos a aquellos países que poseen una rica historia reguladora en torno a la sostenibilidad y que han liderado la implementación de la EPBD original. Estos países han adoptado métodos de certificación y objetivos antes que el resto de la UE; el Reino Unido (especialmente en Inglaterra y Gales), Alemania y Holanda son los pioneros de nuestro grupo.

Los países de «adopción temprana» son aquéllos que, sin llegar a ser pioneros, han fijado estándares de certificación, materiales y objetivos que los acercan a la EPBD. En nuestra muestra, Francia y Portugal son parte de este grupo.

Finalmente, los países de «adopción tardía» son aquéllos que han estado históricamente rezagados en términos de implementación: España e Italia son ejemplos claros.

Chart 11. Distribution of EPC Grades by Country (2010)

Gráfico 11. Distribución de las calificaciones de Certificados de Eficiencia Energética - CEE por país (2010)



Source: authors' own elaboration

Fuente: elaborado por los autores

Convergence in Regulations

Besides the rapid or slow adoption of the EPBD on their NEEAPs, countries also differ in regards to their capacity to converge in terms of regulation (see Chart 11 for the large differences in the intensity of emissions of green certificates across EU15 countries). Here we can divide countries into Convergent, Chronic or Non-convergent categories.

Convergent MSs are those whose NEEAPs are adapting quickly to the EPBD recast and which seem to take into account a common European goal regardless of the energy efficiency regulation history in that particular

Convergencia en regulación

Además de la rapidez de adopción de la EPBD a través de los PANEE, los distintos Estados miembros también se diferencian en función de su capacidad de converger hacia la regulación europea (ver gráfico 11, donde se aprecia la gran diferencia que existe entre la intensidad de emisión de certificados de eficiencia energética en los países de la UE15). Aquí, la distinción se hace entre «convergentes», «crónicos» y «no convergentes».

Los «convergentes» son aquellos países cuyos PANEE se adaptan rápidamente a normas similares a la EPBD teniendo en cuenta una meta country. In this group, we find the UK, The Netherlands and Portugal.

Chronic countries are those that seem too committed to previous/existing regulation to implement a convergent NEEAP. Two examples are France and Germany, countries with a long history of energy efficiency regulation that have been unable to, for example, implement a national registry for Energy Performance Certificates.

Non-convergent Member States are those that, despite having a NEEAP in force, have been unable to coordinate its implementation at a national level. Both Spain and Italy have failed on this regard, leaving the implementation of the EPBD to the different regions or autonomies. Hence, these countries are further away from the convergence goal.

Intensity

An important aspect is the "intensity" of adoption of the EPCs, that is to say, the outstanding stock of EPCs per existing dwelling. If we limit the analysis to the amount of certificates issued, we would mistakenly believe that the UK and The Netherlands are very different cases. But when analyzing them in terms of "intensity" we see how the two countries are converging (see Chart 12), being both *Convergent Pioneers*.

europea sin importar la historia reguladora particular en términos de eficiencia energética. En este grupo encontramos al Reino Unido, Holanda y Portugal.

Los «crónicos» son aquellos países que siguen comprometidos con la regulación que han promulgado con anterioridad a la EPBD y que evitan una rápida convergencia. En este grupo encontramos a Francia y Alemania, ambos con una rica historia de regulación de la eficiencia energética pero que han sido incapaces todavía de crear, por ejemplo, un registro nacional para los certificados de eficiencia energética (CEE).

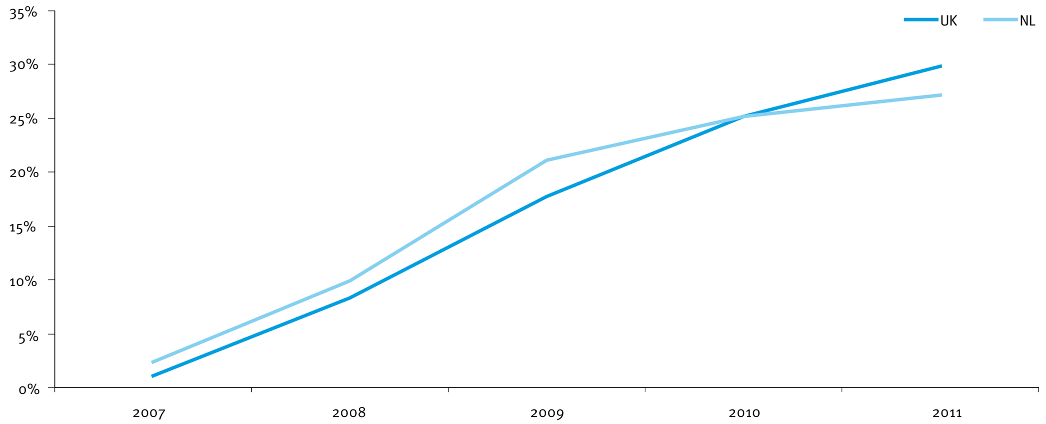
Los países «no convergentes» son aquellos que, a pesar de haber promulgado un PANEE y/o su reforma a partir de 2010, han sido incapaces de implementarlo a nivel nacional. España e Italia han fallado en este aspecto, al descentralizar la implementación de los aspectos claves de la EPBD.

Intensidad

Un aspecto importante a tener en cuenta es la «intensidad» de adopción de los certificados de eficiencia energética, es decir, la cantidad de certificaciones vigentes respecto al inventario de viviendas. Si solo tuviéramos en cuenta la cantidad de CEE vigentes, veríamos una enorme diferencia entre el Reino Unido y Holanda, por ejemplo. Sin embargo, si tenemos en cuenta la «intensidad», veremos que ambos países siguen una senda muy similar (ver gráfico 12), lo que se corresponde con su condición de *pioneros convergentes*.

Chart 12. EPC Intensity in England and The Netherlands

Gráfico 12. Intensidad de los CEE en Inglaterra y Países Bajos



Source: own elaboration

Fuente: elaboración propia

We can analyze "Intensity" as a snapshot, that is to say, by looking at the current EPC intensity of each of the seven selected countries. Again, we see how *Convergent Pioneers* like UK and The Netherlands are in better shape than the rest. We also find that a laggard like Portugal has a surprisingly high EPC intensity.

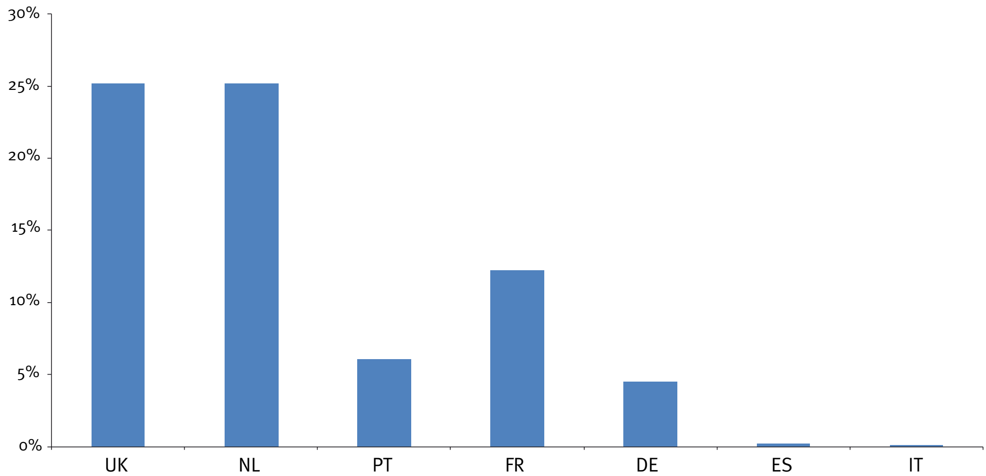
France and Germany, *Early adopters* but *Chronic* countries, also seem to have high EPC intensity, although this assertion is based on rough estimates due to the fact that both these countries do not hold a national register.

Si analizamos la «intensidad» desde un punto de vista estático, es decir, si examinamos la intensidad actual para cada uno de los siete países, podemos observar que los *pioneros convergentes* como el Reino Unido y Holanda se encuentran en mejor forma que el resto, pero también que el desempeño de Portugal en términos de intensidad ha sido sorprendente.

Alemania y Francia, países de *adopción temprana* pero *crónicos* parecen tener una alta intensidad de adopción, pero esta conclusión debe tomarse con precaución al basarse en estimaciones imprecisas (ninguno de los dos países posee un registro nacional de CEE obligatorio).

Chart 13. EPC Intensity in the Seven Selected Countries (2010)

Gráfico 13. Intensidad de los CEE en los siete países seleccionados (2010)



Source: own elaboration

Fuente: elaboración propia

Table 1. Speed of Adoption and Convergence of Countries

Cuadro 1. Velocidad de adopción y convergencia de los países

	Pioneer	Early adopter	Laggard
Convergent	UK, The Netherlands	Portugal	
Chronic	Germany	France	
Non Convergent			Spain, Italy

Source: own elaboration

Fuente: elaboración propia

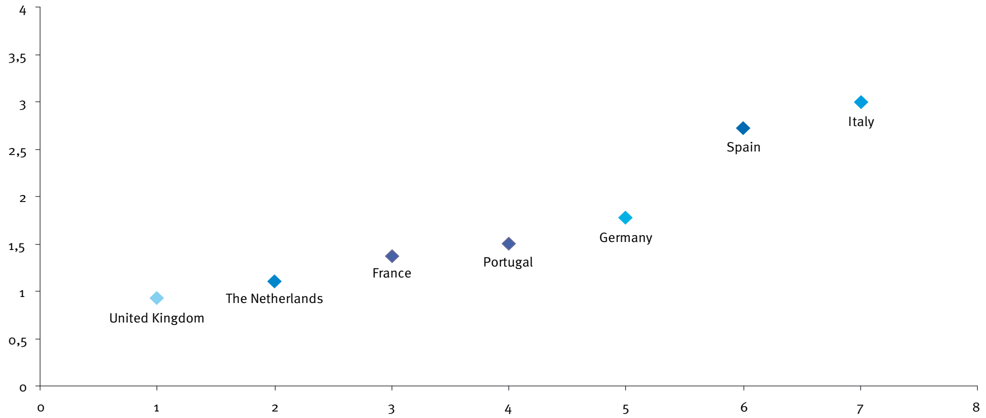
Our ranking for EPBD Convergence shows very interesting results. It gathers data and assesses how each country has fared on several aspects such as energy efficiency track record, whether it has implemented the EPBD recast at a national level, the number of EPCs issued (see Chart 13), the "Intensity" of EPCs, the type of label chosen, whether it has a national

De esta forma, elaboramos un *Índice de Convergencia* de países en términos de cómo han respondido históricamente al desafío de la eficiencia energética, a si han implementado la reforma de la EPBD, al número de certificados CEE vigentes (ver gráfico 13), al tipo de certificación que se ha implementado, a la existencia de un registro nacional de CEE, o a si se han register or not, whether it has implemented requirements for recycled materials of for public tenders (see Table 1 and Chart 14).

implementado requisitos mínimos para materiales de construcción en licitaciones públicas, entre otros aspectos (ver cuadro 1 y gráfico 14).

Chart 14. Convergence Ranking of the Seven Selected Countries

Gráfico 14. Clasificación de la convergencia de los siete países seleccionados



Source: own elaboration
Note: perfect convergence is the (0,0) point. As we move right along the X-axis, countries are farther away from EPBD convergence; as we move up along the y-axis, velocity of convergence is lower.

Fuente: elaboración propia
Nota: punto de convergencia perfecta es (0,0). Según nos movemos a lo largo del eje de abscisas, los países divergen más de la EPBD; según nos movemos a lo largo del eje de ordenadas, la velocidad de convergencia de los países es menor.

What is the Evidence of Green Incentives and Impact on Markets?

Given the lack of available and proper data in most countries, a meta-analysis of the existing research can yield important conclusions on the effects of regulation on the markets. In this case, existing research suggests that consumers are willing to pay higher prices for “greener” properties and companies are willing to pay higher rents for “greener” office spaces. In some cases, consumers and companies appear to be willing to pay more than the potential economic savings of a more efficient dwelling or building. Hence, owners and leasers of buildings will be interested in investing more in more efficient buildings and this will probably

¿Qué evidencia existe del impacto de los incentivos «verdes» en los mercados?

Debido a la falta de información fiable disponible en la mayoría de países de Europa, hemos realizado un meta análisis de la investigación existente sobre los efectos de la regulación en los distintos mercados. Los estudios realizados indican que los consumidores están dispuestos a pagar precios más altos por propiedades «verdes», sean estos individuos o empresas. En algunos casos, incluso, se sugiere que las empresas y los consumidores parecen estar dispuestos a pagar más por una propiedad u oficina que el correspondiente ahorro en eficiencia energética que se muestra en la certificación. Por ende, se estima que esta mayor affect the behavior of constructors, architects and construction material suppliers.

Hence, a first step in our research has been to analyze the existing research in the field of "green" labels. Although willingness to pay for green buildings is a growing field, especially fuelled by the findings of researchers in The Netherlands and the US, the extent of current research is not vast. We were able to identify only two sources of studies in Europe, one in Australia and three in the United States.

In terms of implementation, Leed and BREAM certificates in the US have led the way since 1997, specially regarding commercial properties, both for rent and sale. The studies conducted by Miller (2008), McAllister & Fuerst (2008, 2009, 2011) and Eichholtz, Kok & Quigley (2009) synthesize the most important results.

In Australia, since 2004 the Australian government committed to mandatory energy efficiency disclosure. The study conducted by the Department of the Environment, Water, Heritage and the Arts on the Australian Capital Territory summarizes the conclusions for 2005 and 2006.

In Switzerland, studies have been conducted around the *Minergieproject*. However, these studies are not available online and the lead researchers have not responded to our requests for copies of their papers or access to their datasets.

More recently, a group of researchers based in The Netherlands has analyzed the effects of EPC labels on the residential and commercial sectors in The Netherlands and the US. Kok, Brounen, Eichholtz, Menne, Jennen and Quigley have conducted more than five studies on

disposición a pagar se convierte en un incentivo importante para que los promotores construyan viviendas y oficinas más eficientes, lo que a su vez debe influir en el comportamiento de los arquitectos y los proveedores de materiales de construcción.

Nuestro primer paso ha sido analizar la investigación existente en el campo de la certificación «verde» de edificios. Aun cuando la disposición a pagar por los edificios «verdes» es un campo de estudio en crecimiento, especialmente gracias a las investigaciones realizadas en EE.UU. y Holanda, todavía no es un campo maduro. Hemos podido identificar solo dos fuentes de estudios en Europa, una en Australia y tres en los EE.UU.

En términos de implementación, los certificados LEED y BREAM en los EE.UU. han existido desde 1997, especialmente para propiedades comerciales, tanto para operaciones de venta como de alquiler. Los estudios de Miller (2008), McAllister y Fuerst (2008, 2009, 2011) y Eichholtz, Kok y Quigley (2009) sintetizan los resultados más importantes en EE.UU.

En Australia, desde 2004 el Gobierno se ha comprometido a publicar la eficiencia energética de los edificios. El estudio realizado por el Departamento de Medio Ambiente, Agua, Patrimonio y Cultura en el Territorio de la Capital de Australia (ACT) resume las principales conclusiones para 2005 y 2006.

En Suiza, varios estudios han sido desarrollados en torno al proyecto *Minergie*. Sin embargo, éstos no se encuentran disponibles.

Más recientemente, un grupo de investigadores afiliados principalmente a universidades holandesas han analizado los efectos de los CEE en los sectores comerciales y residenciales de dicho data from 2008 onwards testing a similar model, with interesting results.

Our meta-analysis begins by describing the existing body of research on this topic. We then consider the methodology used by existing research, the descriptive statistics and the results obtained by previous researchers. Finally, we outline the conclusions on the existing research on the willingness to pay for green buildings.

The existing body of research can be subdivided into three groups: residential dwellings for sale, commercial buildings (and dwellings) for rent, and commercial buildings (and dwellings) for sale.

The results for the first group are shown in Table 2. These results show positive effects for the residential sector. Labels for energy efficiency appear to be successful: they signal a certain characteristic that is valued by consumers, hence creating an incentive for owners.

país y de los EE.UU. Kok, Brounen, Eichholtz, Menne, Jennen y Quigley han producido más de cinco estudios desde 2008 que arrojan resultados similares.

Nuestro meta análisis comienza por describir cada una de las investigaciones existentes, su metodología, las muestras utilizadas y los resultados obtenidos. También formulamos conclusiones sobre los resultados obtenidos por estas investigaciones en lo referente a la disposición a pagar por edificios más ecológicos.

Podemos dividir las investigaciones existentes en tres grupos: viviendas residenciales en venta, oficinas comerciales en alquiler y oficinas comerciales en venta.

Los resultados de la investigación del primer grupo se muestran en el cuadro 2. Estos nos muestran el efecto positivo de una buena certificación en el precio de las viviendas. La certificación «funciona» en el sentido de que señala una característica de la vivienda que es valorada por el consumidor y, por ende, seguramente crea un incentivo para que el productor invierta en eficiencia energética.

Table 2. Value of Energy Efficiency in Residential Dwellings for Sale

Cuadro 2. Valor de la eficiencia energética en las viviendas residenciales en venta

	Brounen & Kok (2010)*	Brounen et al (2009)**	Brounen et al (2009)***	ACT (2008) ^
Energy Efficiency or Green Rating	0,037	0,034	0,025	0,010
	0,001	0,001	0,001	0,001
Label Category				
A	0,102	0,121	0,129	0,061
	0,001	0,001	0,001	0,001
B	0,056	0,069	0,073	0,063
	0,001	0,001	0,001	0,001
C	0,022	0,043	0,049	0,059
	0,001	0,001	0,001	0,001
D	n/a	0,019	0,037	0,030
	n/a	0,001	0,001	0,001
E	-0,005	0,014	0,027	0,016
	>0,10	0,001	0,001	0,002
F	-0,025	0,000	0,017	n/a
	0,001	>0,10	0,001	n/a
G	-0,051	n/a	n/a	n/a
	0,001	n/a	n/a	n/a
Observations	31993	18176	32846	2819
Adj. R2	0,527	0,510	0,568	0,830

* Using the result from model 1 and model 2. Green rating in this case refers to the effect of an A, B or C label. Uses Heckman 2 Step estimation

** Using the results from model 2 in Tables 3 and 4. Brounen, Kok & Menne (2009)

*** Brounen, Kok & Quigley (2009)

^ Using results from model 2 with 2005 data, which includes non-thermal characteristics, ratings are “translated” from EER to EPC terms

Source: own elaboration

Fuente: elaboración propia

The meta-analysis conducted by our research group arrives to a series of interesting results. First, Energy Performance Certificates appear to be significantly related to prices in the three

Las principales conclusiones del meta análisis son las siguientes: primero, los CEE parecen explicar diferencias significativas en los precios en los tres grupos descritos (viviendas scenarios: Residential dwellings for rent, Office buildings for rent and Office buildings for sale. In this regard, we are inclined to state that there is a premium for green buildings, as demonstrated by the higher sale prices or rents that consumers and corporations pay for greener labels.

However, the interpretation of these results is not completely clear: energy performance certificates fulfill two signaling goals that may be impossible to separate. In the case of the intended "green signaling," the label means a property is more or less green in the sense that it contributes more or less to global warming or climate change. However, the label works also for "energy signaling": a greener dwelling or office is also a more energy efficient dwelling or office. The problem hinges on whether consumers want to pay more in order to mitigate climate change or just want to save on energy costs.

This important point is related to a second conclusion: several results show that the green premium is higher than the estimated energy savings associated to the label. That is to say, some studies estimate the net present value of the energy savings of more efficient dwellings or offices and compare it to the premium in price or rent paid by consumers or corporations. This comparison often shows that ABC label premiums are greater than the energy efficiency savings. However, net present value calculations of the energy efficiency savings rest on a number of assumptions about the discount rate, the behavior of consumers, the evolution of energy prices, and so on. These assumptions need to be carefully checked in the data before we can definitely conclude that the green premium is larger than the corresponding energy savings.

residenciales en venta, oficinas comerciales en alquiler y oficinas comerciales en venta). Concluimos que existe una prima por propiedades «verdes», como indican los mayores precios de venta y de alquiler pagados por individuos y por empresas por propiedades con «certificación verde».

Sin embargo, lo que representa esta disposición a pagar más alta no está muy claro. Primero, está la cualidad de «verde»: el certificado significa que una vivienda contribuye en mayor o menor medida al cambio climático. Sin embargo, la certificación también señala un «ahorro energético»: una vivienda «verde» será necesariamente más eficiente en términos de uso de energía. Entonces, ¿cómo distinguir si los consumidores valoran el aspecto económico o el ecológico?

Este punto se relaciona con nuestra segunda conclusión: algunos estudios intentan estimar el valor presente del ahorro energético para compararlo con la disposición a pagar. Esta comparación muestra, casi siempre, que la prima por un «certificado ABC» es mayor que el valor presente del ahorro energético correspondiente. Sin embargo, este cálculo se basa en supuestos sobre la tasa de descuento, la conducta de los consumidores, la evolución de los precios de la energía y el horizonte de cada consumidor, entre otros. Estos supuestos hacen que las conclusiones acerca de una prima verde mayor al ahorro sean poco robustas.

Finalmente, la localización geográfica de estos estudios, la mayoría en Holanda o en los EE.UU., nos permite pensar que podemos encontrarnos ante dos casos muy especiales y, quizás, poco extrapolables. En el caso de Holanda, por ejemplo, algunos aspectos metodológicos pueden ser cuestionados debido a la voluntariedad de la certificación.

A further conclusion relates to the geographical location of the markets studied. Most of them have been conducted either in The Netherlands or the US. This fact reduces the potential generalization of results and could hide two special cases. Also, especially in The Netherlands, several methodological problems could hide an endogeneity problem or some kind of self-selection problem due to the voluntary nature of the labels.

The study in Australia is far more comprehensive and methodologically complex than the other cases and could serve as a guide for further studies. In what follows, we try to extend this model to two European cases; London and France, in order to further assess the effect of the EPBD when it is of mandatory implementation.

Can We Confirm the Evidence of Willingness to Pay for Green Dwellings?

We construct two datasets of properties, for London and France, with the intention to see if the results obtained by the existing research on willingness to pay for green dwellings also arise in these markets.

We test the demand model developed by Eichholtz, Kok & Quigley (2010) and Brounen & Kok (2010), on 2,352 properties posted at Hamptons Inc. for London and 8,000 properties posted at Century 21 for France. The prices are posted sale prices and the property characteristics used are those that are on the website.

The model equation is the following:

$$\log P_i = \alpha + \beta_i X_i + \delta_n L_n + \rho G_i + \varepsilon_i$$

where Log P_i is the natural logarithm of the posted sale price; X_i is a vector of dwelling

El estudio realizado en Australia es mucho más exhaustivo y complejo desde el punto de vista metodológico, por lo que puede servir de modelo para futuras investigaciones. En ese sentido, intentamos ampliar este modelo con dos casos europeos, los de Londres y Francia, con el fin de evaluar el efecto de la EPBD cuando su cumplimiento es obligatorio.

¿Podemos confirmar la existencia de una mayor disposición a pagar por viviendas «verdes»?

Con el fin de examinar si los resultados obtenidos por la investigación existente respecto a la mayor disposición a pagar por viviendas ecológicas se extiende a otros mercados, hemos construido dos bases de datos, una para la ciudad de Londres y otra para Francia.

Basándonos en Eichholtz, Kok y Quigley (2010) y Brounen y Kok (2010), estimamos un modelo de demanda utilizando datos de 2352 propiedades publicadas en la web de la inmobiliaria Hamptons Inc. para Londres y datos de 8000 propiedades publicadas en la web de la inmobiliaria Century 21 para Francia. Los precios de venta publicados y las características utilizadas para cada caso son las disponibles en Internet.

La ecuación del modelo es la siguiente:

$$\log P_i = \alpha + \beta_i X_i + \delta_n L_n + \rho G_i + \varepsilon_i$$

characteristics such as square foot, number of rooms, number of bathrooms, age of property, type of dwelling (attached, detached, studio, etc.); G_i is a vector of scores in the energy label, ranging from A to G; Ln is a set of variables capturing neighbourhood characteristics such as average household income, average household price, average house age, distance to Trafalgar square in the city of London, etc. We do not identify a distance variable for France. More refinement would come from actual sale prices data and from completing additional dwelling characteristics with information such as age of building.

The model uses the following independent variables *lepcscore*, *lenvscore*, *lage2*, *lintsqft* (could be used as a proxy for type of dwelling), l*avgprice*, *lavgincome* and *ldist* as regressors. The dependent variable is *lpricesqft*. The variable *lepcscore* is the natural logarithm of the EPC score for each of the dwellings in the sample, *lenvscore* is the natural logarithm of the Environmental score for each dwelling in the sample, *lage2* is the natural logarithm of an age variable for each postal code that we describe in methodology section, *lintsqft* is the natural logarithm of the size of the dwelling in square feet, *lavgprice* and *lavgincome* are the natural logarithms of the average price and average income for each Borough in the sample, and *ldist* is the natural logarithm of the distance from Trafalgar square for each dwelling in the sample.

The model has a good explanatory power, reaching an R-square of 0.75. Furthermore, the variables not included in the analysis do not threaten the robustness of the model.

In terms of coefficients, our results are in line with those reflected by similar models in the

donde $\log P_i$ es el logaritmo natural de los precios por metro cuadrado publicados (o pies cuadrados, en el caso de Londres); X_i es un vector de características de las viviendas, tales como tamaño, número de habitaciones, número de baños, tipo de vivienda (adosada, independiente, estudio); G_i es un vector de calificaciones de eficiencia energética, las cuales van desde la A a la G (o sus equivalentes numéricos); L_n es una variable que captura la distancia de una determinada vivienda (por su código postal) a Trafalgar Square en la ciudad de Londres. En el caso de Francia, la variable de distancia no ha sido definida.

De obtener acceso a los datos reales de venta, en lugar de a las características publicadas, el modelo obtendría resultados más robustos.

El modelo utiliza las siguientes variables independientes: *lepcscore*, *lenvscore*, *lage2*, *lintsqft* (puede ser utilizada como un proxy para el tipo de vivienda), *lavgprice*, *lavgincome* y *ldist*. La variable dependiente es *lpricesqft*. La variable *lepcscore* es el logaritmo natural del CEE score para cada vivienda en la muestra, *lenvscore* es el logaritmo natural del score de emisiones para cada vivienda en la muestra, *lage2* es el logaritmo natural de una variable de edad de la vivienda definida para cada código postal que detallamos en la sección de metodología, *lintsqft* es el logaritmo natural del tamaño de la vivienda en pies cuadrados, *lavgprice* y *lavgincome* son los logaritmos naturales del precio promedio y del ingreso promedio para cada Borough en la muestra, y *ldist* es el logaritmo natural de la distancia a Trafalgar square de cada vivienda en la muestra.

Para el caso de Londres, el modelo tiene un R-cuadrado de 0,75. Además, las variables que no se han podido incluir en el modelo no le restan solidez.

literature (see Table 3). A 1% increase in the EPC score accounts for a 0,073% increase on the price per square foot of the dwelling. That is to say, for example, that the difference between an average D score (61) and an average Green label (85) represents a 2,87% change in the price per square foot. This compares with a 3,7% increase in Brounen & Kok (2011) for the same range. Put differently, passing from a D label to a B label means around 17 GBP more per square foot for a given dwelling.

En términos de los coeficientes del modelo para el resto de las características de las viviendas, nuestros resultados son similares a los de otros modelos de la literatura (ver cuadro 3). Un aumento del CEE de un 1% representa un aumento del 0,073% en la variable de precio por pie cuadrado. Esto significaría que el cambio de una categoría D a una "verde" significaría un incremento en el precio por pie cuadrado del 2,87% para las viviendas de Londres. Esto es equivalente a 17 Libras esterlinas más por pie cuadrado.

Table 3. Coefficients for the Model Based on the London and France Sample

Cuadro 3. Coeficientes del modelo basados en la muestra de Londres y Francia

	London	France
lepcscore	0.073	-0.022
lintsqft	-0.35	-0.007
lage	0.56	-0.582
lavgprice	0.46	0.459
lavgincome	0.473	0.34
ldist	-0.041	n/a
Adj R-square	0.75	0.67

Source: own elaboration

Fuente: elaboración propia

The rest of the results are in line with what is expected. First, the size of the dwelling affects prices: as the size increases, the price per square meter diminishes, even if the total price rises. Second, age has a positive effect on prices. Demand in London places greater value on older properties. Also, average income in the neighborhood and average price of properties in the neighborhood are important factors for determining the price of a dwelling. Finally, the distance of the dwelling to downtown London affects its price: more distance means a lower price in this case.

Asimismo, el resto de los resultados son los esperados. En primer lugar, el tamaño de la vivienda incide en los precios, reduciendo el precio por pie cuadrado, aun cuando el precio final aumenta. Segundo, la antigüedad de la vivienda tiene un efecto positivo: la demanda en Londres valora más las viviendas «clásicas» que las modernas. Los ingresos medios y el precio promedio de las propiedades en un distrito de Londres son factores que influyen positivamente en el precio de la vivienda. Finalmente, la distancia de la vivienda al centro

In the case of France, the model has a good explanatory power, reaching an R-square of 0.671.

In terms of estimated coefficients, our results are, qualitatively but not quantitatively, in line with those obtained in similar studies in the literature. A 1% increase in the EPC score accounts for a 0,022% decrease in the price per square meter of the dwelling. That is to say, for example, that the difference between an average D score (190) and an average Green label (72) represents a 0,014% change in the price per square meter. This compares with a 4,7% increase in Kok & Jennen (2011) for the same range in commercial rentals in The Netherlands. Put differently, passing from a D label to a B label means around 0,4 Euros more per square meter for a given dwelling. Possible reasons for this lower effect are related to a National more diverse sample, a more benign weather, or the lower convergence to the EPBD by France.

The rest of the results are in line with what is expected. First, as the size increases, the price per square meter diminishes, even if the total price rises.

Second, age has a negative effect on prices. Demand in France values older properties less. Finally, average income in the neighborhood and average price of properties in the neighborhood are important factors for determining the price of a dwelling.

de Londres, representado por Trafalgar Square, afecta negativamente al precio de la misma.

En el caso de Francia, nuestro modelo de la demanda de viviendas explica el 67% de la variación en el precio.

En términos de coeficientes estimados, los resultados son similares a los de Londres desde un punto de vista cualitativo. Un aumento del CEE de un 1% representa un aumento del 0,022% en el precio por metro cuadrado de la vivienda en Francia. Es decir, pasar de una categoría D a una "verde" significaría un aumento del 0,014% en el precio por metro cuadrado. Esto puede compararse con el 4,7% de incremento que Kok & Jennen (2011) obtienen en propiedades comerciales en alquiler en Holanda. Es decir, pasar de una categoría D a una B significaría cerca de 0,4 euros más por metro cuadrado para una vivienda. Algunas razones posibles para este menor efecto se relacionan con la diversidad de una muestra nacional, un clima más benévolo o la menor convergencia a la EPBD de Francia.

Los demás resultados también coinciden con lo esperado. En primer lugar, el tamaño de las viviendas afecta al precio negativamente: a medida que aumenta el tamaño, el precio por metro cuadrado se reduce.

Segundo, la antigüedad esta vez tiene un efecto negativo en los precios: una propiedad más vieja tiende a valer menos que una nueva. Finalmente, los ingresos medios y el precio promedio de las viviendas de cada departamento de Francia son factores que influyen positivamente en el precio de las mismas.

What Does this Evidence Imply for the Impact of EU Policies on Markets?

One of the most important goals of this project is to assess the effects of energy efficiency regulation on the market for construction materials. Besides understanding that willingness to pay for green creates incentives for dwelling owners to refurbish and build with greener construction materials, we want to analyze the exact impact of the regulation in place. For instance, does the consumer ask for greener products (e.g.: recycled material)? Has the demand of a certain product changed since the implementation of the regulation?

A potential source of information about the impact of European climate mitigation incentives such as the EPBD on the construction material market is the market for windows and doors.

Market researchers indicate that overall European demand for windows has dropped significantly in 2009, although the decline was not felt to the same extent in all countries. In France, Spain, the United Kingdom and The Netherlands, market demand for windows declined sharply in 2009, following the downward trend in overall construction activity. However, sales of windows in Germany increased by at least 2% in 2009 due to state funding and public commitment for energy-efficiency measures.

We have tried to relate demand for different doors and windows with refurbishment expenditures in England. Doors and windows have been identified in several studies as sources of energy efficiency for a dwelling. Refurbishing doors and windows has been a typical recommendation by these reports.

¿Qué implicaciones tiene esta evidencia sobre el efecto de las políticas de la UE en los mercados?

Uno de los objetivos más importantes de este proyecto es medir el efecto de la regulación de la eficiencia energética en edificios sobre la demanda de materiales de construcción. Además de comprender que existe una disposición a pagar precios más altos por viviendas más eficientes y que esto crea incentivos para que tanto productores como dueños de viviendas mejoren sus productos, queremos extender el análisis al impacto específico de la regulación sobre los materiales de construcción. Por ejemplo, ¿valora el consumidor la utilización de materiales de construcción «verdes» (por ejemplo, reciclados)? ¿Ha cambiado la demanda de determinados materiales de construcción a partir de esta regulación?

Una fuente de información potencial sobre el impacto sobre los materiales de construcción de las políticas europeas de mitigación del cambio climático, tales como la EPBD, es la evolución del mercado de puertas y ventanas en los últimos años.

Las investigaciones de mercado disponibles nos indican que la demanda europea de puertas y ventanas ha caído de forma significativa en 2009, aun cuando esta caída no ha sido igual en cada país. En Francia, España, el Reino Unido y Holanda, la demanda de ventanas cayó abruptamente en 2009, debido a la tendencia negativa de la construcción. Sin embargo, las ventas de ventanas en Alemania aumentaron un 2% en 2009 debido a las ayudas y al compromiso público con la eficiencia energética.

Se ha intentado relacionar la demanda de puertas y ventanas de diferentes materiales con la evolución del gasto en reacondicionamiento

Our research team gathered information of refurbishment expenditures since 1990 in England from the Communities Department in order to assess how it related to sales of doors and windows. What follows is our main conclusions in this regard.

Chart 15 shows the evolution of Refurbishment Expenditures in England since 1990. Our aim is to identify trends and changes in trends in order to explain the effect of mitigation regulation (subsidies and other incentives such as labels) on repairs in the dwelling stock. We analyze both public and private expenditures in order to identify any possible difference in behavior patterns.

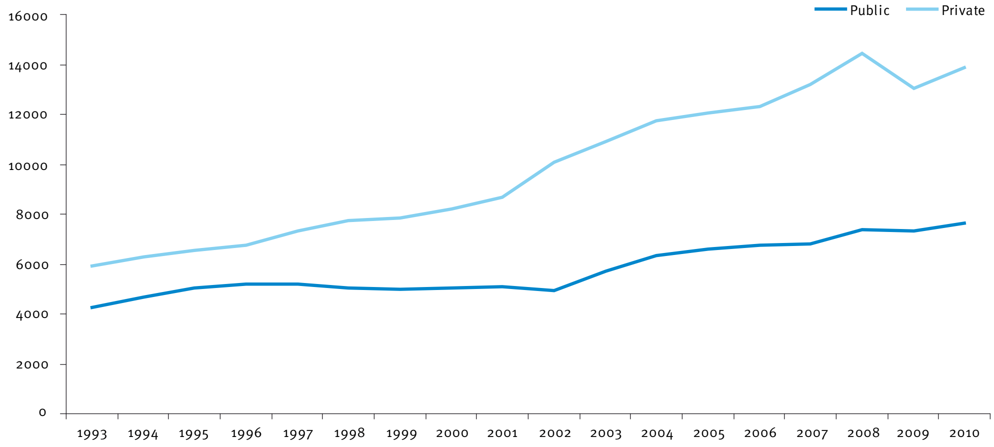
en Inglaterra, dado que las puertas y ventanas han sido identificadas por varios estudios como fuentes potenciales importantes de eficiencia energética.

Por tanto, hemos recabado también información del Departamento de las Comunidades de Inglaterra sobre el gasto en reacondicionamiento desde 1990, para entender su relación con las ventas de puertas y ventanas. Nuestras principales conclusiones al respecto se explican a continuación.

El gráfico 15 muestra la evolución del gasto en reacondicionamiento en Inglaterra a partir de 1990. La idea es intentar identificar tendencias y cambios en las mismas para poder explicar el efecto de la regulación destinada a mitigar el cambio climático sobre las reparaciones del inventario habitacional. Analizando gastos privados y públicos, buscamos patrones de demanda.

Chart 15.Annual Evolution of Refurbishment Demand in England (GBP Million annual).

Gráfico 15. Evolución anual de la demanda de remodelaciones en Inglaterra (Millones de libras anuales)



Source: Communities Department

Fuente: Communities Department

We identify a change in the trend of refurbishment expenditures (private and public) since 2002. After 2007, trend growth diminishes as shown by the change in the slope.

Finally, total refurbishment expenditures grew 60% since the enactment of the European Performance of Buildings Directive. This represents an annual 7% increase in refurbishment expenditures and an acceleration of these expenditures, probably caused by new economic incentives and more information.

We found some relevant evidence for the hypothesis that firms left the market of doors and windows after 2008 provoking a shock in supply (contraction) that resulted, in spite of the likely fall in demand due to the economic crisis, in higher prices. We conducted an analysis of the data published by the Communities Department of England on the contractor market.

The analysis of the contractor market shows very interesting results. First, the number of firms drops in 2009, with the exit of 8,000 companies. Small firms were the hardest hit by the crisis leaving the market more often than others.

Second, the number of joinery firms, which specialize in doors and windows, drop in 2009 after the exit of 1,200 companies. At the same time, "Liquidations" rise to almost 20% of the total, the highest since 1996. Both these facts support our hypothesis of a supply contraction. However, in 2010, Communities registers 62,000 entries in the contractor market with joinery firms up 3,600.

De esta forma, hemos identificado un cambio en la tendencia de los gastos de *reacondicionamiento* (públicos y privados) desde 2002, año de la EPBD. Desde 2007, además, la tendencia disminuye tal y como se aprecia en el cambio en la pendiente.

Los gastos totales de *reacondicionamiento* crecen un 60% desde la EPBD, lo que representa un aumento del 7% anual, debido a los nuevos incentivos económicos y a la mayor información disponible.

A su vez, analizamos la evolución del mercado de puertas y ventanas y encontramos evidencia relevante para nuestra hipótesis acerca de la causa de la caída en las ventas y la subida de precios: a partir de 2008, un *shock* produce una contracción en la oferta, debido a la salida de firmas del mercado. Esto provocó que algunos productos experimentaran un incremento en los precios a pesar de la crisis económica. Esta hipótesis se corresponde con los datos del Departamento de Comunidades de Inglaterra acerca de los promotores.

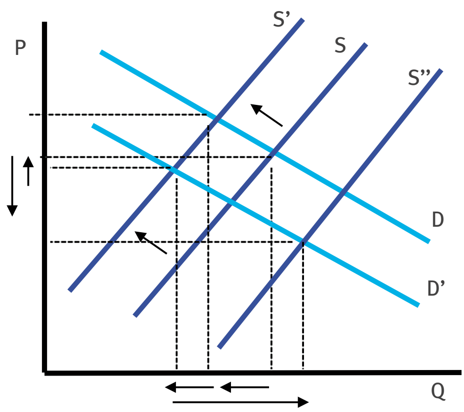
El análisis del mercado de los promotores ofrece datos interesantes. En primer lugar, el número de empresas descendió en 2009 tras la salida de 8.000 compañías. La crisis golpeó con más fuerza a las pequeñas empresas, que fueron las que más abandonaron el mercado.

En segundo lugar, el número de empresas de «carpintería», que suele especializarse en puertas y ventanas, cae en 2009 por la salida de 1.200 firmas. Al mismo tiempo, las «liquidaciones» de compañías aumentan a un 20% del total, el nivel más alto desde 1996. Ambos factores apoyan nuestra hipótesis de una contracción de la oferta.

Sin embargo, en 2010, se registraron 62.000 entradas de promotores, con un aumento de 3.600 en las empresas de carpintería.

Chart 16. Shifts in Supply and demand of steel Doors and Windows

Gráfico 16. Cambios en la oferta y demanda de puertas y ventanas de acero



Source: authors' own elaboration

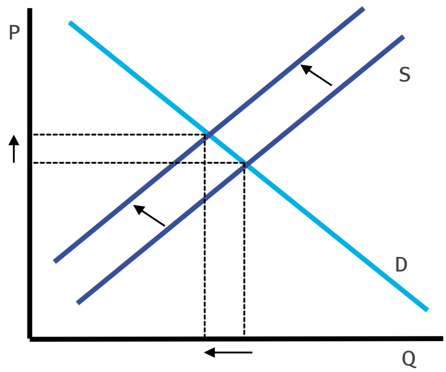
Fuente: elaboración de los autores

In Chart 16, however, there are shifts in Supply and Demand of Steel Doors and Windows. After the economic crisis we also see here a shock in supply that moves the curve leftward reducing quantities and hiking the price. However, Demand also drops, reducing quantities even more and offsetting the price hike, ending up in a mild price reduction. Finally, Supply reacts to the new prices by increasing significantly, producing more quantities than at the beginning at lower prices. A potential explanation is that after the initial shock some companies left the market and the ones that stayed were underutilizing capacity. This could have created a situation in which it made sense for the remaining firms to produce at lower prices.

En el gráfico 16, sin embargo, hay cambios tanto en la demanda como en la oferta de puertas y ventanas de acero. La crisis económica produce también una salida de firmas que genera menores cantidades y mayores precios, sin embargo, la demanda también cae, reduciendo los precios y las cantidades aún más, terminando en un precio de equilibrio algo menor que el inicial. Finalmente, la oferta reacciona nuevamente produciendo mayores cantidades que al inicio pero a precios inferiores. Una explicación potencial puede basarse en que tanto las empresas que salen como las que quedan estaban trabajando con una menor capacidad de producción de la ideal. Esto puede haber generado una situación en la que tendría sentido producir mayores cantidades a menores precios.

Chart 17. Potential Shifts in Supply and Demand of aluminun, plastic and wood Doors and Windows

Gráfico 17. Cambios potenciales en la oferta y demanda de puertas y ventanas de aluminio, plástico y madera



Source: authors' own elaboration

Fuente: elaboración de los autores

In Chart 17, we can see how the market for doors and windows of plastic, wood and aluminum reacted to the economic crisis. At first, there is a shock in the supply function, with shifts leftwards reducing the quantity supplied. However, there does not seem to be a shock in demand for doors and windows of these materials given that even though quantities drop, prices rise. The reason for this shock in supply is a probable exit of firms from the market. This potential exit appears to be backed by the data.

Finally, the number of insulation firms rises in 2009. This is the only segment with a growth in the number of companies. This points towards a greater effort in energy efficiency in England after the EPBD and despite the crisis.

Given the incomplete database and the information restrictions we encountered, our analysis is limited to identifying potential patterns of behavior and changes in these patterns in order to extract conclusions that could be tested in the future.

En el gráfico 17, podemos ver como el Mercado para puertas y ventanas de plástico, aluminio y madera respondió ante la crisis económica. Al principio, hay una reducción de la oferta que disminuye las cantidades producidas y aumenta los precios de los productos, debido a que la demanda permanece constante. La razón aparente es que la caída de la oferta se debe a la salida de empresas del mercado. Esta potencial salida parece ser confirmada por los datos estadísticos.

Finalmente, las empresas dedicadas a «aislamientos» son el único segmento que muestra un aumento en 2009, lo que nos indica un mayor esfuerzo hacia la eficiencia energética a pesar de la crisis.

Dado que nuestra base de datos no es completa y que nos hemos encontrado con restricciones informativas serias, nuestro análisis se limita a identificar patrones potenciales de conducta y cambios en los mismos para extraer conclusiones que puedan ser comprobadas en un futuro cercano.

A very simple way to obtain some information consists of computing correlations between public and private refurbishment expenditures and sales of doors and windows of different materials (see Table 4). The hypothesis is that refurbishment is often focused on these products and that, if refurbishment has increased since the EPBD, a change in the consumption pattern could indicate that certain materials are identified as "greener" than others.

Table 4. Correlations of Refurbishment and Sales of Doors and Windows (1993-2010)

Una herramienta analítica muy básica es el análisis de las correlaciones entre los gastos de *reacondicionamiento* públicos y privados, y las ventas de puertas y ventanas de distintos materiales (ver cuadro 4). Nuestra hipótesis es que el reacondicionamiento sin duda resulta en el reemplazamiento de puertas y ventanas y que, si se ha registrado un aumento del primero, cambios en el patrón de consumo indicarían que ciertos materiales son identificados como más «verdes» que otros.

Cuadro 4. Correlaciones entre remodelaciones y ventas de puertas y ventanas (1993-2010)

Correl. 93-10	Manuf Sales	Net Supply	Wood	Aluminum	Steel	Plastic
Total Ref	0,8906	0,8721	0,8965	0,8559	0,9336	0,7673
Public Ref	0,7930	0,7661	0,8037	0,8504	0,9088	0,6412
Priv Ref	0,9123	0,8972	0,9164	0,8444	0,9280	0,8014

Source: own elaboration

Although we cannot infer causation, these correlations show interesting results. First, between 1993 and 2010, there is a high correlation of door and window sales and refurbishment expenditures, both public and private.

Also, since the EPBD (2002-2010), aluminum and steel doors and windows seem to be preferred for refurbishment as its shown by a higher correlation of expenditures in refurbishment with sales of aluminum and steel doors and windows than wood or plastic (see Table 5).

Finally, public refurbishment, which can be related to Green Public Procurement since 2002, reduces expenditures in Doors and Windows. This could signal future expenditures on this segment by public procurement.

Fuente: elaboración propia

Aun cuando la causalidad no está clara, estas correlaciones son interesantes. Primero, entre 1993 y 2010, las ventas de puertas y ventanas de cualquier material están altamente correlacionadas con los gastos públicos y privados en reacondicionamiento.

Asimismo, desde la EPBD (2002-2010), las puertas y ventanas de aluminio y acero parecen gozar de cierta predilección en lo que se refiere al gasto en reacondicionamiento: se observan correlaciones más altas entre los gastos de reacondicionamiento y las ventas de puertas y ventanas de aluminio y acero que entre los mismos gastos y las ventas de puertas y ventanas de madera o plástico, especialmente para *reacondicionamiento* privado (ver cuadro 5).

Finalmente, el *reacondicionamiento* público, que puede identificarse con las adquisiciones públicas verdes desde 2002, tiene una correlación menor en puertas y ventanas. Esto puede señalar que se realizarán en el futuro mayores gastos públicos en este segmento.

Table 5. Correlations of Refurbishment and Sales of Doors and Windows (2002-2010)

Cuadro 5. Correlaciones entre remodelaciones y ventas de puertas y ventanas (2002-2010)

Correl. 02-10	Manuf Sales	Net Supply	Wood	Aluminum	Steel	Plastic
Total Ref	0,5473	0,1039	0,5785	0,7711	0,8763	-0,6475
Public Ref	0,6098	-0,0185	0,4989	0,6722	0,8009	-0,6854
Priv Ref	0,6006	0,1779	0,6168	0,8176	0,9062	-0,6114

Source: own elaboration

Fuente: elaboración propia

As mentioned above, we are constructing a complete database of units, sales and prices of construction materials to be able to compare these data to energy consumption databases, determine direct expenditures on these goods and evaluate other effects of the European regulation.

Finally, a very short time has elapsed since the enactment of the EPBD and the enforcement of NEEAPS, even in pioneer-convergent countries such as England. We intend to complete these data and develop new demand models in the upcoming years.

Conclusions

This project represents an attempt to study the effect of policies and regulations regarding climate change mitigation on the markets they attempt to regulate. We focus on analyzing the effects of European Union policies regarding energy efficiency, which are mostly aimed towards residential dwellings due to the identification of this sector as one of the main

Tal como mencionamos anteriormente, construir una base de datos de unidades, ventas y precios de materiales de construcción y tener la posibilidad de comparar esta información con las bases de datos de consumo de energía, consumo de estos materiales y otros efectos de la regulación europea, sería lo más deseable.

Finalmente, poco tiempo ha pasado desde la promulgación de la EPBD y la implementación de los PANEE, aun en países pioneros convergentes como Inglaterra. Nuestra intención es completar la base de datos y, entonces, desarrollar modelos de demanda más complejos.

Conclusiones

Este proyecto representa uno de los pocos intentos de estudiar el efecto de las políticas y regulaciones sobre la mitigación del cambio climático en los mercados que regulan. Centramos nuestro análisis en los efectos de la políticas de la Unión Europea acerca de la eficiencia energética, las cuales se dirigen primordialmente a viviendas residenciales, que se han identificado como una de las principales sources of energy inefficiency and, hence, of Greenhouse Gases emissions.

First, we develop an overview of the situation in Europe in contrast to the 2020 environmental targets. Our conclusion is that these targets are still far from being reached. Even though recent economic activity has resulted in lower GHG emissions and energy consumption, this situation is temporary and growth in emissions and energy consumption will resume once the recession is over. If the current targets are still far from being reached in this situation, efforts towards energy efficiency will have to be renewed.

We continue with the analysis of Energy Efficiency regulation at the European level and we focus on the European Performance of Buildings Directive and its 2010 recast. The recast leaves many issues unresolved which will need to be addressed either by National Energy Efficiency Action Plans (by Member States) or by the European Commission. Hence, we proceed to analyzing the state of these plans in seven European countries.

Our National Energy Efficiency Action Plan analysis for the United Kingdom, The Netherlands, Spain, France, Germany, Portugal and Italy provides two interesting tools in order to measure the national efforts to comply with European mitigation regulation. These tools are combined into a Convergence Index that takes into account both the speed of adoption of EPBD rules at the National Level and the Convergence of these rules to the EPBD 2010 recast.

These tools show that there are three types of countries in terms of speed of adoption (pioneers, early movers and laggards) and

fuentes de ineficiencia energética y, por tanto, de emisiones de gases de efecto invernadero.

En primer lugar, desarrollamos una revisión de la situación en Europa respecto de los objetivos medioambientales para 2020. Nuestra conclusión es que los objetivos de reducción de emisiones están todavía lejanos. Aun cuando la caída en la actividad económica reciente ha propiciado un descenso de las emisiones de GEI y un menor consumo de energía, esta situación es provisional y las emisiones y el consumo de energía tenderán a aumentar cuando termine la recesión. La conclusión es que los esfuerzos hacia una mayor eficiencia energética deberán renovarse.

Nuestro estudio continúa con el análisis de la regulación sobre la eficiencia energética a nivel europeo, donde nos centramos en la *Directiva europea relativa a la eficiencia energética de los edificios* y su reforma de 2010. Dicha reforma deja, según nuestro análisis, muchos temas por resolver y decidir a nivel de los Estados miembros o, en última instancia, por la Comisión Europea. Por ende, analizamos también la implementación a nivel nacional en siete países europeos.

Dicho análisis, enfocado en el Reino Unido, Alemania, Holanda, Francia, Portugal, Italia y España, provee dos herramientas útiles para medir los esfuerzos a nivel nacional para cumplir con la regulación europea: *velocidad de adopción* y *convergencia* regulatoria. Además, combinamos estas herramientas en un *índice de convergencia* que tiene ambos aspectos en cuenta.

Estas herramientas muestran que existen nueve posibles combinaciones de países en términos de *velocidad de adopción* (pioneros, other three types in terms of convergence to the EPBD (convergent, chronic and non-convergent). Countries like the UK, The Netherlands and Portugal are important not only because they have advanced rapidly and are convergent, but also because they provide guidance and experience in terms of regulation enforcement and on the effects of this regulation on the markets.

We conduct a meta-analysis of all the studies that dwell on the Willingness to Pay for Green Dwellings. Our aim is to understand the results, but also the methodologies employed and their soundness. We find that there are three different groups of analysis from a conceptual standpoint (residential dwellings for sale, commercial buildings for sale, and commercial buildings for rent) and that studies have been conducted in Australia, The Netherlands, the US and Switzerland. The methodologies and samples differ in many aspects, but also the results obtained appear to be more credible in some cases than others due to problems with the sample or the methodology.

In fact, only the study in Australia and the studies that have been conducted regarding the willingness to pay for green dwellings in The Netherlands (or the ones conducted by the mentioned Dutch researchers in the US) seem conclusive.

Knowing this, our research team conducted similar tests on the Greater London Area, which show that dwelling buyers value more energy efficient dwellings. We found that energy efficient (i.e., "green") dwellings are valued 0,073% more than non-efficient dwellings. This results in an increase of 2,87% in price per square foot when a dwelling moves

adopción temprana y adopción tardía) y *convergencia* (convergentes, crónicos y no convergentes). Por ejemplo, países como el Reino Unido, Holanda y Portugal son importantes porque han avanzado rápidamente de forma convergente, pero también porque de ellos se pueden extraer conclusiones acerca de la implementación de la regulación nacional y su efecto en los distintos mercados.

A partir de este punto, conducimos un meta-análisis de la disposición a pagar más por viviendas «verdes» con el fin de incluir las conclusiones de la investigación existente en este campo. Nuestra intención es comprender los resultados obtenidos pero también las metodologías utilizadas. El análisis agrupa los estudios en tres grupos (viviendas residenciales en venta, oficinas comerciales en venta y oficinas comerciales en alquiler) en base a estudios realizados en Australia, Holanda, EE.UU. y Suiza. Si bien las muestras y la metodología difieren, los resultados tienden a la misma conclusión: existe una prima por viviendas «verdes». Sin embargo, las conclusiones de algunos estudios (Australia y Holanda) parecen más robustas que las de otros.

A partir de los resultados obtenidos por investigaciones previas, desarrollamos un análisis similar para el caso de Londres y alrededores que demuestra que las viviendas «verdes» son más valoradas que las «no verdes», con un incremento del 2,87% en el precio por pie cuadrado (17 libras esterlinas más por pie cuadrado).

Un segundo grupo de países incorpora a Alemania y Francia, países que tienen una larga historia de regulación de la eficiencia energética pero que no han convergido hacia la EPBD de la misma forma que el resto: la historia from a D label to a Green Label (average). That is to say, 17 GBP more per square foot.

In a second group we find countries like France or Germany, which have a long history of energy efficiency regulation. History proves, however, that such regulation is an obstacle for convergence. In this sense, the national effort seems troubled by pre-existing regional and local regulations. More convergence will definitely take place in the next years but it will demand intra-convergence too, i.e., regional and local regulation inside each country will have to be adapted towards a common, unique national regulation that follows the EPBD mandate.

In order to analyze how consumers behave in these countries, we conducted research on the willingness to pay for green dwellings in France. The results were positive and interesting: green dwellings were valued more than non-green dwellings, but the premium was very small.

Even though some of the ideas and concepts we developed could be improved in many aspects, they provide an interesting map of the areas where different countries need to improve in order to comply with the EPBD and so reach what other members of the EU are achieving.

Incentives towards convergence are also both positive and negative. Positive incentives are those related to achieving greater energy efficiency, reducing Greenhouse emissions and creating new sources for employment, given the new markets that arise due to regulation and consumer needs.

Negative incentives will take the form of both sanctions from the EU Commission to the

es un obstáculo en este caso. Es de esperar que una mayor convergencia hacia la EPBD ocurra en los próximos años pero esto implicará medidas centralizadoras para adaptar la regulación local y regional a una regulación común nacional acorde con el mandato de la EPBD.

Para analizar la conducta de los consumidores en estos países también realizamos un estudio en Francia, con el fin de evaluar la disposición a pagar por viviendas ecológicas. En este caso, los resultados fueron también positivos e interesantes: las viviendas más ecológicas se valoraron por encima de las menos ecológicas, pero con un incremento muy pequeño.

Aun cuando las ideas y conceptos desarrollados en este trabajo pueden mejorarse bastante, sirven como indicación en cuanto a aquellos campos en los que los diferentes países deberán mejorar de cara a cumplir con la EPBD.

Los incentivos hacia la convergencia son tanto positivos como negativos. Los primeros son los relacionados con una mayor eficiencia energética, la reducción de las emisiones y la creación de nuevas fuentes de empleo, a partir de los nuevos mercados que surgen por las nuevas necesidades. Los negativos tomarán la forma de sanciones de la CE a los Estados miembros, o del voto de castigo a políticos nacionales que no persigan la reducción de las emisiones.

Es lógico concluir que una mayor convergencia en políticas ocurrirá y que aquellos países rezagados (España e Italia, entre otros) deberán actuar rápidamente y ajustar sus políticas y mercados para responder adecuadamente a los desafíos que el cambio climático nos presenta.

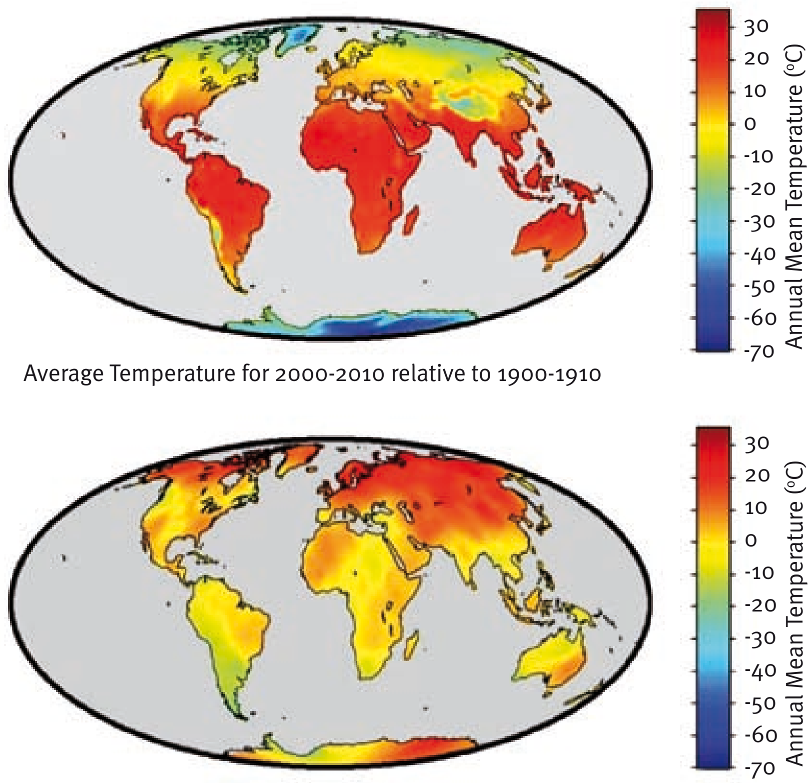
Member States and voters punishing national leaders that fail to guide a country into the desired direction of emissions reductions.

It is fair to say, then, that convergence will occur and that countries that lag in terms of policies (Spain and Italy, among others) will have to act quickly and adjust their policies and markets to respond adequately to the challenges that climate change presents.

1. Introduction

Climate change mitigation is one of the most important goals for the global economy, although not one of the most urgent ones lately. Several studies have recently and definitively confirmed that the Earth is warming and that climate patterns are changing accordingly (see Charts 1 and 2, which compare medium earth temperatures in 2000-2010 to 1900-1910 and 1960-1970 respectively. An anomalous increase is evident: around 1.2 degrees since the first period, around 0.6 degrees since the 70s). Scenarios such as the complete melting of the ice cap have become more likely. These changes affect the economy in several ways and their mitigation will have its own effects on the economy as well.

Chart 1. Global Annual Mean Temperatures



Average Temperature for 2000-2010 relative to 1900-1910

Average Temperature for 2000-2010 relative to 1960-1970

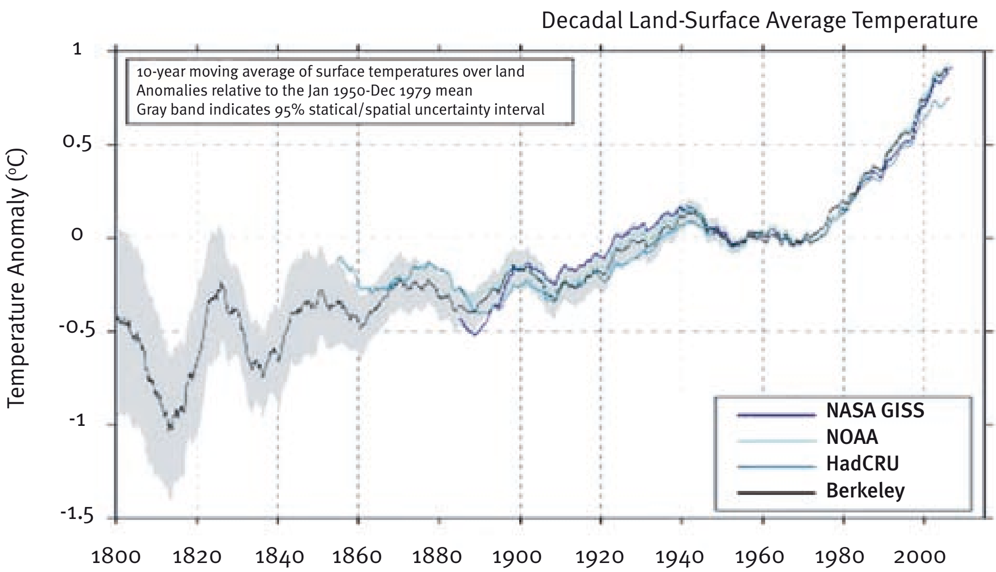
Sourrce: Berkeley Earth Surface Temperature Project (2011). The graph shows anomalies in temperature in Europe and Antarctica

There are three compilations of mean global temperatures, each one based on readings from thousands of thermometers, kept in weather stations and aboard ships, going back over 150 years. Two are American, provided by the NASA and the National Oceanic and Atmospheric Administration (NOAA); the third is the outcome of a collaboration between Britain's Met Office and the University of East Anglia's Climate Research Unit (Hadley CRU). The three measures suggest a similar pattern of warming: about 0.9°C over land in the past half century.

Whether this climate change is new or if it responds to a pattern experienced by the Earth in previous historical ages remains debatable. However, it appears to be clear that the current global warming process is sharper than previous ones and is highly correlated with the larger than ever accumulation of carbon dioxide and other Greenhouse Gases (GHG) in the atmosphere. This correlation does not imply causation yet, but it creates a big "IF" that needs to be addressed: IF mankind causes the current process of global warming or if humans have accelerated it, its mitigation must also be possible through human intervention.

Mitigating climate change potential factors produced by mankind, such as Greenhouse Gases emissions, becomes essential in this new setting. Governments and supranational entities are thus creating new tools for mitigating climate change. Several of these tools are intended to change the economic incentives of consumers and producers of polluting products.

Chart 2. Trend in Global Average Temperatures



Source: Berkeley Earth Surface Temperature Project (2011). The graph shows how the ten-year moving average land-surface temperatures upward trend has intensified since the 1960s

The European Commission (EC) has enacted regulation in order to react and mitigate climate change in the region, setting targets for the reduction of GHG emissions by member states for 2020. These targets, known as 20-20-20, aim at contributing to the EU's effort towards the Kyoto Protocol goals. Even though several climate change conferences have been held since Kyoto, these targets remain the main point of reference towards climate change mitigation. The analysis of Greenhouse Gases emissions in the continent shows that Europe will have a hard time reaching the 2020 target levels set in the Lisbon Treaty.

The European Union is usually a pioneer in what regards to regulation and, specifically, sustainability regulation. As a leader, other regions and countries such as the United States often mimic the regulations enacted in the EU. For instance, the Environmental Protection Agency has begun contacts with the European Commission in order to understand the scope of current regulation and its intended effects.

Several sectors of the economy were analysed by the EU and the Building sector was identified as one of the best targets for mitigation effort, due to the large stock of dwellings in the EU and the large energy inefficiency of those dwellings.

One of the tools that the EC has chosen to use is the European Performance of Buildings Directive (EPDB), which sets indications about labels for energy efficiency of dwellings, minimum requirements for construction materials, the necessity of green public procurement and of refurbishment levels.

However, very little has been said by independent researchers about the real effects of the current climate change mitigation regulation on the EU. If this regulation is to be mimicked by other governments or regions, then they must understand and be able to anticipate the exact effects it has on economic agents.

The aim of this project is to analyse and understand the effects this regulation can have on the markets through changes in economic incentives, specifically in the market for buildings (dwellings) and the market for construction materials.

Although parts of our analysis were covered in previous research for other regions, no previous attempts of this kind exist in Europe. One of the reasons for the scarcity of this sort of analysis is that both developments and regulation are very recent: some countries have not even begun to implement the EPBD. Another important reason is the lack of national statistics that could be used to extract samples for economic models. Even the countries that are most advanced in the implementation of the EPBD have incomplete statistics, often compiled by different agencies that are not linked to one another and therefore do not share the information. We created our own databases from almost scratch, but unfortunately such task remains largely incomplete.

The report is structured in the following manner.

Chapter 2 is an overview of the situation in Europe concerning Greenhouse Gases emissions. This situation has led to regulation regarding energy efficiency. Specifically, the chapter discusses the GHG emissions related to the Building sector and the European Performance of Buildings Directive, a piece of regulation that is fundamental to mitigating climate change from the standpoint of the European Commission. The statistics and figures we present can be seen as providing a rationale for further regulation regarding climate change mitigation in Europe.

Chapter 3 is a review of the European Regulation intended to provide incentives for the mitigation of climate change. We analyse the map of existing regulation and we focus on the European

Performance of Buildings Directive and its potential effects on the market for buildings and the market for construction materials.

Chapter 4 analyses how the EPBD is being implemented at the Member State (MS) level. National Energy Efficiency Action Plans (NEEAPs) are the instruments that MS use to regulate the EPBD at the national level. However, differences exist on this implementation both in terms of speed of adoption and in terms of convergence to the recast of the EPBD launched in 2010. We review the NEEAPs of seven EU countries (the United Kingdom, France, Spain, Germany, Portugal, Italy and The Netherlands) in order to understand whether implementation of the EPBD will have similar economic effects on these countries.

Chapter 5 is a meta-analysis of the existing research on one of the most important aspects of the EPBD: the obligation to label dwellings and buildings in general in order to inform buyers and users and so shape their behaviour. Whether there exists a higher willingness to pay for green buildings is a much-debated topic today but little research has appeared about it. We analyse studies conducted in the United States, The Netherlands and Australia for the residential sales sector, the commercial sales sector and the commercial rent sector. Relevant conclusions arise that indicate that labelling initiatives will be enforced also because of their positive results. Important questions remain unsolved, such as the value to consumers of a certain label or the difference between green value and energy savings.

Chapter 6 studies willingness to pay for green dwellings in England and France. In order to do this, we apply a model of the determinants of demand to a sample of dwellings in London and the greater London Area, and in France as a whole. The sample comprised posted dwellings on two real estate agent websites and was appended by a collection of proxies constructed by our research team. Our estimates of the premium for green buildings in London are in line with existing estimates for other countries. For France the effect is also positive but much smaller in magnitude, possibly due to lack of data. The evidence obtained anyway supports the idea that owners and home developers have economic incentives to refurbish the existent dwelling stock in order to attract consumers (purchasers or renters) to green dwellings. Whether subsidies to refurbishment are then justified is therefore put in question.

Chapter 7 summarizes our efforts to understand the economic impact of the EPBD regulation on the market for construction materials. Despite proving that there exist incentives for owners and constructors due to buyers and renters willingness to pay for green dwellings, we intended to find evidence of how these incentives have worked so far. This task proved very difficult because of the serious troubles we encountered to build a database for the demand of doors and windows of different construction materials (wood, plastic, steel and aluminium). For this, we contacted different agencies of the English government, the most reliable source of data we could access. We related data on the demand of different materials to the refurbishment expenditures (private and public) in England, the Greenhouse Gases emissions and the issuance intensity of Energy Performance Certificates in order to find trends that could be used in a future model.

Chapter 8 presents the main results, conclusions and the questions that remain unanswered but that we intend to explain in our future research.

2. Climate Change Mitigation progress in Europe

The European Union sets targets for the reduction of GHG emissions by member states for 2020. These targets, known as 20-20-20, are intended to contribute to the effort of the EU towards the Kyoto Protocol goals. Even though several climate change conferences have been held since Kyoto, these targets remain the main reference towards climate change mitigation.

The European Union, as one of the main economic regions in the world, would contribute significantly towards the reduction in GHG emissions by its own self-control and by example.

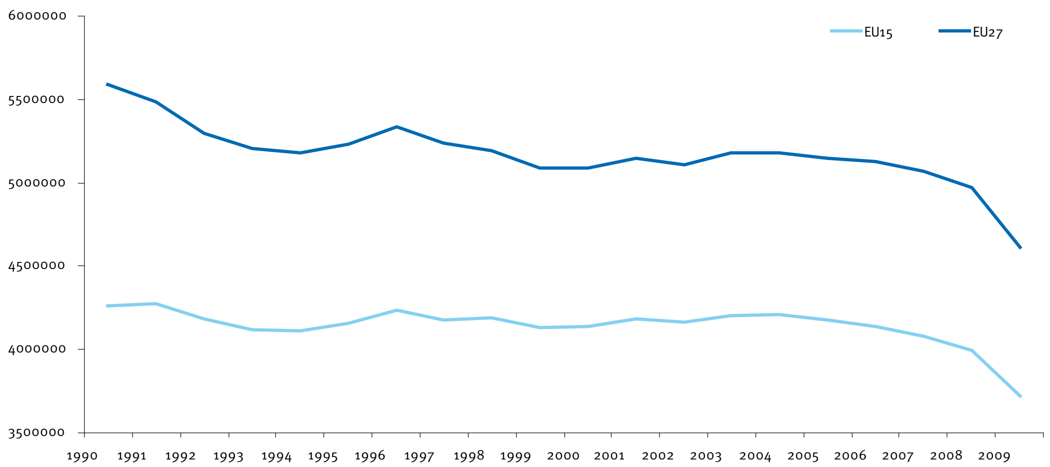
In what follows, we analyze the latest available statistics regarding GHG emissions and Energy Consumption in the EU15 and EU27, in order to assess what the current trends on climate change mitigation in the region are.

This analysis intends to assess how the EU has fared on the 20-20-20 goals so far and whether it would accomplish its goal as main climate change mitigation agent.

European Greenhouse Gases Emissions

Total Greenhouse Gases emissions have not changed much in the core EU15 countries since 1990. The emissions rate has dropped slightly but it does not reflect the steep reduction that the EU is aiming for through its directives. There was only a 12.7% reduction in total GHG emissions between 1990 and 2009 despite the enactment of alternative directives and policies by the EU. This represents an average of 0.67% drop per year. Although it may seem that target reductions are closer to being met, an increase in the pace of reductions would be needed.

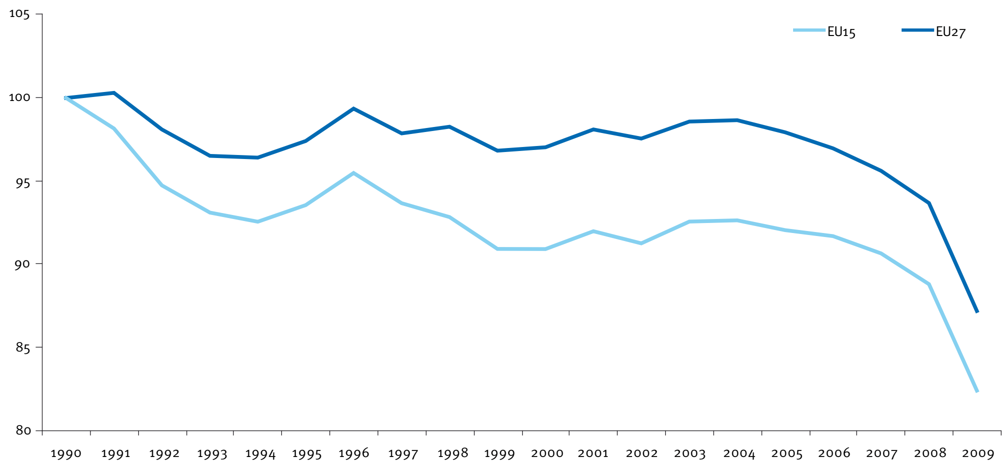
Chart 3. Total GHG emissions in Europe



Source: Eurostat –1000 metric tons CO_2 equivalent– Total Greenhouse Gases emissions

A first conclusion from Charts 3 and 4 is that EU27 has generated a larger or steeper reduction in emissions than EU15. That is to say, new Member States of the EU seem to be adapting to the sustainable development goal and have reduced their GHG emissions almost 30% in this period while EU15 countries have reduced them by almost 7%.

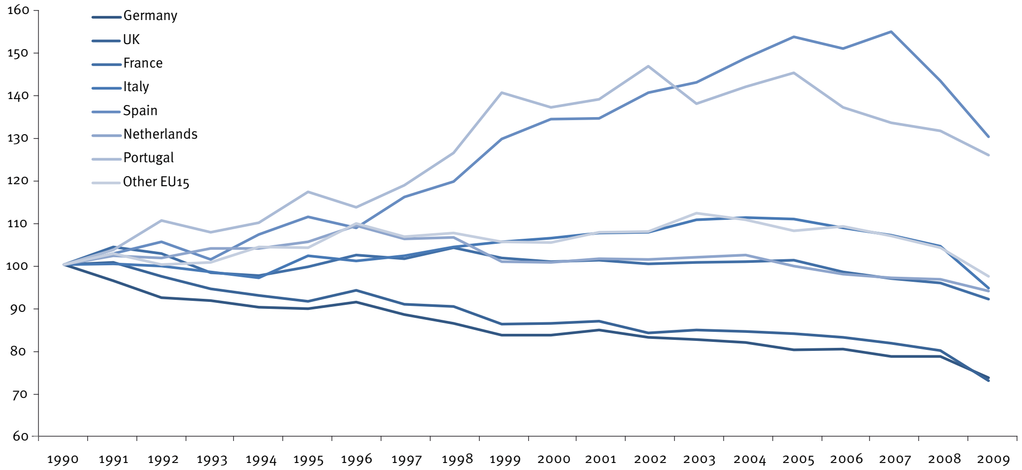
Chart 4. GHG emissions (index)



Source: Eurostat – Index based on Total Greenhouse Gases emissions

The distribution of GHG emissions across the different EU15 countries has changed over time. While countries like Germany or the UK have considerably reduced emissions (around 20%), others, like Spain or Portugal (around 25%), have considerably increased them (see Chart 5).

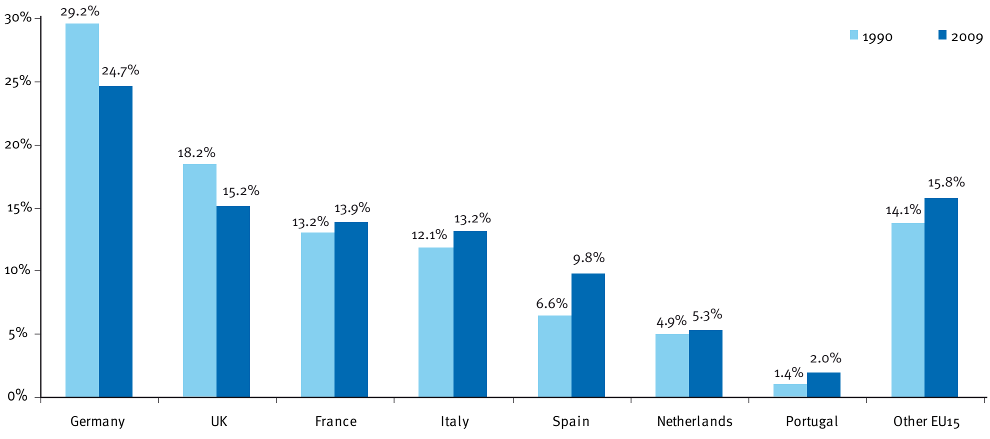
Chart 5. GHG emissions by country evolution



Source: Eurostat – 1000 tonnes CO_2 equivalent – Index base 1990

As we see, in these twenty years the reduction in Greenhouse Gases emissions by the EU was on average less than 0,5% per year.

Chart 6. Share of GHG emissions in EU15



Source: Eurostat – 1000 tonnes CO_2 equivalent - % of Total GHG Emissions

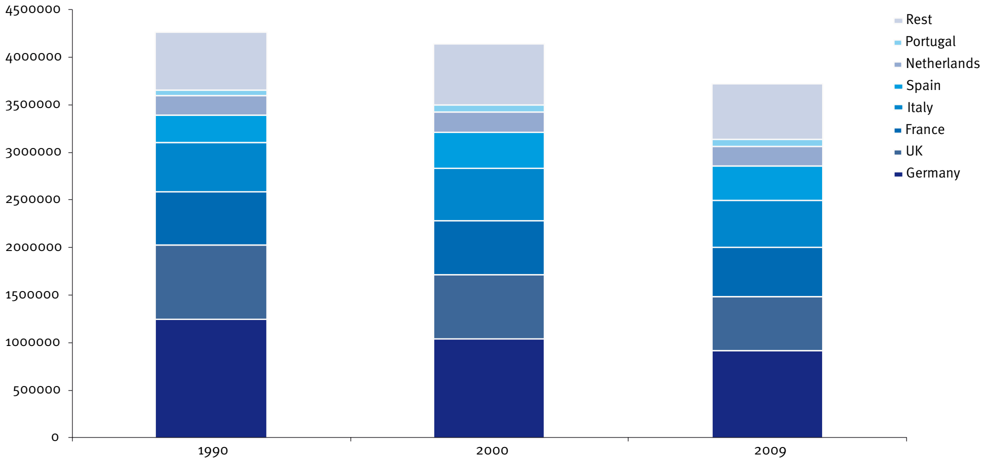
According to the European Environment Agency "The EU27 has committed to reduce its GHG emissions by at least 20% by 2020 compared to 1990 levels and to increase this commitment to a 30% reduction if other major emitting countries agree to similar targets."

Is Europe achieving its emissions targets?

Based on recent EEA estimates, "EU27 GHG emissions in 2009 decreased by 6.9% compared to 2008." Attaining the EU15 goal of an 8% reduction and the EU27 goal of 20% reduction in GHGs emissions by 2020 seems attainable at the moment, although not very impressive. However, one important question is how close to the target would the EU be without the drop in economic activity observed in the last three years. Since GHG emissions and energy consumption are highly correlated with economic activity, a possible "help" to achieving the target is the recent economic and financial crisis. In this sense, the sharp descent in GHG emissions recorded since 2006 results in Europe being closer to its 2020 goal.

As we see in the following graphs, though some countries are complying with their duties well, Europe as a whole is still at some distance from its mitigation targets. If every country did its part the EU as a whole could have more ambitious targets. However, the EU is not yet there because several countries underperform. In Chart 7, we can see the contribution of different EU15 countries to the evolution of GHG emissions. Main contributors to the less than desirable reduction in GHG emissions are Spain and Portugal. Other countries, again Germany, France and the UK, show a progressive reduction in total GHG emissions.

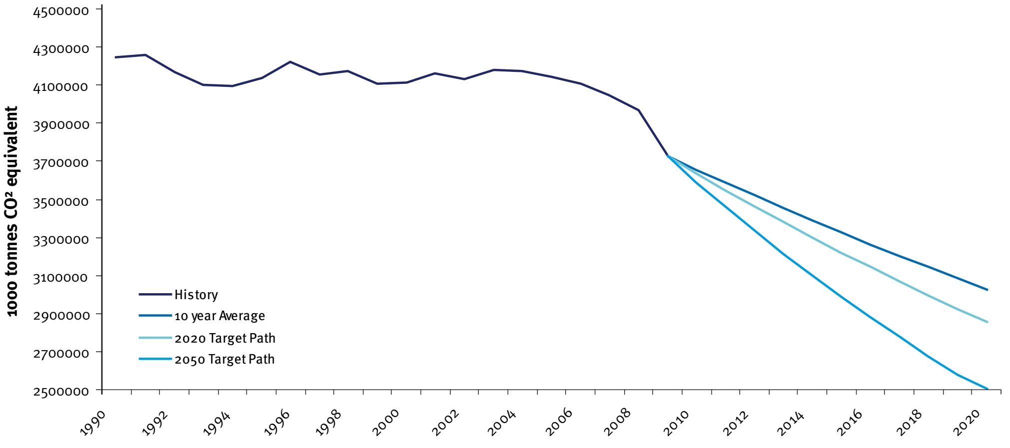
Chart 7. Evolution of share of GHG emissions by countries in EU15



Source: Eurostat – 1000 tonnes CO_2 equivalent

As we see in the following graphs (see Charts 8-11), Europe is far from achieving its mitigation targets.

Chart 8. Scenarios simulation for total GHG emissions in EU15 (2020)

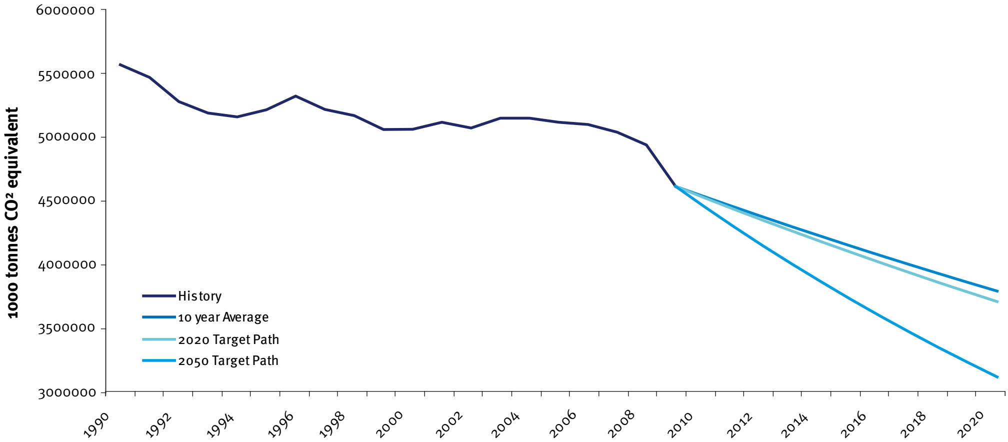


Source: authors' own elaboration -– 1000 tonnes CO_2 equivalent

A projection of the historic reduction of GHG emissions in the EU15 over the next decades allows us to state that additional efforts are needed to reach both the 2020 and 2050 targets.

Specifically, projecting the last ten years average into the future leaves EU15 far from the 2020 mitigation target, although EU27 is closer to it.

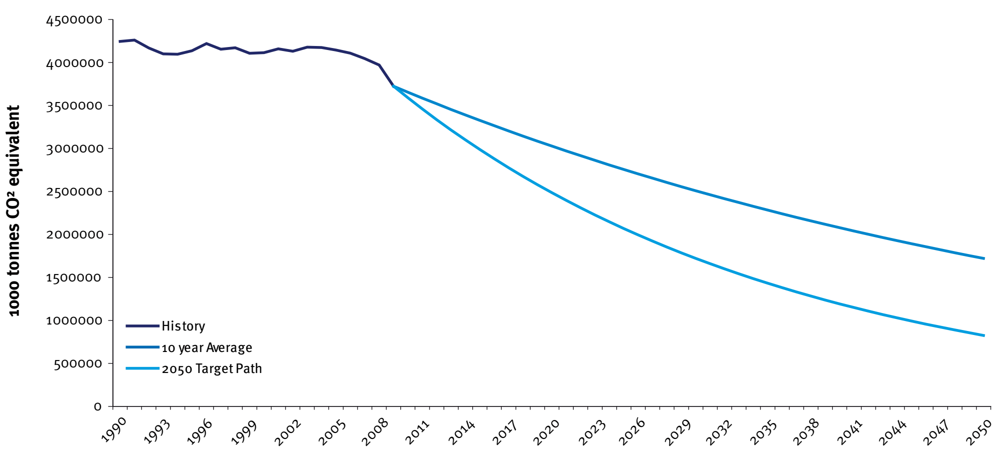
Chart 9. Scenarios simulation for total GHG emissions in EU27 (2020)



Source: authors' own elaboration – 1000 tonnes CO_2 equivalent

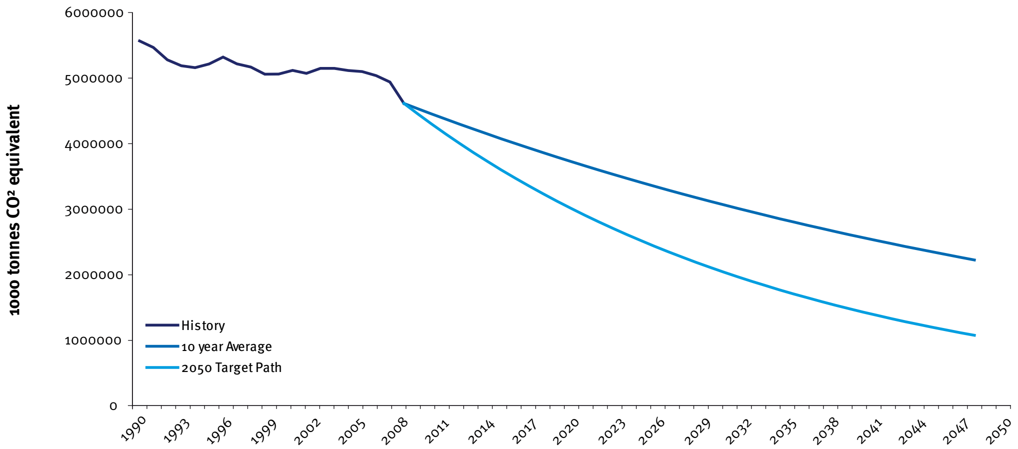
However, continuing with the current mitigation intensity both EU15 and EU27 appear to be far from the 2050 targets, as we can see in the Charts.

Chart 10. Scenarios simulation for total GHG emissions in EU15 (2050)



Source: authors' own elaboration – 1000 tonnes CO_2 equivalent

Chart 11. Scenarios simulation for total GHG emissions in EU27 (2050)



Source: authors' own elaboration – 1000 tonnes CO_2 equivalent

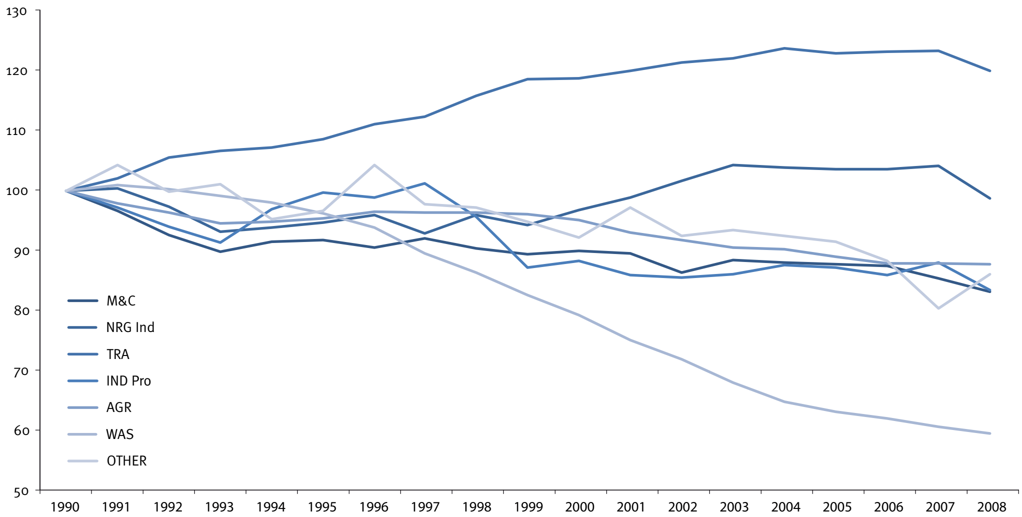
Finally, in order to achieve the larger goals (shown by the trend to the target) the EU27 will have to accelerate reforms aimed at emission reductions. One important part of this acceleration will rely on higher energy efficiency, as we will see in the next section.

GHG emissions in Europe by industrial sector

Besides analyzing how Europe has fared since the adoption of the mitigation targets as a whole, we need to understand which sectors contribute most to emissions. The usual focus is put on traditional industries, such as Transport, Manufacturing or Energy. Other sectors considered are Waste Disposal and Construction.

Chart 12 shows that while most sectors produce a significant 10%-15% reduction of emissions in this period, two sectors do not contribute to this reduction: Transport (TRA), with a 20% hike in emissions, and the Energy Related industries (NRG Ind), with a mere 1 % reduction.

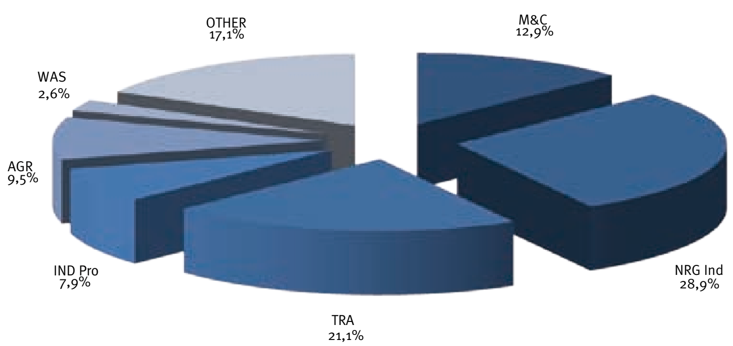
Chart 12. GHG emissions by sector in EU15



Source: Eurostat – 1000 tonnes CO_2 equivalent – Index Base 1990

Furthermore, according to Eurostat, these sectors (TRA and NRG Ind) represent 50% of total GHG emissions in the EU15 in 2008 (see Chart 13). The Waste management sector, on the other hand, produces a 40% reduction of emissions, but it only accounts for less than 3% of total GHG emissions.

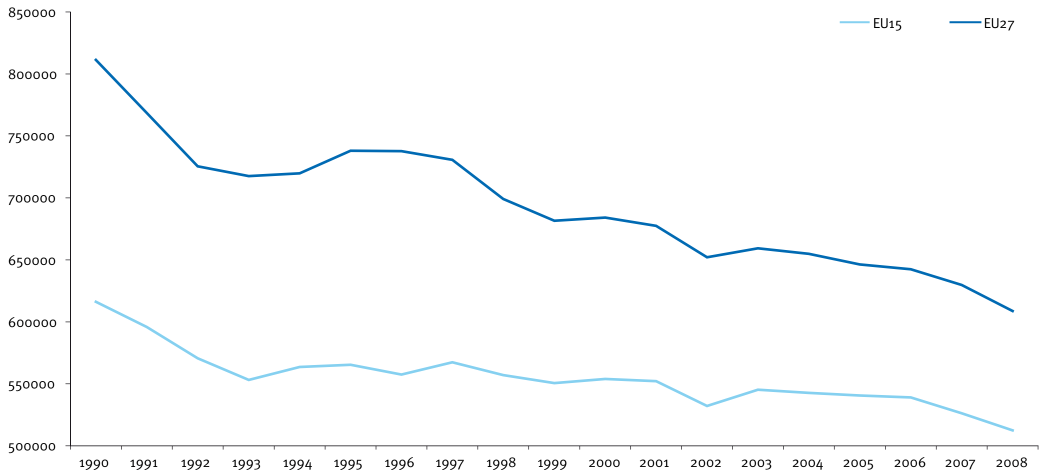
Chart 13. Share of GHG emissions by sector in EU15



Source: Eurostat – 1000 tonnes CO_2 equivalent - % of Total emissions

Hence, when we analyse the different contributing sectors to GHG emissions we find that Transport and Energy related industries are responsible for this lack of reduction in GHG emissions, while Manufacturing & Construction, with a 13% share of the total GHG emissions, contribute marginally to the reduction.

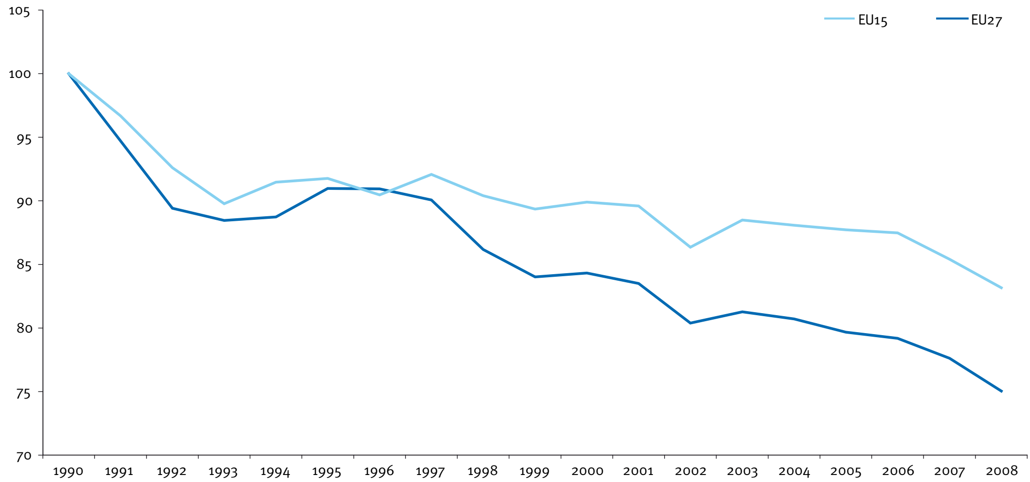
Chart 14. GHG emissions in the Manufacturing & Construction sector



Source: Eurostat – 1000 tonnes CO_2 equivalent

Precisely, one of the business sectors that have come under recent review is that of construction: recent studies by the European Union show that buildings account for a third of the EU's Greenhouse Gases emissions.

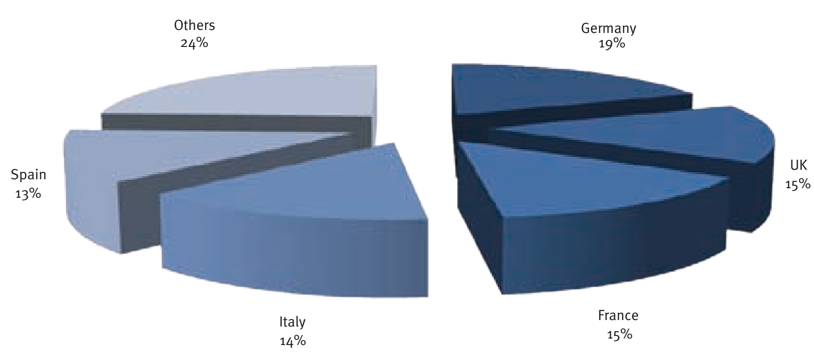
Chart 15. Evolution of GHG emissions in the Manufacturing & Construction sector



Source: Eurostat – Index based on Sectors Greenhouse Gases emissions

Concerning EU15 vs. EU27, the same pattern as in total GHG emissions is detected: new EU countries are adapting to its sustainable development target and reducing GHG emissions in a steeper way in the Manufacturing and Construction sector (see Charts 14 and 15). However, the reduction by central EU countries is much higher in this sector: EU 15 countries reduce emissions by almost 17% on average. Within this sector, we find that the highest emitters are again Germany, United Kingdom, France, Italy and Spain (see Chart 16).

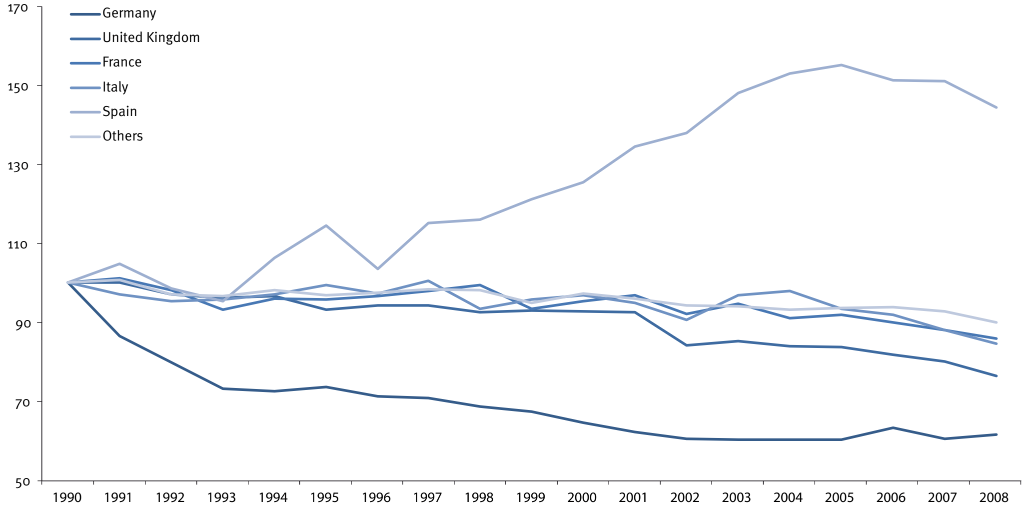
Chart 16. Share of GHG emissions in M&C sector



Source: Eurostat – 1000 tonnes CO_2 equivalent - % of Sector GHG Emissions

However, the reduction by the first four countries (near -25%) is more than offset by an increase in emissions by Spain (+45%). In the EU 15, the only countries that increase their emissions are Austria, Portugal, Greece and Ireland (see Chart 17). The largest reduction in the Manufacturing and Construction sector is achieved by Luxembourg (-70%), while Germany reduces emissions by almost 40%.

Chart 17. Evolution of GHG emissions by the M&C sector (index)

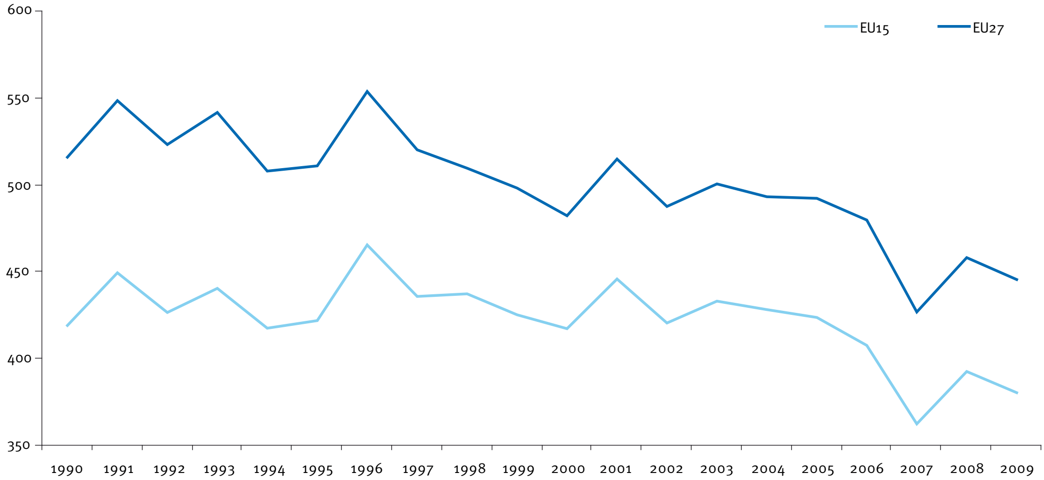


Source: Eurostat – 1000 tonnes CO_2 equivalent – Index base 1990

GHG emissions by the Residential Sector in Europe

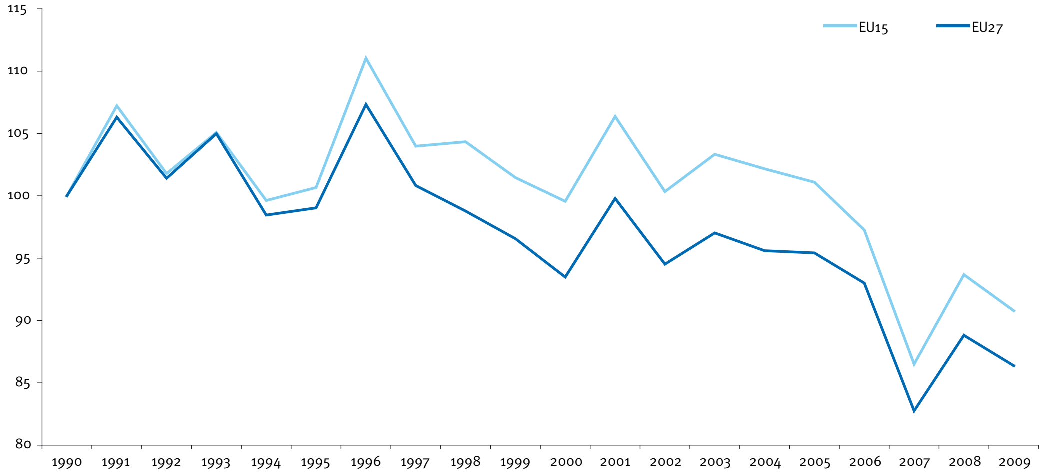
A crucial contributor to GHG emissions in Europe is the dwelling stock (see Charts 18 and 19): energy used by the residential sector is highly correlated with Greenhouse Gases emissions. The Building sector represents around 40% of final energy consumption and between 25% and 36% of GHG emissions in Europe, depending on the reporting standard. Hence, achieving energy efficiency in the residential sector would imply a significant cut in GHG emissions in Europe. A comparison between total and residential GHG emissions can be seen in Chart 20.

Chart 18. GHG emissions by the Residential sector in Europe



Source: EEA (TG million tonnes)

Chart 19. Evolution of Residential GHG emissions in Europe



Source: Index from EEA data (base: 1990), show annual change in GHG emissions.

As we can see in Table 1, residential GHG emissions by country since 1990 have been constantly reduced by EU15 countries with only two major exceptions: Spain and Portugal, both with two digit increments in residential GHG emissions.

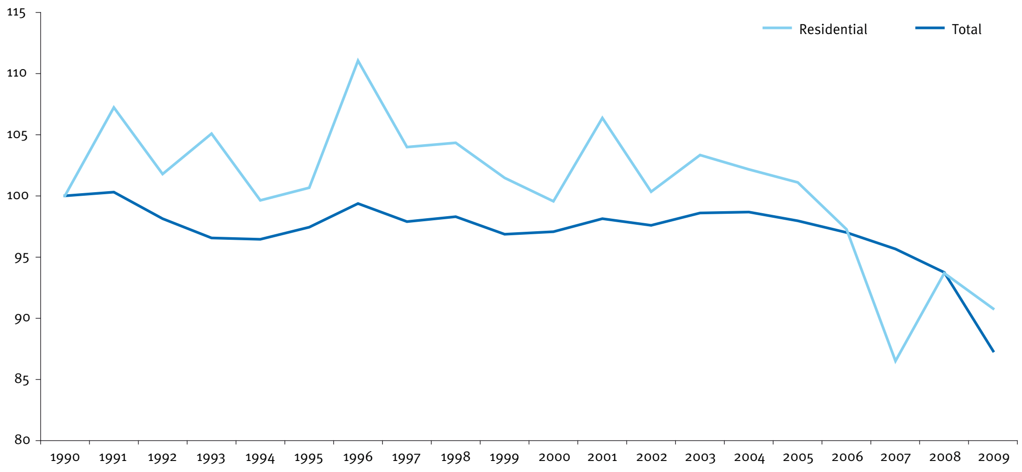
Table 1. Evolution of residential GHG emissions and share for Europe

Residential	Germany	UK	France	Italy	Spain	Netherlands	Portugal	Big 7	Other EU1	EU15	EU27
1990 of EU15	31,4%	18,9%	14,5%	12,6%	3,3%	4,7%	0,5%	86,0%	12,2%	100,0%	
1990 of EU27	25,5%	15,4%	11,8%	10,3%	2,7%	3,9%	0,4%	69,8%	14,1%	81,3%	100,0%
1990	131,5	79,2	60,6	52,9	14,0	19,9	2,0	360,1	58,8	418,9	515,5
1991	133,3	88,0	68,6	57,4	15,4	22,4	2,1	387,2	61,9	449,1	548,0
1992	124,8	85,3	65,9	53,4	15,5	20,2	2,2	367,3	59,1	426,3	522,8
1993	135,3	89,3	64,4	52,8	15,3	21,4	2,3	380,7	59,4	440,2	541,3
1994	129,7	84,7	61,7	45,7	15,9	20,3	2,3	360,3	57,0	417,3	507,6
1995	130,2	80,2	63,0	50,9	14,9	21,4	2,3	362,9	58,8	421,7	510,6
1996	143,5	91,4	68,3	52,5	16,1	24,9	2,4	399,1	66,0	465,1	553,3
1997	139,5	84,2	62,9	50,2	16,0	20,8	2,4	376,0	59,6	435,6	519,8
1998	133,0	86,2	65,7	52,4	16,3	19,8	2,5	376,0	61,0	437,1	509,2
1999	120,9	86,0	65,0	54,9	17,1	19,6	2,7	366,2	58,8	425,0	497,8
2000	118,9	86,2	63,7	51,1	17,4	19,6	2,7	359,6	57,5	417,0	481,9
2001	132,3	88,4	71,5	52,7	17,5	20,4	2,6	385,4	60,1	445,6	514,5
2002	122,2	85,0	65,7	49,9	18,1	19,3	2,6	362,8	57,5	420,3	487,3
2003	122,9	85,8	67,1	54,3	19,6	19,7	2,7	372,0	60,8	432,8	500,2
2004	113,9	87,3	70,0	55,1	20,3	19,5	2,7	368,9	59,1	428,0	492,8
2005	111,9	83,0	69,8	58,3	20,5	18,5	2,7	364,8	58,7	423,5	491,9
2006	114,4	80,4	64,9	53,3	18,9	17,8	2,6	352,2	55,2	407,4	479,4
2007	89,1	76,8	60,4	47,6	19,3	16,4	2,5	312,0	50,3	362,3	426,6
2008	107,7	78,7	62,6	51,0	19,5	18,3	2,3	340,0	52,4	392,4	457,9
2009	103,4	73,9	60,7	52,3	18,2	18,3	2,3	329,2	51,1	380,3	445,3
2009 of EU15	27,2%	19,4%	16,0%	13,8%	4,8%	4,8%	0,6%	86,6%	13,4%	100,0%	
2009 of EU27	23,2%	16,6%	13,6%	11,7%	4,1%	4,1%	0,5%	73,9%	11,5%	85,4%	100,0%
Change in GHG	21,4%	-6,7%	0,2%	-1,1%	30,2%	-7,7%	12,5%	-8,6%	-13,1%	-9,2%	-13,6%

Source: EEA

This situation is more problematic in the Spanish case due to its larger contribution to total GHG emissions in the EU15.

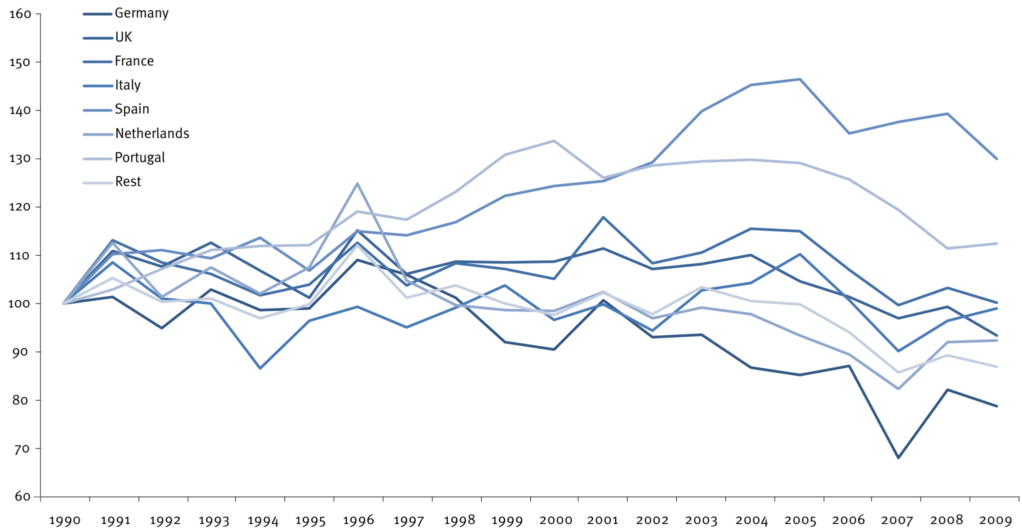
Chart 20. Compared evolution of Total and Residential GHG emissions in Europe



Source: Author's own elaboration (Index base 1990)

The reductions in residential GHG emissions by Germany, The Netherlands, Italy and the UK are evident (see Chart 21).

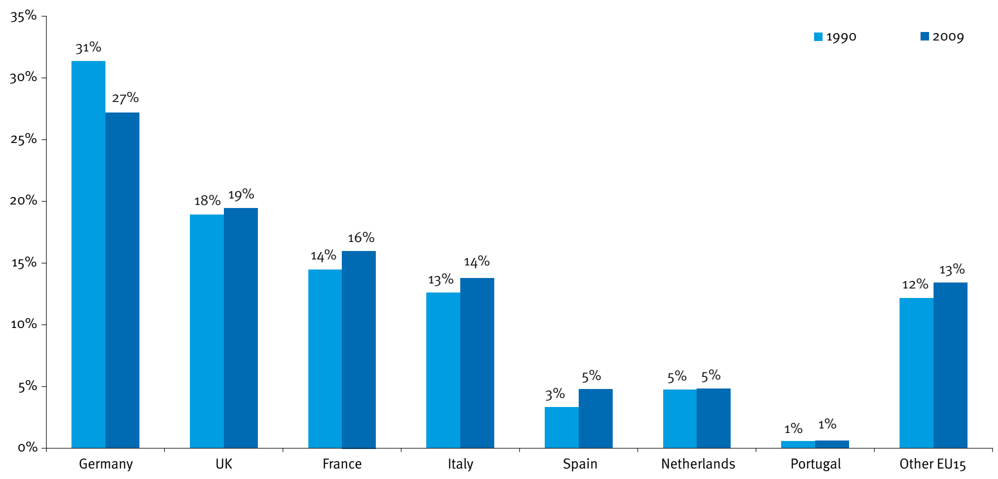
Chart 21. Residential GHG emissions by country



Source: Author's own elaboration (Index base 1990)

Chart 22 shows the shares of Residential GHG by countries in the EU15 in 1990 and 2009.

Chart 22. Shares of Residential GHG emissions by country (1990 v. 2009)

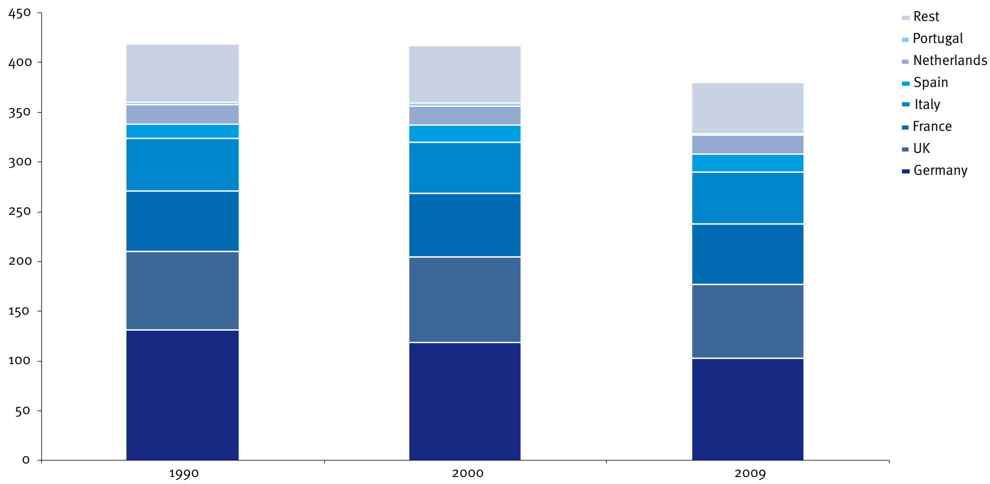


Source: EEA

Germany started the 1990s with a 31,4% share of residential GHG emissions and it has reduced it to only 27,2% in 2009, although it remains the larger residential emitter. At the same time, Germany, the UK, France and Italy add to more than 75% of total residential GHG emissions in the EU15.

With Spain and The Netherlands adding to a further 10% of total residential GHG emissions, we can conclude that major reductions in emissions by the residential sector will have to be accomplished by further increments in energy efficiency of dwellings in the larger EU15 countries (see Chart 23 for the shares of residential GHG emissions by country).

Chart 23. Evolution of shares of Residential GHG emissions by counry



Source: EEA (Tg Million tonnes)

European Energy consumption

Energy consumption is one of the major environmental concerns in the European Union and the rest of the world. Energy efficiency in buildings is considered as one of the main targets for GHG reductions.

Besides being a big source for GHG emissions, buildings also account for 40% of Europe's energy use. Hence, improving the energy efficiency of buildings will result in lower emissions and in less global warming. Regulation will be set to establish minimum requirements for construction materials based on a Life Cycle approach (LCA).

The European Performance of Buildings Directive (EPBD), which is currently under reform, will set new standards for new and existing buildings, both privately and publicly funded.

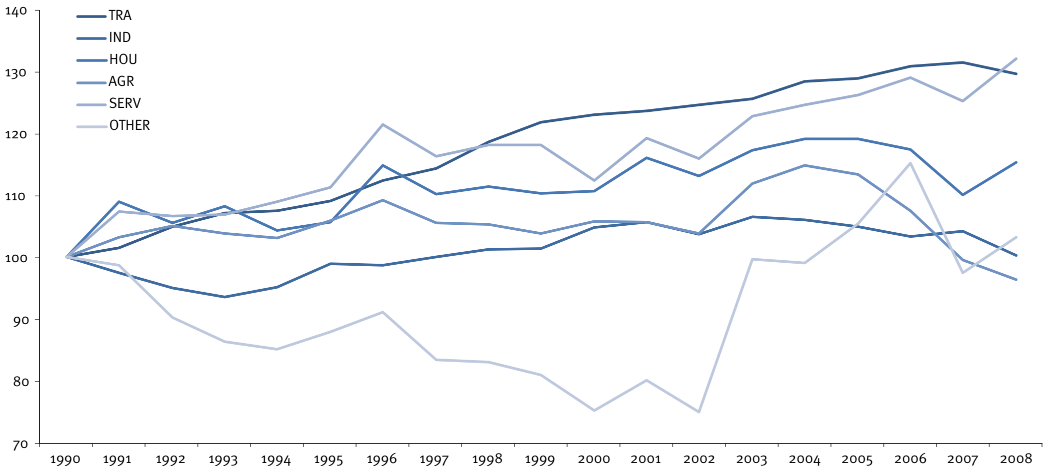
Regarding "Procurement", the EPBD will set a target of "near zero energy" government buildings since 2018 that will include new and renewed buildings. This requirement will be extended to all private buildings since 2020. Clearly, this change in regulation will affect the demand and supply of construction materials: aluminium, cement, wood and other materials will have to prove that their LCA complies with the minimum requirements set by the Directive.

According to the World Business Council for Sustainable Development, "Buildings account for 30% to 40% of primary energy use in most countries. Unsustainable energy increases in all sectors stem from the growing global population (expected to be nearly 50% higher in 2050 than in 2000) and from increasing energy usage per person due to rising standards of living. The critical challenge is to accommodate population growth and rising living standards for those in developing economies while creating a global sustainable future."

At the same time, final consumption of energy in the EU15 has followed an upward trend: since 1990, energy consumption has increased 16% overall. Of the total energy consumption, three sectors account for almost 85% of the use: Transport (TRA, 33%), Industry (IND, 27%) and Households (HOU, 25%) (see Chart 24).

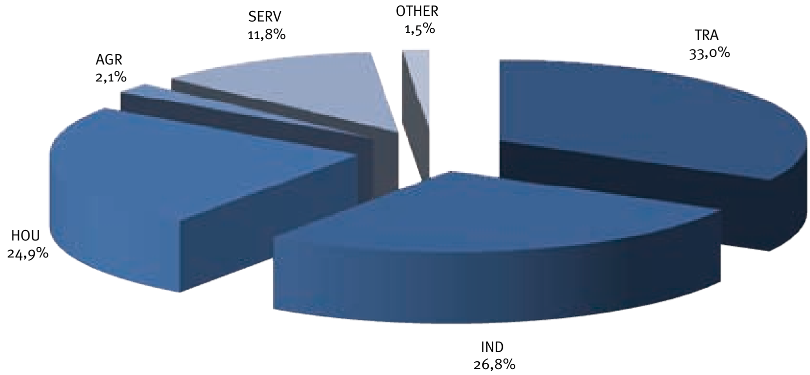
Only the industrial sector has maintained the same level of consumption (0.3% increase). Transport, on the other hand, has increased consumption by 28%, while Household increased merely by 15%. Services (SERV), a small sector on the overall consumption account (12% of total consumption), have increased its consumption by 33%.

Chart 24. Energy consumption by economic sector



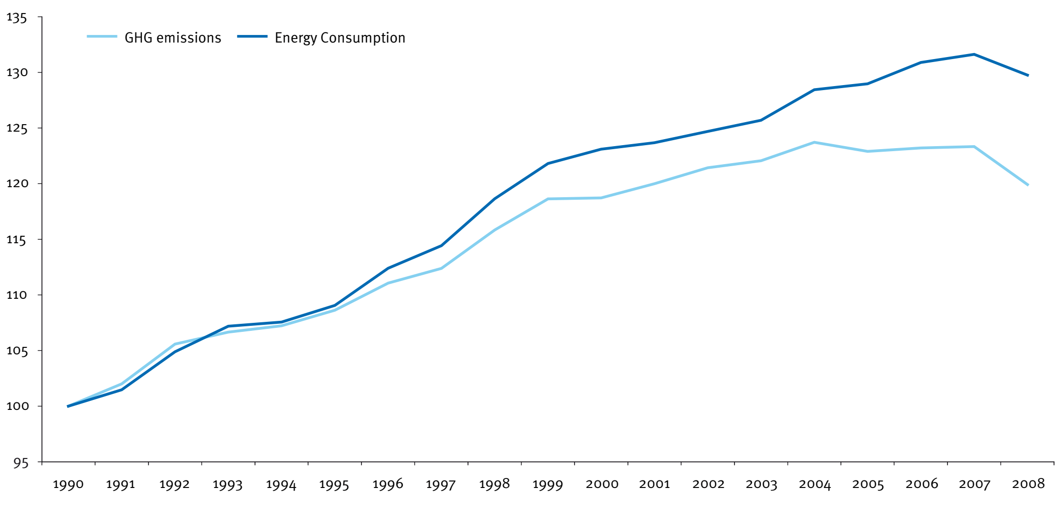
Source: Index from Eurostat data (base: 1990) showing annual change in GHG emissions and Energy Consumption

Chart 25. Share of Energy consumption by economic sector



Source: Eurostat

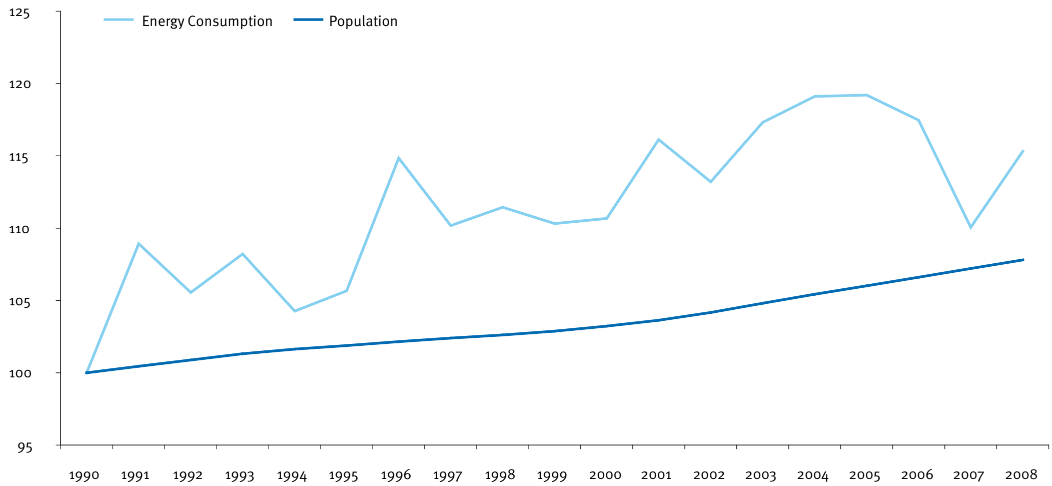
Chart 26. Evolution of GHG emissions and Energy consumption of the Transport sector



Source: Index from Eurostat data (base: 1990)

As we can see in Chart 26, both Greenhouse Gases emissions and Energy Consumption (NRGC) in the transport sector experiments an upward trend that only recedes when the recent financial crisis strikes. Clearly, there is a correlation between this sector's by-products (GHG and NRGC) and economic growth.

Chart 27. Evolution of Population and Energy consumption of households in EU15

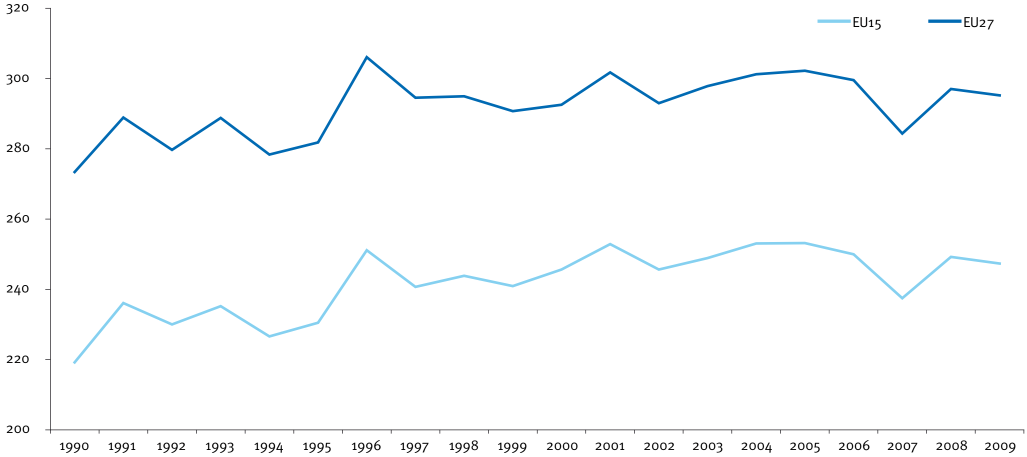


Source: Index from Eurostat data (base: 1990), show annual change in Population and Energy Consumption

In the case of the household sector a better indicator would be, perhaps, that of building permits (new and reformed, POPin) and energy consumption. The trend in Household energy consumption is also upward, although not many conclusions can be drawn from its relation with population growth (see Chart 27).

Residential sector energy consumption

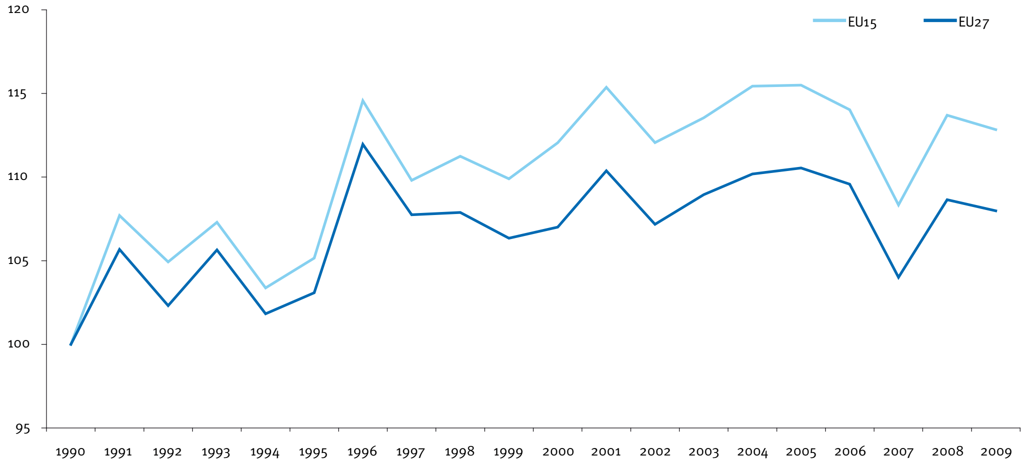
Chart 28. Energy consumption by the residential sector in Europe



Source: EEA

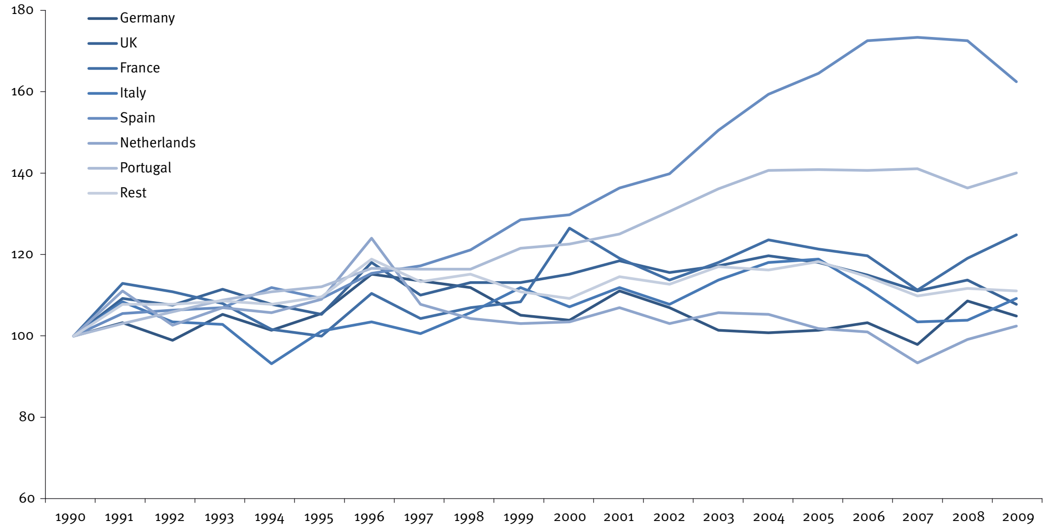
Although the evolution of Energy consumption by the residential sector in the EU dropped significantly in 2007, as we can see in Charts 28 and 29, the upward path is evident.

Chart 29. Evolution of energy consumption by the Residential sector



Source: Index from EEA data (base: 1990), showing annual change in GHG emissions and Energy Consumption

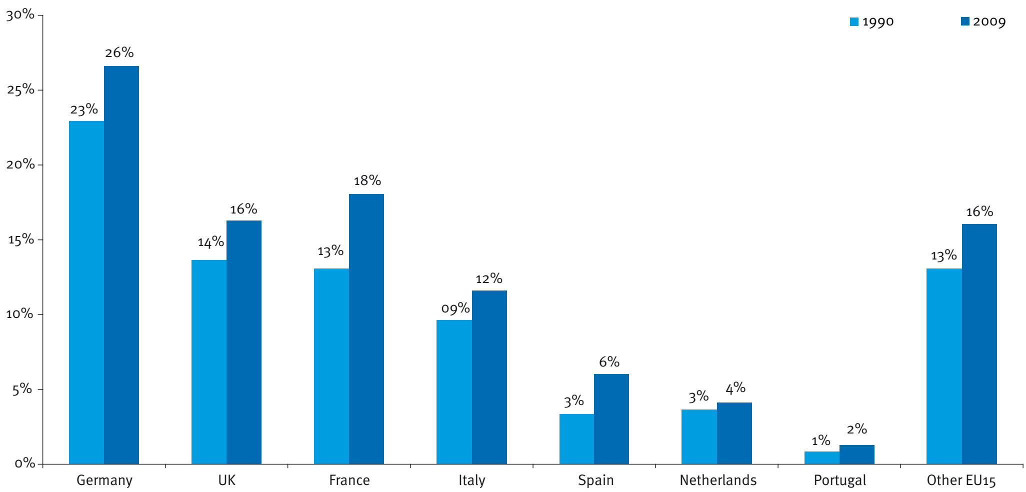
Chart 30. Evolution of Residential energy consumption by country



Source: Index from EEA data (base: 1990), showing annual change in GHG emissions and Energy Consumption

As we see in Chart 30, again, main contributors to this upward path are Spain and Portugal, although Spain, The Netherlands and Portugal only add up to 10% of total residential energy consumption in the EU15.

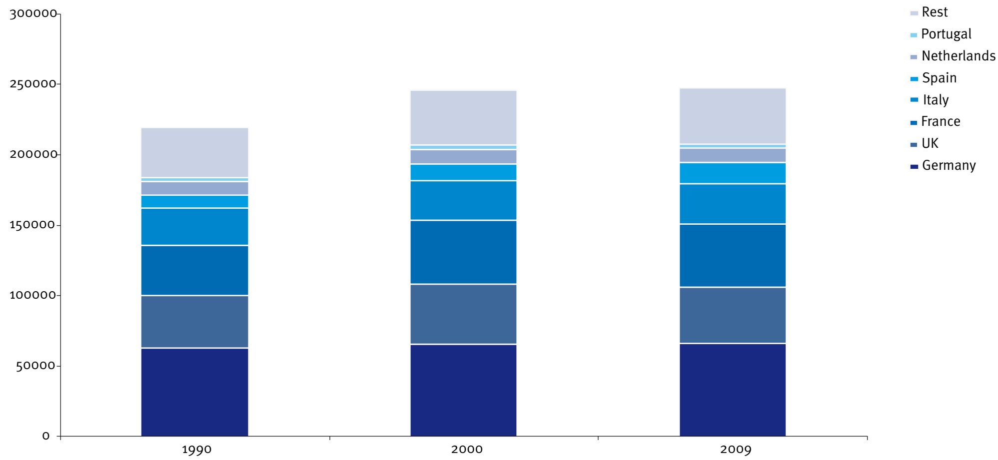
Chart 31. Evolution of shares of Residential Energy consumption (1990 v. 2009)



Source: EEA

Chart 31 shows how, despite reducing residential GHG emissions, countries like Germany, France, and the UK have increased their energy consumption. A preliminary conclusion is that they have also increased energy efficiency, resulting in a lower consumption per dwelling.

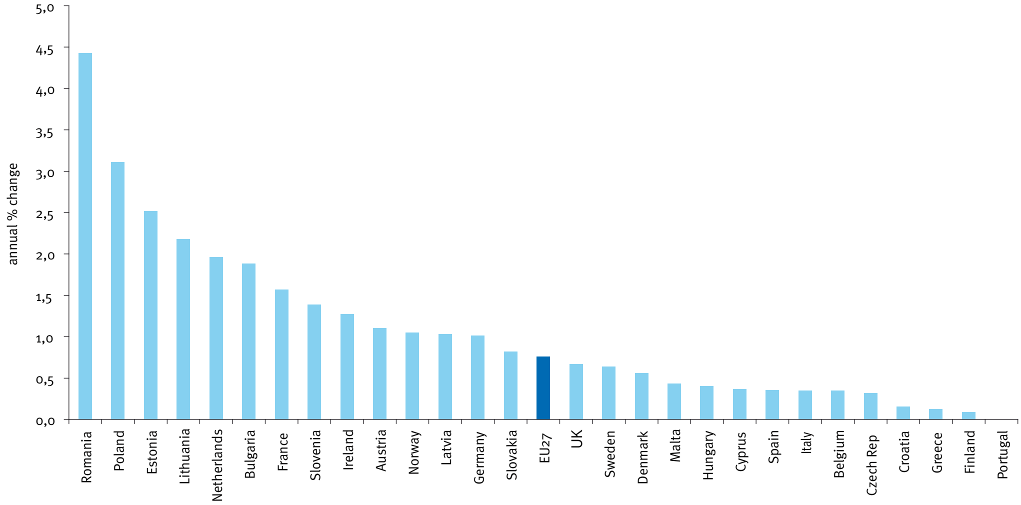
Chart 32. Evolution of energy consumption by country



Source: Eurostat - Thousand tones of oil equivalent (TOE)

Chart 33 gives the change in energy efficiency index by country in the period 1997-2008. A higher percent change signals a higher increase in energy efficiency by a particular country on this period. We can see here how Germany, The Netherlands, France, the UK and Ireland are the countries that have increased more their residential energy efficiency between 1997 and 2008 in the EU15.

Chart 33. Index of Residential Energy Efficiency in Europe

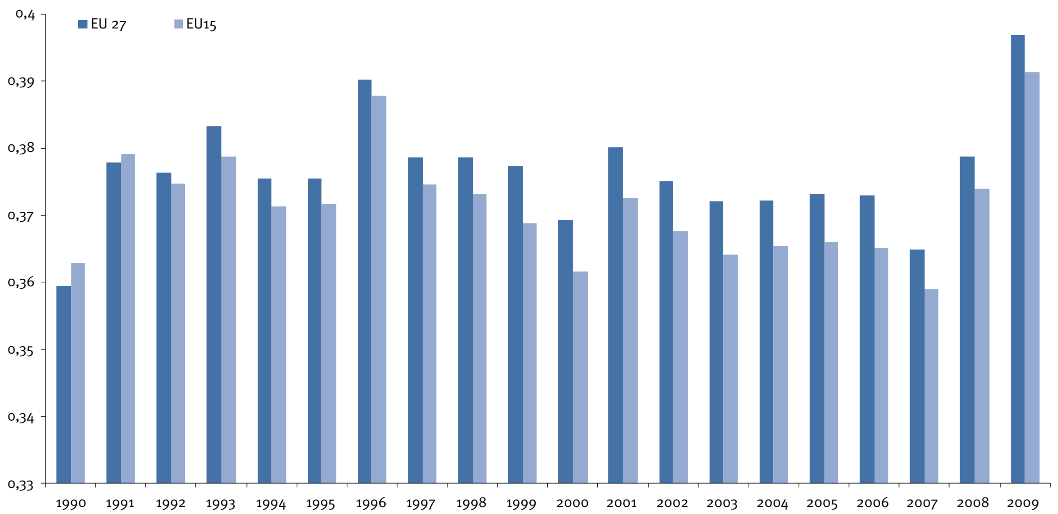


Source: EEA

How would increasing energy efficiency in dwellings help achieve the targets?

Energy efficiency in dwellings is an important goal for the European Union and it could be very helpful in order to achieve the emissions reduction targets. As we can see in Chart 34, the share of Final Energy Consumption that the Building sector represents is close to 40% in both the EU15 and the EU27.

Chart 34. Buildings Share of Final Energy Consumption in Europe

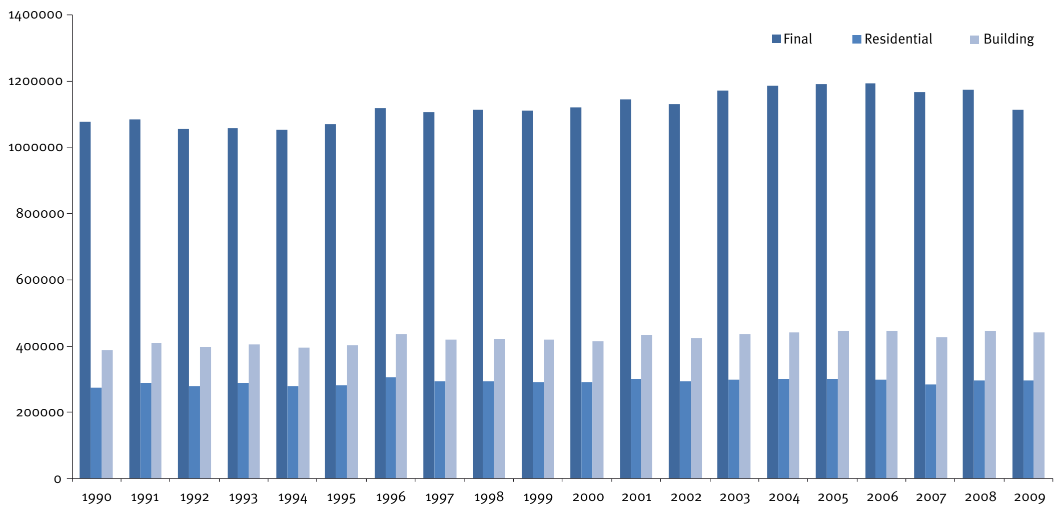


Source: Eurostat 2011

The Building sector comprises both the energy use of the Residential sector, the Construction sector and the Services sector (including Government). The share of final energy consumption has increased from near 36% to the current levels.

Final Energy Consumption, however, remains at a level very similar to that of 1990, as we see in Chart 35. The share of Final Energy Consumption that buildings represent has increased since the adoption of the mitigation targets. This fact may lead to the erroneous conclusion that Europe has become more energy inefficient despite the new policies. However, we need to analyze the Building sector part by part and understand the causes of this increment.

Chart 35. Residential and Building Sector as a Share of Final Energy Consumption (EU27)



Source: EEA – authors' own elaboration (Thousand tones of oil equivalent -TOE-)

Analyzing the growth in final energy consumption, we can see that the corresponding growth in energy consumption by the Buildings Sector comes primarily from Services (see Table 2). This sub-sector includes Government and it has augmented its energy consumption by near 30% both in the EU15 and the EU27.

Table 2. Growth in final energy consumption (1990-2009)

Growth (1990-2009)	EU15	EU27
Final Energy Consumption	10.52%	3.25%
Residential Energy Consumption	12.84%	7.98%
Construction sector	46.65%	4.34%
Services sector	33.65%	29.75%
Buildings	19.20%	14.02%

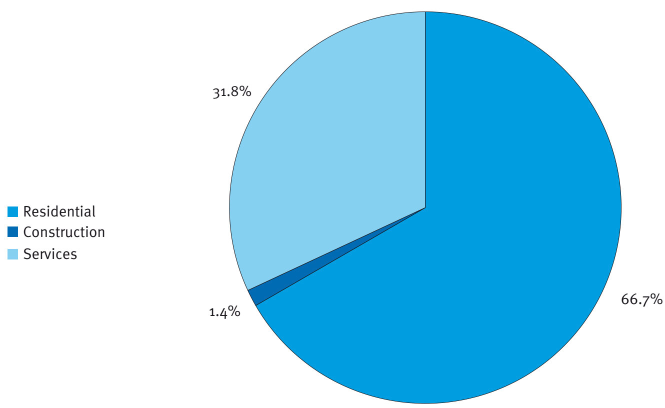
Source: Eurostat 2011

The Construction sector has increased its energy usage in the period 1990-2009 by almost 50% in the EU15.

However, both of these sectors represent only a small share of total energy consumption on the building sector. As we can see in Chart 36, the most important contributor to energy usage on the building sector is the Residential sector, comprised mostly of the Dwelling Stock.

The dwelling stock share of final energy consumption by Buildings in Europe nears 67% in both the EU15 and EU27. The increment of energy usage in this sector reached 12,68% in the EU15 and 8,0% in the EU27. This implies that the residential sector has increased energy usage since the implementation of the mitigation targets and in spite of them.

Chart 36. Building Sector shares (EU27)



Source: Eurostat

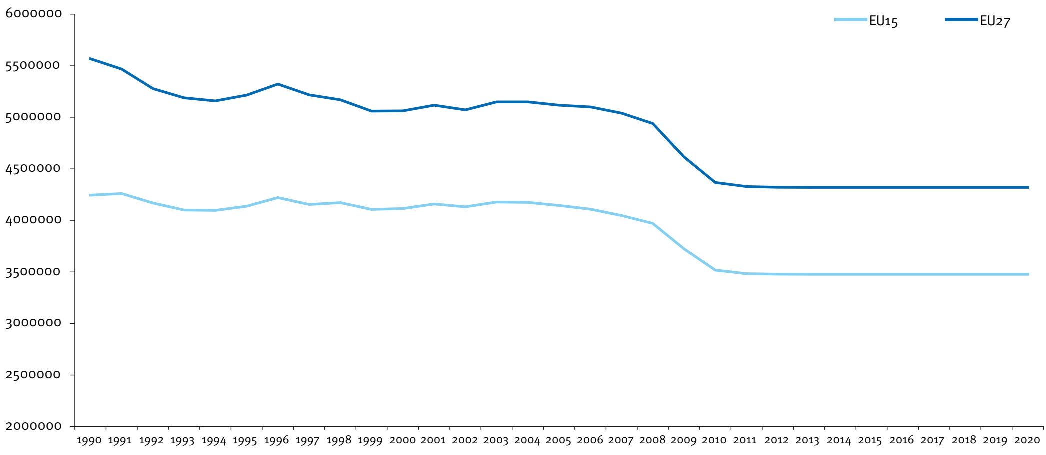
However, over the 1990-2008 period, driven by the existence of more efficient buildings, space heating technologies and electrical appliances, energy efficiency in the household sector increased by 19% in EU27 countries, or 1.1% per year.

This effect was counterbalanced by an increase of 13%, at an annual average rate of 0.7%, in final energy consumption of households. Hence, we can see that mainly two opposite drivers influence household energy consumption. Efficiency improvements in space heating and large electrical appliances reduced consumption while size of dwellings increased.

At the same time increased use of electrical appliances and central heating contributed to a raise in consumption, which offsets part of the energy efficiency benefits. CO_2 emissions per dwelling were 24% below their 1990 level in 2008, mainly because of CO_2 savings resulting from the switch to fuels with lower CO_2 content.

If we analyze these trends assuming that more energy efficiency will result in lower energy consumption, for instance, through the achievement of Net Zero Buildings on the Residential sector and assuming all else constant, then, we can see how total GHG emissions are impacted by this reduction (see Chart 37). More energy efficient homes result in much lower GHG emissions for Europe.

Chart 37. Scenarios simulation for Net Zero Residential GHG emissions



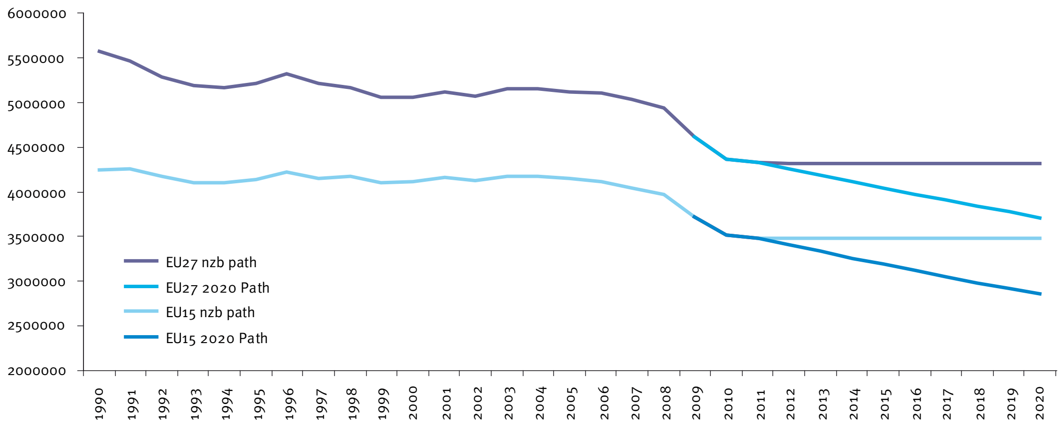
Source: authors' own elaboration –– 1000 tonnes CO_2 equivalent

The above paths are achieved when inducing a progressive path of energy efficiency on residential dwellings in order for them to use net zero energy in 2020. Both the Services and Construction segments remain as today and, hence, the Building sector use of final energy consumption is reduced by 66% (the current share of the Residential sector energy use).

As we can see in Chart 38, Net Zero buildings would account for 6.4% reduction in total GHG emissions for EU27 and 6.7% reduction in total GHG emissions for EU15. Even though 2020 targets are not reached with Net Zero Buildings, almost 85% of the targets would be obtained thanks to this policy.

Hence, energy efficiency in residential dwellings is necessary but not sufficient for achieving the 2020 targets. Europe will need to foster energy efficiency in government and commercial buildings as well, in order to get closer to the targets.

Chart 38. Scenarios simulation for Net Zero Residential GHG emissions with 2020 Path



Source: authors' own elaboration – 1000 tonnes CO_2 equivalent

Annex

Table 3. GHG emissions evolution and shares

Total	Germany	UK	France	Italy	Spain	Netherlands	Portugal	Big 7	Other EU15	EU15	EU27
1990 of EU15	22,3%	13,9%	10,1%	9,3%	5,1%	3,8%	1,1%	65,5%	10,8%	76,3%	100,0%
1990 of EU27	29,3%	18,2%	13,2%	12,2%	6,6%	5,0%	1,4%	85,8%	14,2%	100,0%	
1990	1.247.901,0	776.142,0	562.886,0	519.157,0	283.168,0	211.852,0	59.417,0	3.660.523,0	604.388,0	4.264.911,0	5.588.798,0
1991	1.202.094,0	780.976,0	586.090,0	520.271,0	290.626,0	216.436,0	61.515,0	3.658.008,0	619.854,0	4.277.862,0	5.487.286,0
1992	1.151.934,0	754.572,0	577.526,0	517.318,0	298.183,0	215.086,0	65.544,0	3.580.163,0	604.851,0	4.185.014,0	5.297.950,0
1993	1.143.334,0	732.336,0	552.688,0	510.818,0	286.866,0	220.065,0	63.956,0	3.510.063,0	607.789,0	4.117.852,0	5.207.080,0
1994	1.123.282,0	720.477,0	548.253,0	503.099,0	303.247,0	220.038,0	65.274,0	3.483.670,0	629.754,0	4.113.424,0	5.176.710,0
1995	1.119.906,0	710.168,0	559.672,0	529.951,0	314.839,0	223.249,0	69.499,0	3.527.284,0	628.208,0	4.155.492,0	5.231.962,0
1996	1.139.506,0	730.421,0	575.935,0	523.315,0	307.484,0	231.296,0	67.368,0	3.575.325,0	662.581,0	4.237.906,0	5.338.901,0
1997	1.103.395,0	704.312,0	570.735,0	529.668,0	328.041,0	224.664,0	70.435,0	3.531.250,0	643.643,0	4.174.893,0	5.238.343,0
1998	1.077.646,0	700.178,0	585.554,0	540.840,0	337.880,0	225.524,0	74.934,0	3.542.556,0	649.366,0	4.191.922,0	5.192.456,0
1999	1.043.510,0	668.656,0	572.108,0	547.098,0	366.241,0	213.520,0	83.296,0	3.494.429,0	636.471,0	4.130.900,0	5.086.171,0
2000	1.042.071,0	669.832,0	566.838,0	551.640,0	379.563,0	213.161,0	81.225,0	3.504.330,0	635.435,0	4.139.765,0	5.085.820,0
2001	1.056.941,0	674.330,0	569.147,0	557.476,0	379.820,0	214.995,0	82.337,0	3.535.046,0	650.054,0	4.185.100,0	5.145.129,0
2002	1.036.680,0	653.223,0	563.708,0	558.668,0	396.775,0	214.317,0	86.897,0	3.510.268,0	651.559,0	4.161.827,0	5.104.918,0
2003	1.030.603,0	657.625,0	565.719,0	573.477,0	403.731,0	215.370,0	81.703,0	3.528.228,0	676.788,0	4.205.016,0	5.177.396,0
2004	1.021.218,0	655.557,0	566.462,0	576.600,0	419.511,0	216.762,0	84.078,0	3.540.188,0	668.141,0	4.208.329,0	5.181.206,0
2005	999.776,0	651.027,0	568.972,0	574.893,0	433.847,0	211.105,0	85.984,0	3.525.604,0	652.045,0	4.177.649,0	5.148.753,0
2006	1.002.257,0	644.637,0	552.969,0	563.911,0	426.023,0	207.129,0	81.272,0	3.478.198,0	658.837,0	4.137.035,0	5.128.892,0
2007	979.873,0	634.159,0	544.501,0	554.569,0	437.130,0	205.405,0	79.107,0	3.434.744,0	644.974,0	4.079.718,0	5.071.328,0
2008	981.112,0	620.257,0	539.178,0	541.749,0	404.771,0	204.601,0	77.935,0	3.369.603,0	628.387,0	3.997.990,0	4.969.052,0
2009	919.698,0	566.210,0	517.248,0	491.120,0	367.548,0	198.872,0	74.583,0	3.135.279,0	588.435,0	3.723.714,0	4.614.526,0
2009 of EU15	24,7%	15,2%	13,9%	13,2%	9,9%	5,3%	2,0%	84,2%	15,8%	100,0%	
2009 of EU27	19,9%	12,3%	11,2%	10,6%	8,0%	4,3%	1,6%	67,9%	12,8%	80,7%	100,0%
Change in GHG	?26,3%	?27,0%	?8,1%	?5,4%	29,8%	?6,1%	25,5%	?14,3%	?2,6%	?12,7%	?17,4%

Source: Eurostat – 1000 tonnes CO_2 equivalent – Total Greenhouse Gases emissions

3. European policies for Climate Change mitigation through Energy Efficiency

Analysing the structure of European regulation intended to create incentives for climate change mitigation will provide us with useful guides for several objectives.

First, we will be able to understand the amount of policies and regulations that have been enacted and reformed by the EU since Kyoto. The process of enactment, enforcement and reform of regulations will help us understand whether the initial regulations had the intended effects or if they fell short of their objectives.

Second, we will be able to understand where the current focus of European regulation lays regarding climate change mitigation. Economic policies aiming for incentives towards energy efficiency are the tools currently more under emphasis by the EU. Some of these energy efficiency policies have very specific sectors, such as the European Performance of Buildings Directive, which aims towards climate change mitigation through a better use of the European dwelling stock.

Finally, as the European Union usually leads the way for the rest of the world in what regards to regulation and specifically climate change mitigation policy, this analysis will help us understand what instruments would be mimicked by other countries and to compare regulatory instruments. It will also allow us to understand which effects will the regulation have on markets in new countries and regions.

Introduction to European Policies on Energy Efficiency

One of the main results of the Lisbon Treaty, which entered into force on December 1st, 2009, has been the European Union's goal of Sustainable Development. The treaty directs the EU to "help develop international measures to preserve and improve the quality of the environment and the sustainable management of global natural resources, in order to ensure sustainable development".

The treaty, hence, aims to improve existing directives for energy efficiency and sustainable products, such as EcoDesing Directive, and the policies derived from them. These policies focus on a Life Cycle approach towards achieving "greener" products, in the sense that these products result in both lower Greenhouse Gases emissions and in higher energy efficiency.

The Life Cycle approach (LCA) is broadly defined as the total environmental impact of a product since its production to its demise. Different definitions of LCA exist. These definitions vary depending on what each observer considers to be the beginning and end of the life of the product. Hence, some will consider that the life of a product starts when the product is "put together", while others will extend this definition to the point where they include the raw materials involved in its production. This extension is not minor: for some products, such as aluminium or cement, it could add a considerable "LC cost" given the intensity of energy use and the GHG emissions during extraction and processing of raw materials.

At the same time, the "end" of the product is also important: it matters whether and to what extent a product is recycled, and it also matters whether these two issues are included in the LCA. That is to say, does the LC cost include the scope for recycling of the product (which reduces future potential emissions and energy use)?

The definition of LCA, then, is not a minor issue. As we will see later, the most common definition for the Life Cycle Approach is that provided by ISO 14044 standard, which defines LCA as "understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system". Taking this definition broadly will include in the LCA the initial processing of raw material involved in the product as well as the recycling prospects of the product. Hence, the LCA will be equivalent to the term "carbon footprint".

As mentioned before, EU directives are being reviewed aiming towards more Energy Efficiency at the EU based on the understanding that perhaps the most damaging effects on Climate Change are not unavoidable but could be solved through design, innovation and a more rational use of energy. Different studies describe inefficient use of energy as one of the main factors in generating Global Warming or Climate Change.

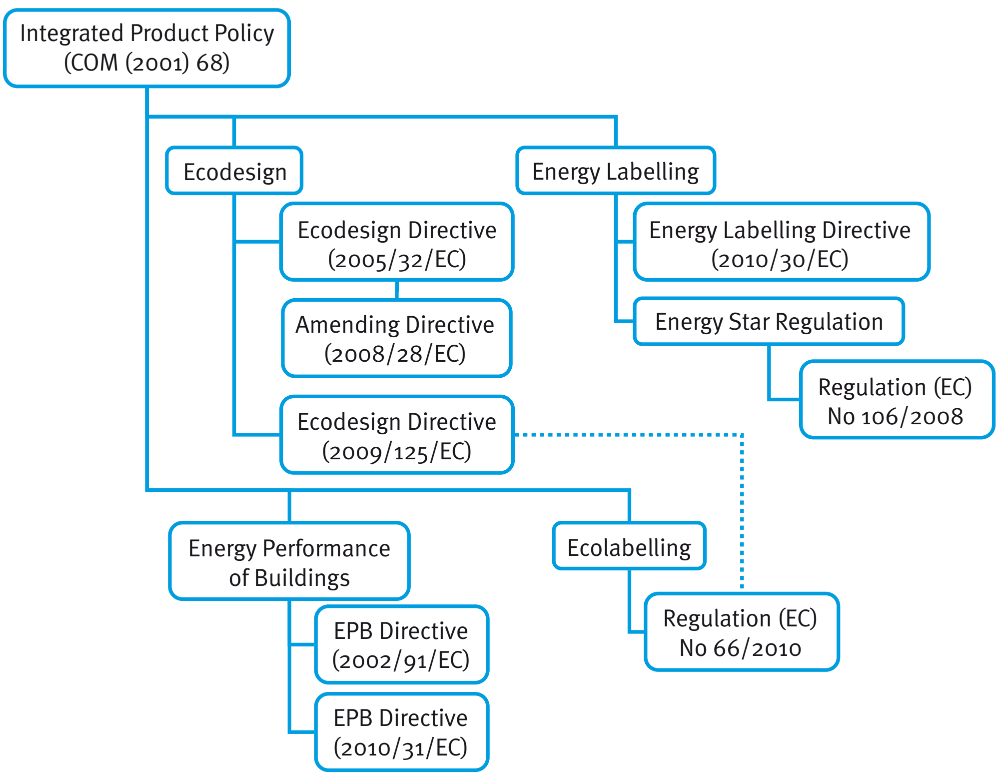
This emphasis on Energy Efficiency has become the focus of the intended new policies of the EU: as the "Ecodesign (EuP) Directive" states, new policies will aim to reduce this environmental impact through incentives, the harmonisation of public procurement and new labelling regulations regarding, for example, construction materials.

Our analysis revolves around two main markets that are affected by European regulation: the market for buildings and the market for construction materials. The market for buildings is affected by Energy Performance Certificates (EPCs) that work as a potential signal for consumers: is there a higher willingness to pay for green buildings? The market for construction materials will be affected both by a possible higher willingness to pay for green buildings (that use green components) and by the imposition of minimum requirements on construction materials. Finally, estimating the refurbishment and procurement market for buildings is an important issue for the work at hand.

3.1 European Union regulation for climate change mitigation

This section will provide a summary of the main EU directives towards the goal of energy efficiency and sustainable development (see Chart 39). It will also focus on the potential reforms to these policies based on the recasts, impact assessment reports and reforms approved by the European Commission that are being debated at the moment.

Chart 39. Map of European Climate Change Mitigation Regulation



Source: authors' own elaboration

Integrated Product Policy

In June 2001, the European Commission adopted the Integrated Product Policy (IPP) aiming to improve the environmental performance of products and services throughout their life cycles: IPP covers all the areas from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale and use to their eventual disposal as waste. IPP is the first stone of the Life Cycle thinking building at the EU.

Ecodesign Directive

The Ecodesign Directive was enacted in 2005 and sets the standard of a Life Cycle approach, although it currently only applies to energy-using products.

According to the communication of the EU Commission on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan: "The scope of the Directive on the Ecodesign of energy-using products will be extended to cover all energy-related products. Minimum requirements will be set for products with significant environmental impacts, focusing on key environmental aspects. To provide markets with information on best performing products, advanced benchmarks of environmental performance will also be identified. Periodic reviews of minimum requirements and advanced benchmarks will take place to adapt them to technological change and provide businesses with a long-term perspective of future regulatory environment [...] following a review of the Ecodesign Directive in 2012, complemented as appropriate by an Ecodesign Labelling Directive to provide consumers with information about the energy and/or environmental performance of products."

The reform will not be binding in terms of requirements for specific products but it will include energy-using products and other products (whose insulation properties influence the energy required for the heating and cooling of buildings), and water-using devices.

The reformed EcoDesign Directive will set two levels of performance:

- Minimum requirements that need to be attained by the product in order to be allowed on the Internal Market;

- Advanced benchmarks of environmental performance, to provide markets with early indication of highly performing products available on the market and of the possible future evolution of minimum requirements.

It will be supplemented by reforms to the Eco Labels related directives. In this sense, we could say that the reform is intended to affect the demand of products directly (through labels and benchmarks) and the supply of products (by "setting" a minimum standard).

Energy Labelling Directive and Energy Star regulation

Energy Star Regulation also obliges EU institutions and Member State authorities to purchase office equipment meeting specific levels of energy efficiency.

The Life cycle approach

For the European Union, Ecodesign is the process of integrating environmental considerations at the early stages of the design of products (or services) in order to reduce the environmental impacts throughout its life cycle.

At the same time, a highly adopted definition of this concept is that of the ISO 14044 standard, which defines Life Cycle Impact Assessment (LCIA) as the "phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system". In LCIA, the emissions and resources consumed that can be attributed to a specific product are compiled and documented in a Life Cycle Inventory (LCI). Hence, the resource inputs and emissions are classified and characterized in order to express their significance in terms of contributions to a recognized set of nine environmental impact categories. These, in turn, are conventionally considered under three areas of protection: human health, the natural environment, and natural resource use. This phase is termed Life Cycle Impact Assessment and enables different emissions and resources consumed, as well as different product options, to be analysed and cross-compared.

Green Public Procurement

The aim of this policy is to reduce expenditures in non-environmentally friendly products: public authorities spend near € 2 trillion per year, an equivalent to 17% of the EU's GDP.

Green Public Procurement (GPP) is defined in the Communication (COM (2008) 400) as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured." GPP is a voluntary instrument, which means that individual Member States and public authorities can determine the extent to which they implement it.

European Performance of Buildings Directive (EPBD)

This directive was enacted in 2002 and reformed in 2010. Its main provisions make it mandatory for builders to display labels showing energy impact per year and set minimum energy requirements for construction materials.

Recent changes to this directive include switching from Member State (MS) Benchmarking Method Development to EU Commission (EC) Development; which implies that from now on MS will have to apply standards of measurement designed by EC, not their own.

However, the main point of the reform is the standard to be set for public procurement regarding buildings: the reformed directive establishes a voluntary goal of "near zero" buildings to be applied to new public buildings. This "near zero" goal is criticized as not ambitious enough: some point towards a "net zero energy" goal. Two main reasons for this criticism are the need for a clear-cut goal for all members and the problem of what is considered to be "near zero" by each Member State. On the other hand, some claim that a "net zero" goal would be unattainable because of its costs while a "near zero" goal would be effective and cheap for Member States.

Zero energy policy for buildings: "net" or "near"?

There are several definitions as to what constitutes Zero Net Energy Buildings:

- Net Zero Site Energy: A site ZEB produces at least as much energy as it uses in a year, when **accounted for at the site**.

- Net Zero Source Energy: A source ZEB produces at least as much energy as it uses in a year, when **accounted for at the source**. Source energy refers to the primary energy used to generate and deliver the energy to the site.

- Net Zero Energy Costs: In a cost ZEB, the amount of money the utility pays the building owner for the energy the building brings to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

- Net Zero Energy Emissions: A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources. (In other words, a Zero Carbon Building.)

- Zero Carbon Buildings: A Zero Carbon Building is one that, over a year, produces sufficient carbon-free energy to offset the carbon emitted from all fossil-fuel derived energy consumed by the building.

According to the above mentioned Energy Performance of Buildings Directive (Recast), 2010/31/EU, all new buildings should be nearly zero energy buildings (a building that has a very high energy performance) by 2020 and Member States shall set intermediate targets for 2015. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources. The debate will then be around what each member state understands to be a nearly zero target: is 10% near zero or not?

The impact of European regulation on the markets

As we have seen in the first sections of this review, the European Union is not yet close to its proclaimed targets on GHG emissions and Energy Consumption. Even though the economic and financial crisis has "helped" to get closer to the goal by significantly reducing economic activity on the region, the annual pace of reduction would need to be increased for both the EU27 and the EU15 in order to achieve the 2020 targets. Furthermore, if the EU were to extend its target reduction on GHG emissions to 30% by 2020, reforms would need to accelerate.

Buildings are key to achieving these targets. GHG emissions by Buildings at the EU represent 36% of total emissions. At the same time, Buildings consume 40% of the energy in Europe. Hence, several EU directives are pointed towards the goal of energy efficiency in buildings. Clarifying the scene, two of these directives are primary: the European Performance of Buildings Directive and the EcoDesign Directive. Both have been recast in 2010 in order to help achieve the goal of energy efficiency in buildings.

We focus on the understanding of the potential effects of the intended reform of a specific European Union sustainable development policy on the market for construction materials. In this connection, the main question is the following:

How would the market for environmentally friendly construction materials respond to the recast of the European Performance of Buildings Directive and the EcoDesign Directive?

To begin with, the main provisions of the new EPBD are not supposed to be implemented supranationally but by the Member States individually. Furthermore, the most important aspects for this study are mainly two: first, the "labelling" of buildings through the implementation of certificates for energy efficiency (as the Energy Performance Certificate (EPC) or the Display Energy Certificates (DEC)) that intend to affect the demand for buildings through a differentiation of products; and second, the implementation of minimum standards for building elements.

Hence, these policies affect the market for buildings by imposing labels and near zero targets on buildings, which builds on requirements for greener construction materials. The regulation will have two potential impacts on the markets: one, through the willingness to pay of European consumers for greener products; another, through requirements imposed on construction materials. We first analyse the potential impact of requirements on construction materials on the specific case of Aluminium and then outline the potential for willingness to pay for green buildings.

Effects on the market for Buildings: labels and willingness to pay of consumers

Information about Energy Performance Certificates is scarce and incomplete. Only two countries in Europe have been implementing EPCs for at least five years before the recast of the EPBD in 2010: England and The Netherlands. However, information is not perfect either because EPCs have been mandatory only for rent and sale of dwellings since 2006. Also, in both these countries the consumers easily obtain a waiver of the need for an EPC and, changes in standards complicate the statistics. For instance, in the United Kingdom, statistics on EPCs could reflect double or triple accounting: some dwellings have asked for a new EPC every year, sometimes twice a year, and this is not accounted for by the statistics office.

Hence, our analysis is centered on the results of previous research on the matter. There are interesting studies that comprise the experiences of The Netherlands, the US, Australia or Switzerland. These experiences can be of guidance to, first, understand whether a building with an EPC is more valuable to the consumer or not, and, second, to choose the best methodology for the analysis to be conducted when the data are available.

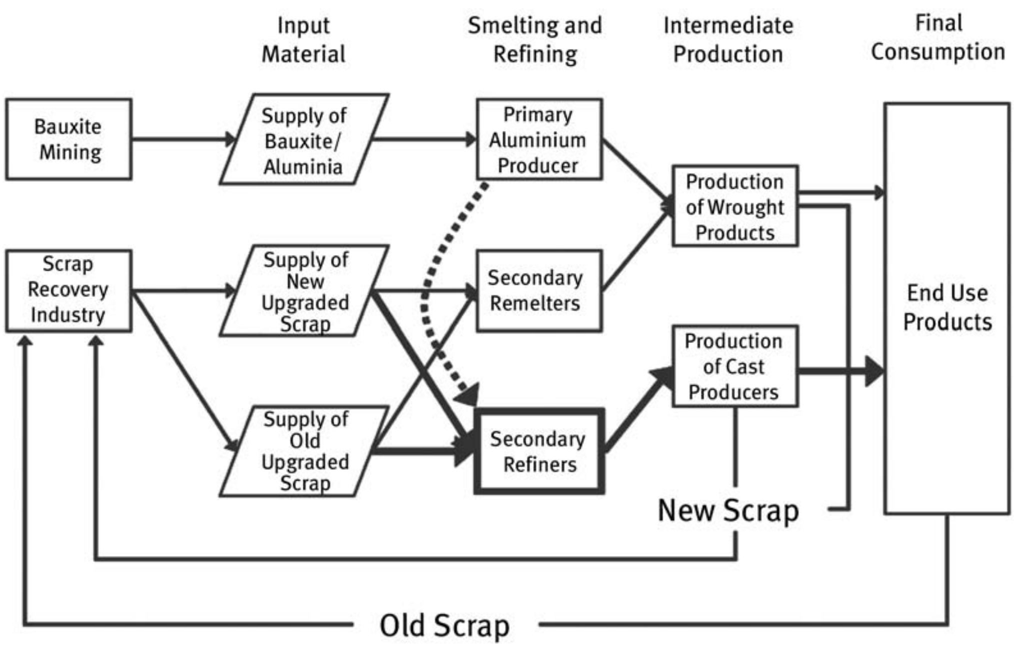
Effects on the market for construction materials: the case of Aluminium

Data on the evolution of construction materials in Europe is particularly difficult to gather due to confidentiality issues and to the lack of information unified by Eurostat. We use data from the Unites States Department of Energy in order to understand the evolution of the construction materials market. Also, we based our analysis on aluminium for Building and Construction (data provided by ALCOA) as a proxy for the evolution of construction materials in buildings. These data, however, do not specify whether aluminium is used for windows, tiles or doors among other possibilities.

The aluminium production process is relevant for this study given that it may involve large uses of energy and emission of GHGs (see Chart 40). While production from raw material (bauxite) clearly involves an intensive use of energy and GHG emissions, aluminium can also be produced from scrap materials, that is to say, through recycling, a process that involves lower use of energy and fewer emissions (Westenbarger et al. 1991; Blomberg & Hellmer 2000).

In fact, a Life Cycle approach that defines minimum requirements for construction materials will probably affect aluminium as a product in two ways: through the environmental impact of aluminium production processes and through the energy efficiency of aluminium construction materials. The first issue would be, then, to understand the current production techniques and the evolution of production processes in the industry. Below, we see a Chart developed by Blomberg & Hellmer (2000) depicting the aluminium production process.

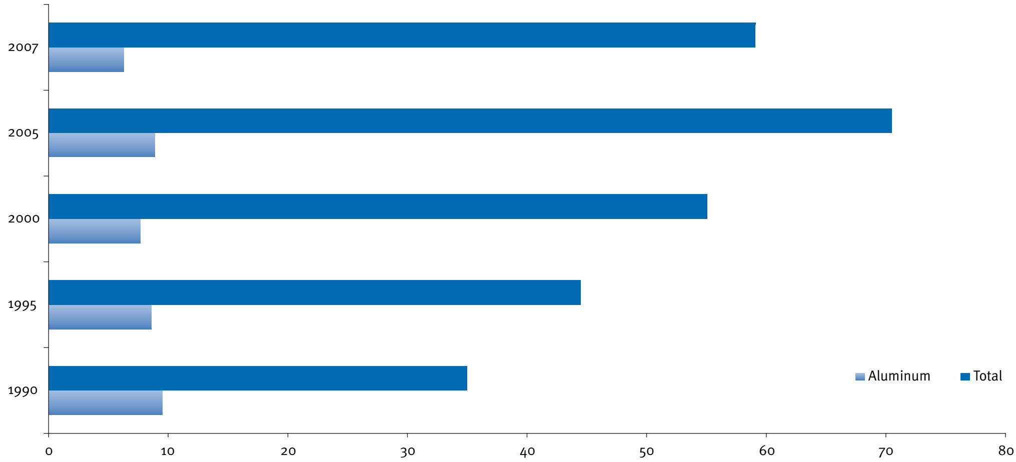
Chart 40. The Life Cycle of Aluminium



Source: the Aluminum Association

The evolution of the demand of aluminium construction materials in the US shows that Aluminium window sales have been decreasing since 1990 both in total units sold and as a proportion of the total windows sold in the market (see Chart 41).

Chart 41. Aluminium share of Construction Materials in the US



Source: USDOE 2009 - authors' own elaboration

As we see in Table 4, aluminium windows demand decreased both for new residential projects and for existing (remodelling) projects. Aluminium windows sales drop almost 35% from 1990 to 2007, and the drop in economic activity seems not to be especially damaging to this product in comparison to its substitutes. Aluminium windows sales for remodelling projects drop in a higher proportion than for new projects.

Table 4. Evolution of the Demand of Doors & Windows in the US

Residential Prime Window Sales, by Type (Million Units) (1)

New Const.	Aluminum (2)	% Al	Wood (3)	% Wood	Vinyl	% Vinyl	Other	% Oth	Total (4)
1990	5,90	35,54%	9,40	56,63%	1,20	7,23%	0,10	0,60%	16,60
1995	4,70	21,96%	11,60	54,21%	4,80	22,43%	0,30	1,40%	21,40
2000	3,70	14,32%	12,77	49,42%	8,97	34,71%	0,40	1,55%	25,84
2005	6,50	19,06%	9,20	26,98%	17,40	51,03%	1,00	2,93%	34,10
2007	4,40	17,74%	6,20	25,00%	13,20	53,23%	1,00	4,03%	24,80

Remodelling	Aluminum (2)	% Al	Wood (3)	% Wood	Vinyl	% Vinyl	Other	% Oth	Total (4)
1990	3,60	19,57%	7,60	41,30%	7,10	38,59%	0,10	0,54%	18,40
1995	3,90	16,88%	9,40	40,69%	9,60	41,56%	0,20	0,87%	23,10
2000	4,00	13,70%	10,20	34,93%	14,80	50,68%	0,20	0,68%	29,20
2005	2,40	6,59%	10,00	27,47%	23,20	63,74%	0,90	2,47%	36,40
2007	1,90	5,54%	8,90	25,95%	22,50	65,60%	1,00	2,92%	34,30

Total Const.	Aluminum (2)	% Al	Wood (3)	% Wood	Vinyl	% Vinyl	Other	% Oth	Total
1990	9,50	27,14%	17,00	48,57%	8,30	23,71%	0,20	0,57%	35,00
1995	8,60	19,33%	21,00	47,19%	14,40	32,36%	0,50	1,12%	44,50
2000	7,70	13,99%	22,97	41,73%	23,77	43,19%	0,60	1,09%	55,04
2005	8,90	12,62%	19,20	27,23%	40,60	57,59%	1,90	2,70%	70,50
2007	6,30	10,66%	15,10	25,55%	35,70	60,41%	2,00	3,38%	59,10

Source: USDOE 2009 - AAMA, Industry Statistical Review and Forecast 1992, 1993 for Note 2; AAMA/NWWDA, Industry Statistical Review and Forecast 1996, 1997, Table 6, p. 6 for 1990; AAMA/WDMA, 2000 AAMA/WDMA Industry Statistical Review and Forecast, Feb. 2001, p. 6 for 1995; 2003 AAMA/WDMA Industry Statistical Review and Forecast, June 2004, p. 6 for 2000 and 2003; and LBNL, Savings from Energy Efficient Windows, Apr. 1993, p. 6 for window life span; AAMA/WDMA, Study of U.S. Market For Windows, Doors, and Skylights, Apr. 2006, p. 41 for 2005.; AAMA/WDMA. U.S. Industry Statistical Review and Forecast Mar. 2008, p. 6 for 2007.Notes: 1) Average window life span is 35-45 years. 2) In 1993, 65% of aluminium-framed windows were thermally broken. 3) Includes vinyl-clad and metal-clad units. 4) Due to rounding, sums may not add up to totals.

There are two relevant questions regarding aluminium as a construction material. The first, how has it evolved in European countries that are pioneers in the implementation of the National Action Plan, such as the United Kingdom, The Netherlands or Germany? Is the evolution of aluminium as a construction material explained by the changes in regulation? Are they driven by the willingness to pay for greener products?

Conclusions

We focus our present study on the European Performance of Buildings Directive and on its potential effects on incentives for consumers and producers across Europe. Several aspects have been mentioned as suitable of study, such as, the effect of current incentives on GHG emissions by buildings, or the incentives towards the use of different construction materials.

A further aspect of this directive is that of the notion of “near zero buildings”. As expected, the new directive did not ultimately aimed towards a “net zero” criterion for EU MS, both for procurement and private buildings. Instead, the Directive leaves the definition of what constitutes a “near zero building” open for MS: they are to set these standards on the National Action Plans.

What will ultimately be the definitions of LCA and Near Zero Buildings set by the National Action Plans derived from the new EPBD? There remains some uncertainty about this. The issue lies on how much pressure do MS feel regarding this subject. That is to say, if the target for reduction in GHG emissions if perceived to be too distant and sanctions are to be implemented if a MS does not comply with the targets, then, MS will consider very strict action plans.

4. A review of National Energy Efficiency Action Plans of seven European countries

Introduction

The Energy Performance Building Directive (Directive 2002/91/EC) introduced the compulsory energy certification of buildings in the EU from 2006 and it has played a key role in the common policy to monitor and reduce energy consumption. The Energy Performance of Buildings Directive recast in 2010 sets the stage for Member States to determine the criteria for energy efficiency in buildings. In order to assess the experience gained in this field in Europe overall, and in particular against the highly diverse settings of the different European nations, this paper examines the extent to which the Directive has been implemented by seven EU Member States: The Netherlands, the United Kingdom, France, Germany, Spain, Portugal and Italy.

In this sense, National Energy Efficiency Action Plans (NEEAPs) are under review regarding the specific criteria for the implementation of the new EPBD.

A first step, then, would be to study the existing National Action Plans and their intended effects on the market for buildings (demand, prince, and so on), on energy efficiency and on carbon emissions.

Our research group has surveyed several NEEAP authorities from different countries in order to assess the state of implementation and to look for data regarding this implementation. There are several levels of implementation that interest us. First, are countries' NEEAPs advancing at the same rate? Second, are Energy Performance Certificates (EPCs) equally deployed on every European country? Third, are there common provisions for Green Public Procurement?

As we will see in this chapter, there is a lot of variation across countries in regard to the level and scope of implementation of their NEEAPs. For example, penetration of the EPCs varies greatly across countries (see Charts 42 and 43). According to the European Commission's 'Handbook on Environmental Public Procurement' (European Commission, 2004), the right to specify materials or the content of a product in public tendering also includes the right to demand a minimum percentage of recycled or reused content where possible. In its Green Public Procurement Training Toolkit (EC, 2008), the Commission also recommends that:

- At least 5 % of construction material should derive from recycled or re-used content.

- Recycled material must be accompanied by test documents indicating that they contain no hazardous substances.

Seven cases: England, Germany, The Netherlands, Spain, Portugal, France and Italy

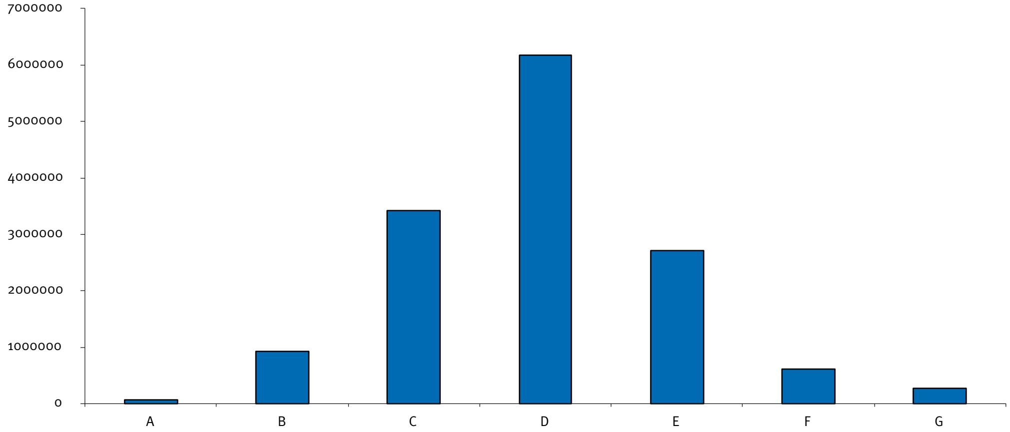
Some countries in Europe were pioneers in the implementation of energy efficiency in Buildings. As usual, countries like England, Germany, The Netherlands and France were among the first to implement some kind of energy performance certificates for buildings. These experiences can shed light into the effects of demand-oriented labels for energy efficiency on the market for buildings.

However, a first obstacle is that while enacting the new regulation the studied countries did not converge in terms of standards. For instance, both the criteria for energy efficiency (classes) and the ranges comprised on the different categories would be different. Furthermore, the type of label used is not the same in all countries. Hence, it will be interesting to understand the chronology, the criteria, the ranges and the effects of these policies on the market for buildings and on energy efficiency.

Also, this analysis will help us map the potential effects of these policies in the markets for buildings and construction materials: countries where the EPBD has been adopted faster and with a more comprehensive style will probably show more significant effects on the sales and rent of dwellings and offices and, hence, on the decision to use different construction materials.

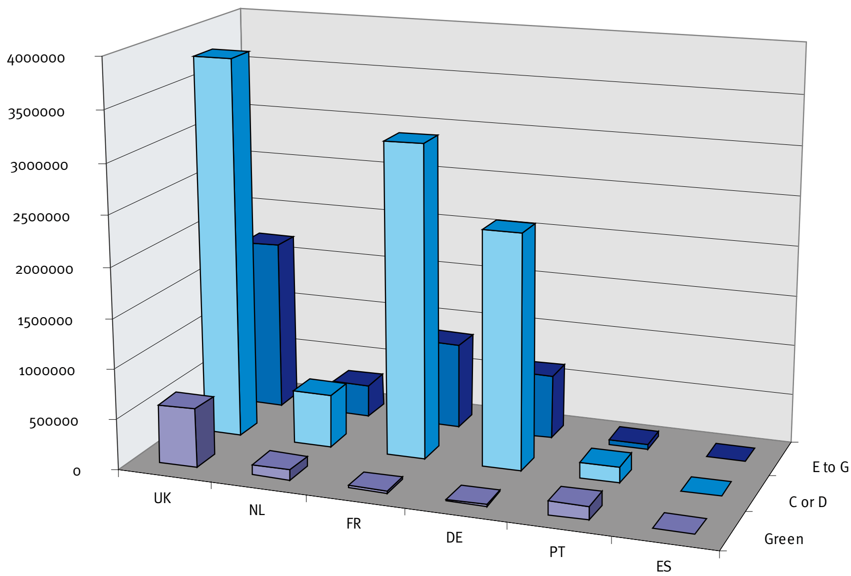
Our analysis will comprise two sets of issues: "velocity of adoption" and "convergence in regulations". The first issue: velocity of adoption will reveal the differences on timing by different EU MS. On the second issue, we will evaluate the capacity for convergence of the different EU MS regardless of the initial velocity of adoption.

Chart 42. EPC Label distribution estimates for 2010 for the seven countries



Source: authors' own elaboration based on available aggregated data

Chart 43. Distribution of EPC grades by country (2010)



Source: authors' own elaboration based on available aggregated data

Velocity of adoption

We can set apart European Member States in three different groups in terms of velocity of adoption: Pioneers, Early Adopters and Laggards (see Table 5).

The "Pioneer" group comprises those countries with a longer history in terms of sustainability regulation and which have led the way in terms of implementing the original European Performance of Buildings Directive. These countries will probably have adopted labels, minimum requirements and targets earlier than its counterparts. Our analysis determines that the United Kingdom (through its NEEAP for England and Wales), Germany and The Netherlands are the Pioneers of our group.

"Early adopters" are those countries that fall short in one of the categories mentioned, but which despite not being the first in the implementation, have also set early standards on labels, minimum requirements and targets. In our sample, France and Portugal are "early adopters".

Finally, the "Laggards" are those countries that historically have been behind in terms of NEEAP implementation in all fronts. We consider the clear examples of Spain and Italy.

Table 5. Velocity of adoption of EPBD

	PIONEERS			EARLY ADOPTERS		LAGGARDS	
Country	England (UK)	Germany	The Netherlands	France	Portugal	Spain	Italy
HISTORY	SAP required since 2005	Voluntary certif. in 1982. For new bldgs. since 1995	Voluntary Novem certificate registry in 1990s	LHI 1980 HPE 1983	No previous experience.	No previous experience	No previous experience
EPBD (2006)	NEEAP 2006	NEEAP 2002 NEEAP 2007	NEEAP 12/2006	NEEAP 7/2005	NEEAP 4/2006	NEEAP 1/2007	NEEAP 2005
EPBD RECAST (2010)	2011	2012	RECAST 3/2011	2012	2012	RECAST 9/2011 (?)	???
EPC labels (mandatory)	New 1/2008 Stock 10/2008	New sales 1/2008 Public 1/2009	New 7/2007 All 1/2009	New 9/2006 Stock 7/2007 Public 1/2008	New 2002. Stock 2007.	New 10/2007 Stock 9/2011	Large 7/2007 All 7/2009

Convergence in regulations

Besides the rapid or slow adoption of the EPBD on their NEEAPs, countries are also different in regards to their capacity to converge in terms of regulation (see Table 6). Here we can divide countries in terms of Convergent, Chronic or Non-convergent categories.

Table 6. Convergence of NEEAPs to the EPBD

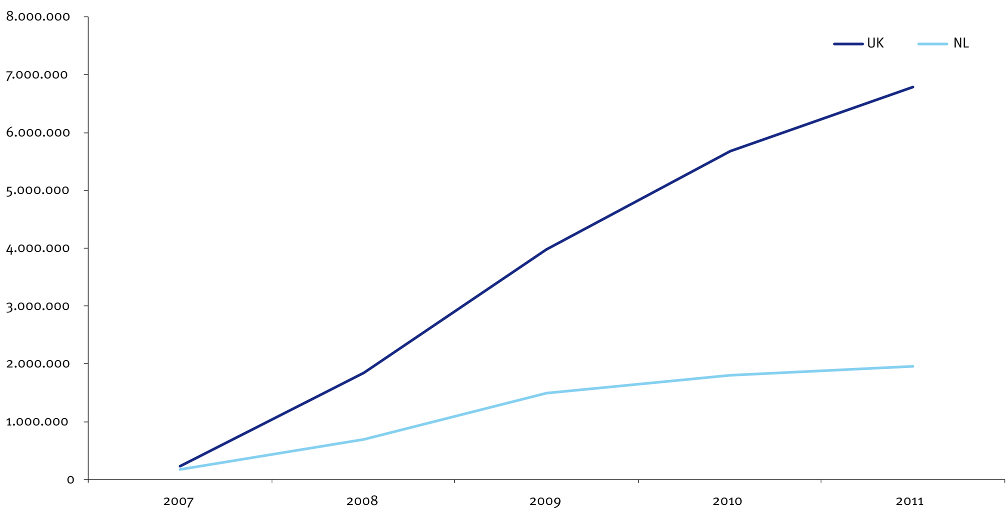
	CONVERGENT			CHRONIC		NON-CONVERGENT	
COUNTRY	England (UK)	The Netherlands	Portugal	France	Germany	Spain	Italy
EPC labels (#)	6.105.931	1.287.000 20% of private	347.2440	4.000.000 (est.) 14% of private	1.800.000 (est.) 30% of private	2.800	??
EPC label type	From A to G Both CO_2 and kWh/ m2/y	From A++ to G Both CO_2 and kWh/ m2/y	Form A+ to G Including only kWh/ m2/y	From A to G Both CO_2 and kWh/ m2/y	Sliding Including only kWh/ m2/y	From A to G Including only kWh/ m2/y	??
EPC Waiver	No	Yes	No	No	No	No, but "fast track"	??
EPC national register	Yes	Yes	Yes	No	No	Yes, but only works by region	??
GPP & EPCs	70% of Public (DECs)	60% of Public	90% of Public Buildings with EPC.	90% of Public Buildings with EPC.	87% of Social Housing with EPC		??
GPP recycled materials (public tenders)	10% of all material value should be recycled	5% of all material value should be recycled	No	No	No	Possible addition of a technical req.	??
Refurbishment	Yes	Yes	Few	Few	No	No national requirement. 4.1% of all Public (Estate)	??
Minimum requirements	Few	Few	No	No	No	No	??
Targets (reduction)	9% savings	9% savings 2%/y intensity	10% savings	9% savings 2.5% /y intensity	9% savings 3%/y intensity	9% savings	9% savings

Convergent MSs are those whose NEEAPs are adapting quickly to the EPBD recast and which seem to take into account a common European goal regardless of the energy efficiency regulation history in that particular country. In this group, we find the UK, The Netherlands and Portugal.

Chronic countries are those that seem too committed to previous/existing regulation to implement a convergent NEEAP. Two examples are France and Germany, countries with a long history of energy efficiency regulation that have been unable to, for example, instrument a national registry for Energy Performance Certificates.

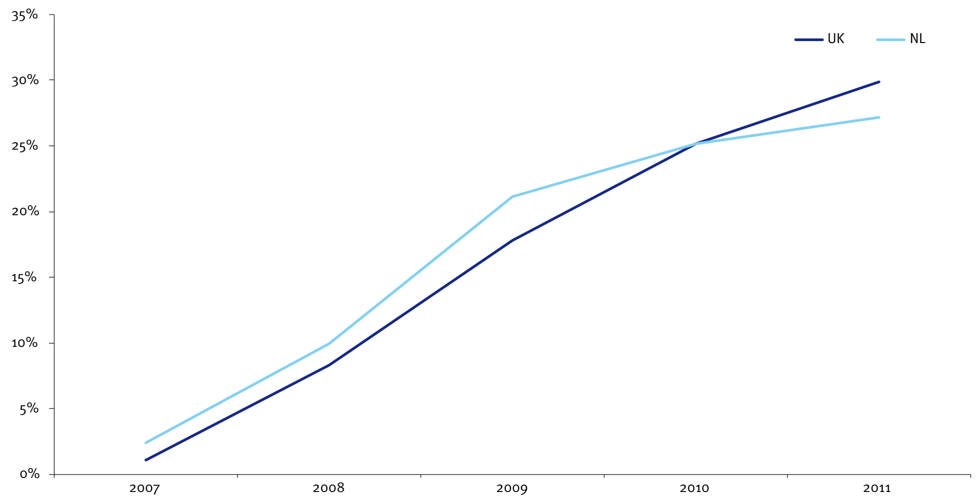
Non-convergent Member States are those that, despite having in force a NEEAP have been unable to coordinate its implementation at a national level. Both Spain and Italy have failed on this regard, leaving the implementation of the EPBD to the different regions or autonomies. Hence, these countries are further away from the convergence goal.

Chart 44. Issued EPCs in England and The Netherlands



Source: authors' own elaboration

Chart 45. EPC Intensity in England and The Netherlands



Source: authors' own elaboration

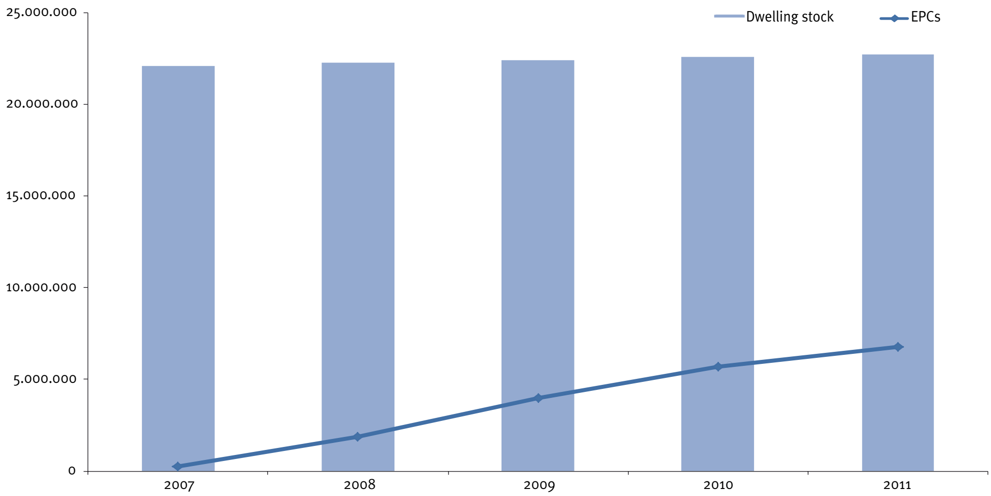
The only two countries that provide enough significant data about EPC evolution (for residential dwellings) are the United Kingdom (for England and Wales) and The Netherlands.

Chart 44 shows the outstanding stock of energy performance certificates in each country since 2007. As we see, the stock of EPCs in England is significantly larger than in The Netherlands. We could interpret this result as an indication of the effort that the Department of Energy and Climate Change is devoting to this purpose in England & Wales.

However, another possible explanation is related to the fact that although EPCs in England and Wales and The Netherlands were mandatory since 2007 (depending on the type of dwelling) for rent or sale transactions, in the later country, the public could ask for a waiver of the EPC requirement.

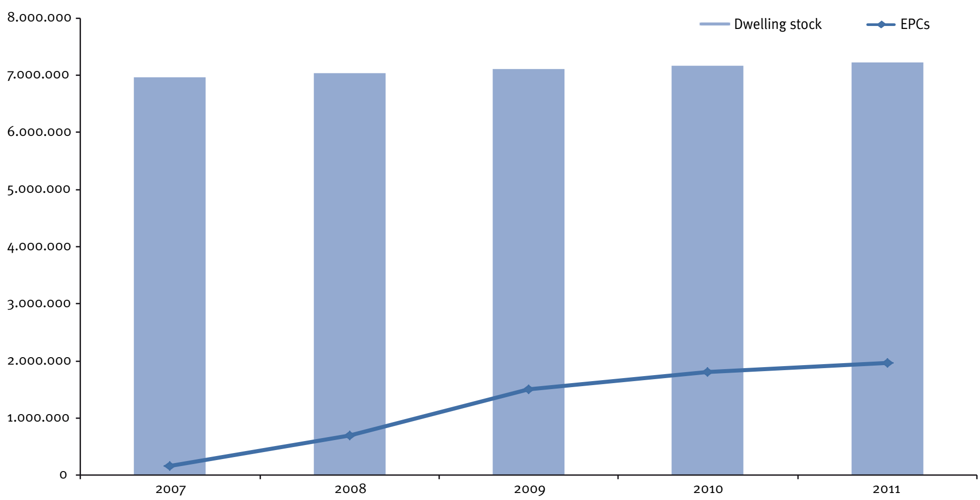
We also can show the data in terms of "intensity" of adoption of the EPCs, that is to say, the outstanding stock of EPCs per existing dwelling (see Chart 45). Here, the UK is also in a better position than The Netherlands. However, the gap between both is narrowing down.

Chart 46. EPC Intensity in England



Source: authors' own elaboration based on available aggregated data on Communities

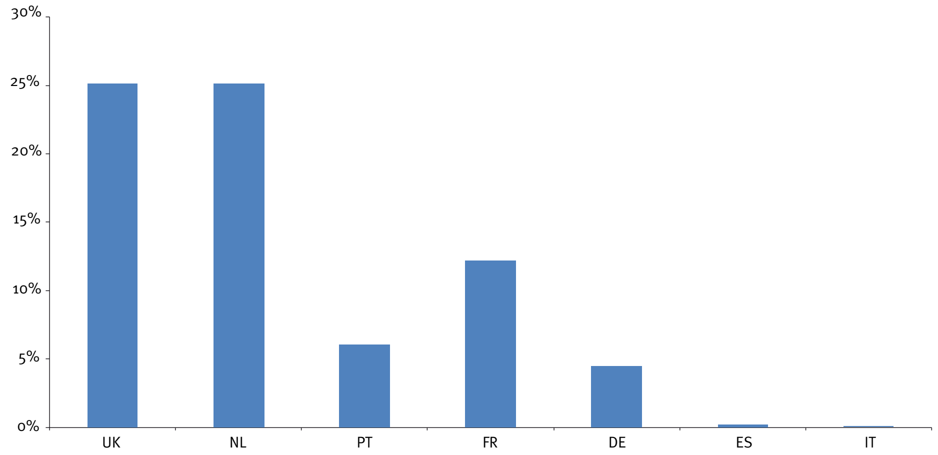
Chart 47. EPC Intensity in The Netherlands



Source: authors' own elaboration based on available aggregated data on SenterNovem

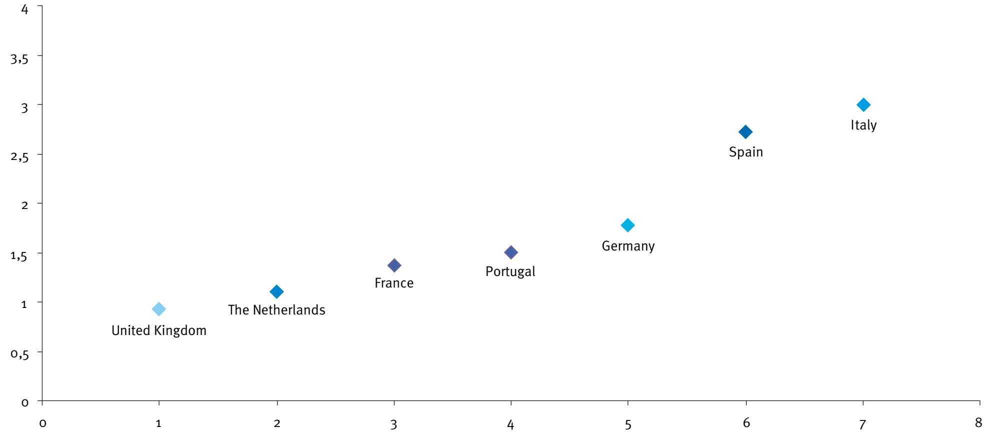
Charts 46 and 47 show the relative evolution of the dwelling stock and the issuance of EPCs in the UK and The Netherlands.

Chart 48. EPC intensity in the seven selected countries



Source: Author's own elaboration .

Chart 49. Convergence ranking of the seven selected countries



Source: authors' own elaboration based on available aggregated data. As we move right along the X-axis, countries are farther away from EPBD convergence; as we move up along the y-axis, velocity of convergence is lower

Chart 49 shows a classification of the seven countries in terms of their performance with respect to the EPBD. We assess how each country has fared on several aspects such as energy efficiency track record, whether it has implemented the EPBD recast at a national level, the number of EPCs issued, the "Intensity" of EPCs, the type of label chosen, whether it has a national register or not, whether it has implemented requirements for recycled materials or for public tenders, etc. Details on these different aspects follow.

Specific information about each of the analysed MS

Following our comparative analysis, we describe certain key aspects of NEEAP implementation in the analyzed countries.

England & Wales

In the United Kingdom, NEEAP control is under the responsibility of the Department of Energy and Climate Change (www.decc.gov.uk). This entity proposes legislation over energy efficiency and Green Public Procurement. However this Government Department is only responsible for implementing the EU Directive in England and Wales. Northern Ireland and Scotland have their own separate arrangements.

A first issue regarding the NEEAP is the availability of EPC labels. England & Wales have mandatory EPC labels since 2006 for every real estate transaction. This duty has evolved in order to comprise almost all the real estate assets in these countries.

In this sense, all buildings in England and Wales are required to have an EPC when constructed sold or rented. The EPC is valid for ten years unless it has been replaced by a newer EPC.

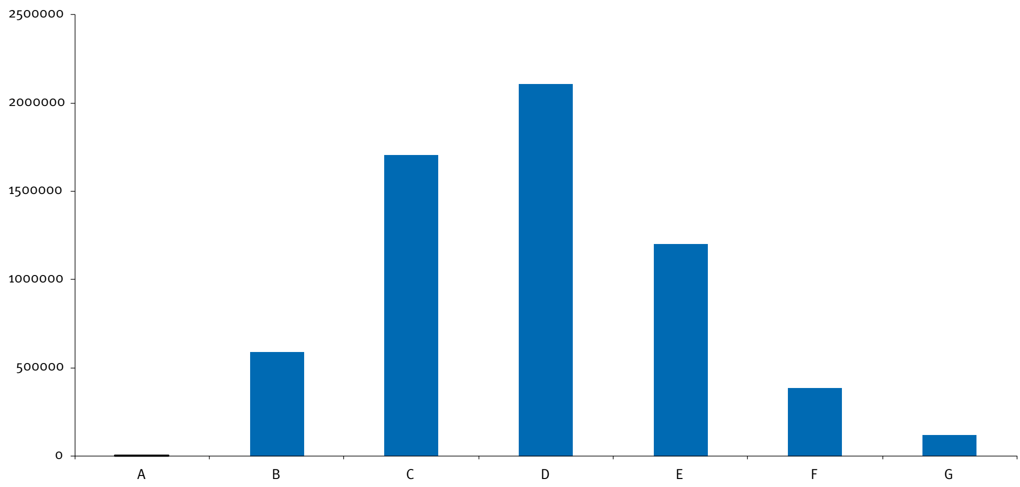
The only buildings, which are exempt under the Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations (EPB Regulations), which implement the EU Directive, are:

- Buildings that are primarily or solely places of worship.
- Temporary buildings which will be used for two years or less, industrial sites,
- Workshops and non-residential agricultural buildings with low energy demand,
- Standalone buildings with a total useful floor area of less than 50m2 which are not
- Dwellings, and buildings to be demolished (subject to the seller being able to demonstrate the building is suitable for demolition.

However, there is no central database of real estate properties, which records the prices of properties. All EPCs, which have been produced, are lodged on a central EPC Register. The Register Operator manages the Register on behalf of the Communities Department. While the Register contains details of all EPCs which have been produced (see Chart 50), it does not have any information on property prices or how the EPC has affected the price of the property. This information is not recorded as part of the assessment process that produces the EPC and is not held on the Register.

Access to EPC information on the central EPC Register data is restricted and can only be disclosed to authorized persons under the EPB Regulations and the Government Department (Communities) to share information that will identify an individual building, although it can provide anonymous and aggregated data provided no building can be identified from the document or data disclosed.

Chart 50. EPC Labels in the UK



Source: Communities Department

Another important issue on the EPBD is related to Government purchases. In this case, Green Public Procurement would entail that government officials set minimum standards in public tenders for the use of "green" materials, such as recycled, for new and refurbished properties.

Hence, in 2003, the Government's Sustainable Procurement Group recommended setting requirements for recycled content in public procurement of construction projects, and WRAP and the Office of Government Commerce (OGC) subsequently formulated the following requirement: "10% of the materials value of a construction project (>£500k) should derive from recycled content."

Department for Trade and Industry (DTI) data show that central government departments and executive agencies spent £2.3 billion on large-scale construction and refurbishment projects in 2005-06. Refurbishment accounted for 60 per cent of this expenditure (£1.35 billion) whilst construction accounted for 40 per cent (£0.92 billion).

However, as the DTI data do not include projects costing less than £2 million, we estimate that departments and agencies spent in the region of £2.8 billion on projects in 2005-06 (of which major refurbishment projects comprised £1.5 billion and construction projects £1.3 billion) Materials production and transport make up 44% of all construction related emissions, while 72% of a building's life cycle carbon is embedded into the physical asset.

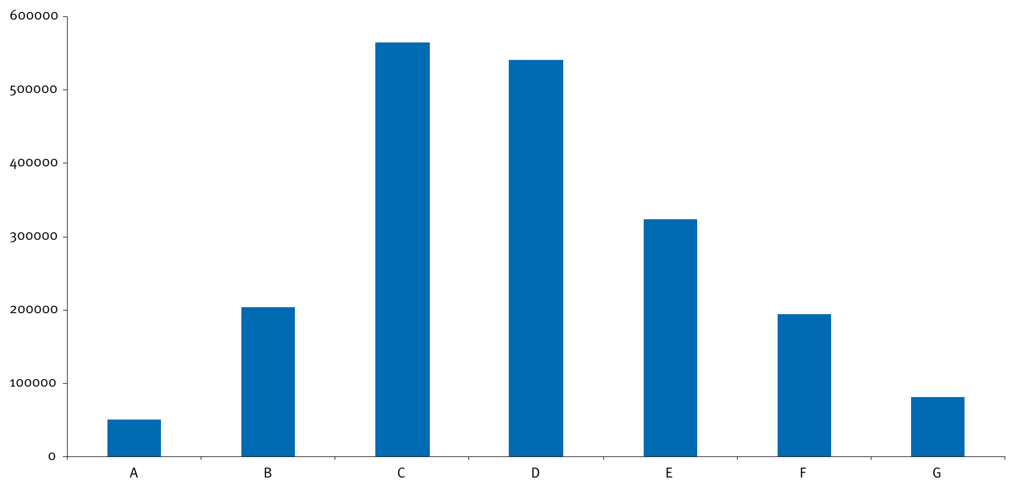
The Netherlands

One of the pioneers in the European Union, The Netherlands is one of the most advanced countries in terms of EPBD recast implementation.

For instance, the Energy Performance Certificate requirements are being reinforced: the minimum level ratings are being raised in order for dwellings to be more energy efficient if they want to receive a green rating.

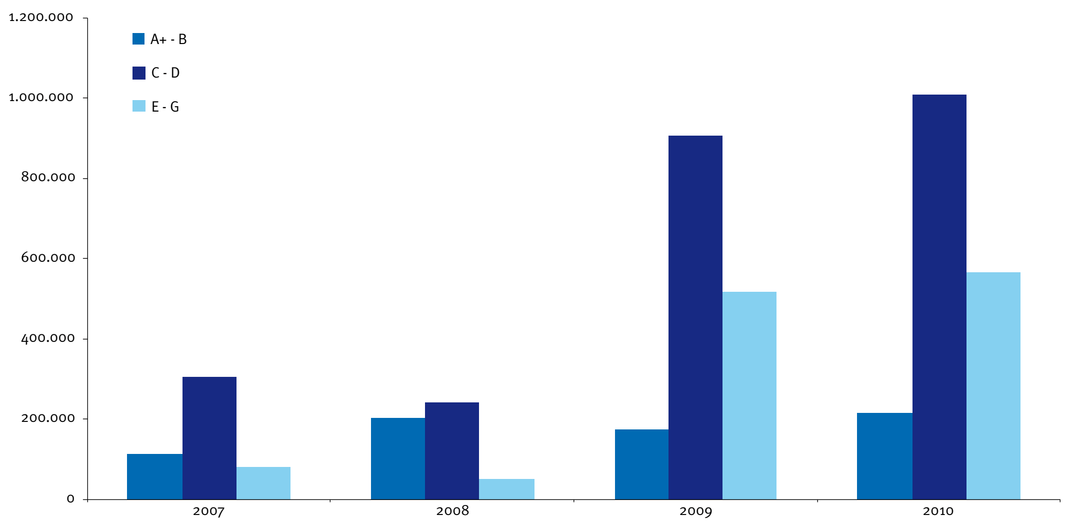
In terms of EPCs, The Netherlands uses a mandatory EPC for all sale or rent transactions. However there exists the possibility of applying for a waiver. In spite of the existence of a waiver the relative amount of EPCs issued is similar to that in the UK (see Chart 51). The EPDB recast will eliminate de waiver. The evolution of the EPCs by category in The Netherlands can be seen in Chart 52.

Chart 51. EPC Labels in The Netherlands



Source: SenterNovem

Chart 52. Evolution of EPCs by Category in The Netherlands



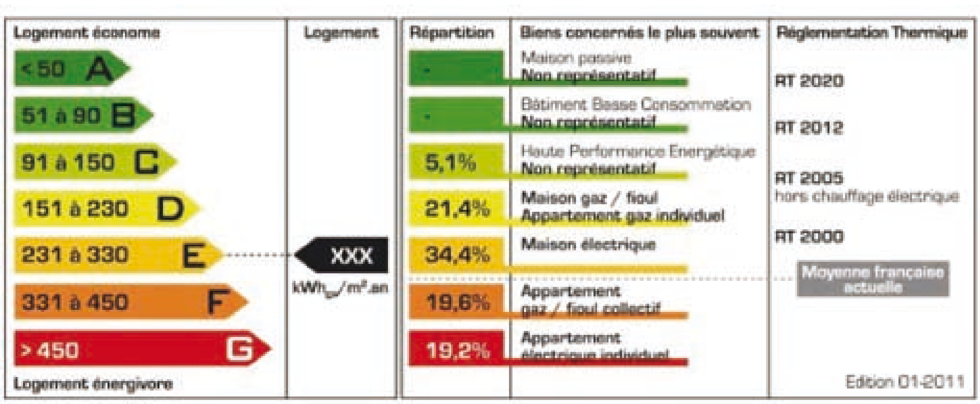
Source: SenterNovem

France

The French Energy Performance Certificate (Diagnostic de Performance Energetique -DPE-, see Table 7) is mandatory for sales of existing real estate since November 1st 2006 and for new dwellings with a building permit issued later than July 1st, 2007, for both rent and purchase.

Since this regulation came into force, non-official registers establish that more than four million DPEs have been issued (see Chart 53). Although this would make a very interesting database, there is no official register at the national level that would allow a more complete analysis of the current overall dwelling situation in France.

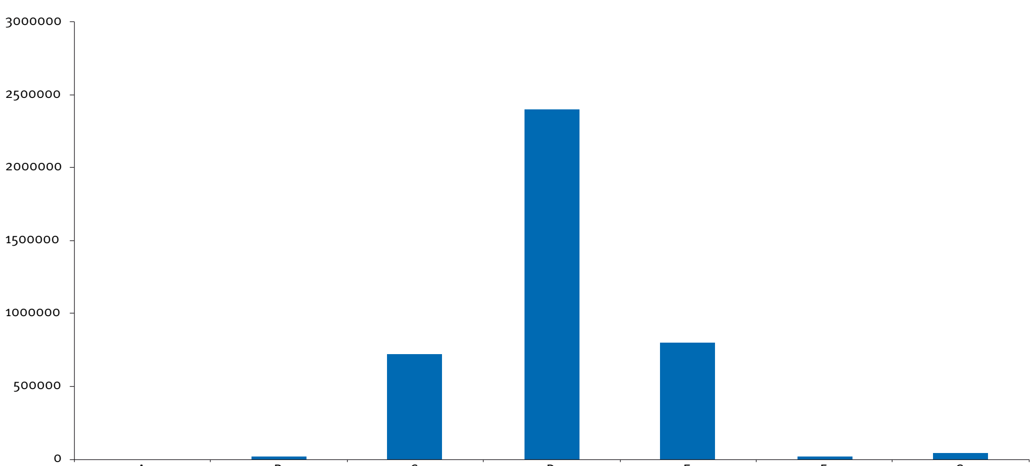
Table 7. DPE sample



Source: Plan Grenelle

However, there are some departmental registers that allow us to see how DPEs are aggregated in terms of categories. Also, some regional organizations have conducted surveys on the national dwelling stock in order to assess the distribution of EPC labels. For instance, the group "De Particulier à Particulier" has conducted a random survey on near 450 dwelling on the Paris area. This sample comprised 69% of apartments and 31% of houses. The following Chart summarizes some of the results of a survey conducted by the "L'Union Sociale pour l'habitat de L'Ile-de-France".

Chart 53. EPC Labels in France



Source: Survey conducted by L'Union Sociale pour l'habitage de L'Ille de France

As we can see, no dwelling on the sample was issued either an A or B category, and very few received a C category. This entails that most of the dwelling stock could be improved in terms of energy efficiency.

The company LocService conducted another survey on 9000 French dwellings. Of theses, 70% of the dwellings belonged to the C to E range; 16.5% were either F or G (the lower categories) and only 10% were either A or B. This results fall in line with the previous conclusion.

Finally, the legislation also establishes that public buildings of more than 1000 m2 need to present a DPE. In terms of Green Public Procurement, it is not one of the most advanced measures given that it does not set a goal in terms of kWh/y per square meter nor a goal for the reduction of energy use per dwelling.

Germany

About 40% of energy consumption in Germany is attributable to buildings. Of a total of approximately 18 million existing residential buildings, approximately 75% built before 1979 as the energy standards were still comparatively low.

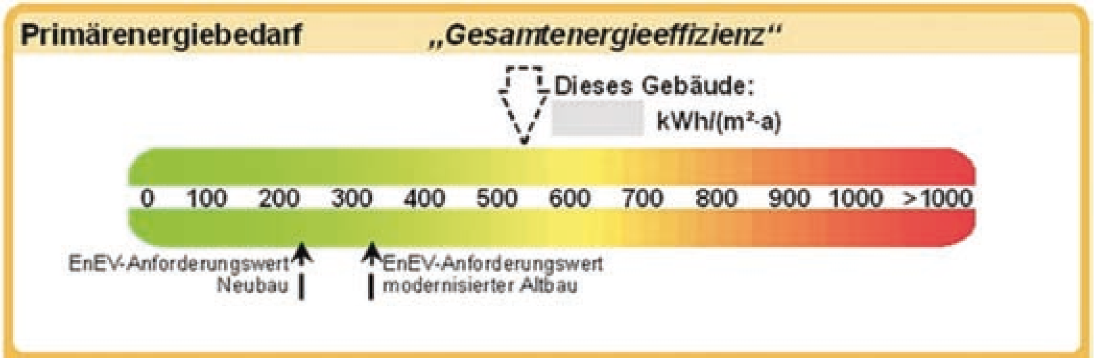
Energy savings potential for the 1.5 million non-residential building is very high. The energy certificate's (*Energiausweiss*, see Table 8) aim is to identify the potential savings in buildings and use and to inform consumers.

On or after the 1st of July 2008, the German Energy Savings Act requires that an energy performance certificate must be made available when selling, renting or leasing a residential building built in 1965 or earlier.

Furthermore, the energy performance certificate is compulsory for newer residential buildings from the 1st of January 2009 and for non-residential buildings from the 1st of July 2009. Since 2002, the energy performance certificate has been compulsory for new buildings and buildings that have been refurbished in a comprehensive way.

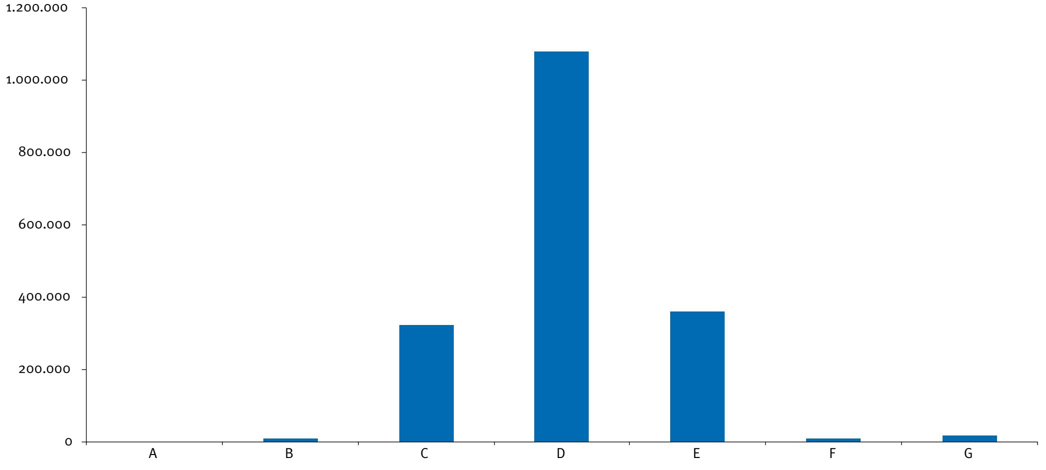
DENA, the German environmental agency, has built up a database in order to keep track of a certain amount of energy certificates and for analyses purposes. However, it is voluntary to upload the issued certificates. The database therefore does not keep track of all created certificates. Although, there might be other databases in Germany as well, there does not exist an official register for certificates that allows deeper analysis.

Table 8. EPC Labels in Germany



Source: energieausweiss EnEv

Chart 54. EPC Labels in Germany



Source: energieausweiss EnEv

Spain

Spain is one of the countries in the EU15 that presents a relative delay in implementation of the EPBD. The "Instituto de Ahorro y Enérgetico" (IDAE) is in charge of proposing legislation and controlling the NEEAP. This entity depends of the "Secretaría de Estado de Energía" from the "Ministerio de Industria, Turismo y Comercio".

This relative delay comprises both the quantitative and the qualitative aspects of the EPBD that we are studying. That is to say, Spain is relatively behind EU15 both in the implementation of Energy Performance Labels and minimum requirements for Green Public Procurement both in terms of the letter of the law and in terms of the implementation of what the law states. The fact that the economic recession in Spain is deeply linked to the drop in construction activity and a huge stock of vacant new dwellings worsens this “delay”.

Although there exists an agreement of the Ministers Board (“Acuerdo del Consejo de Ministros”) of 2006 establishing that new public building projects should include in the tenders technical characteristics aimed to increase energy efficiency of the building, in terms of Green Public Procurement, there are no national or regional (autonomies) requirements for “green” or “recycled” construction materials on public tenders. However, city governments appear to be implementing a point system that values the use of these materials and/or the availability of a label (for materials or buildings).

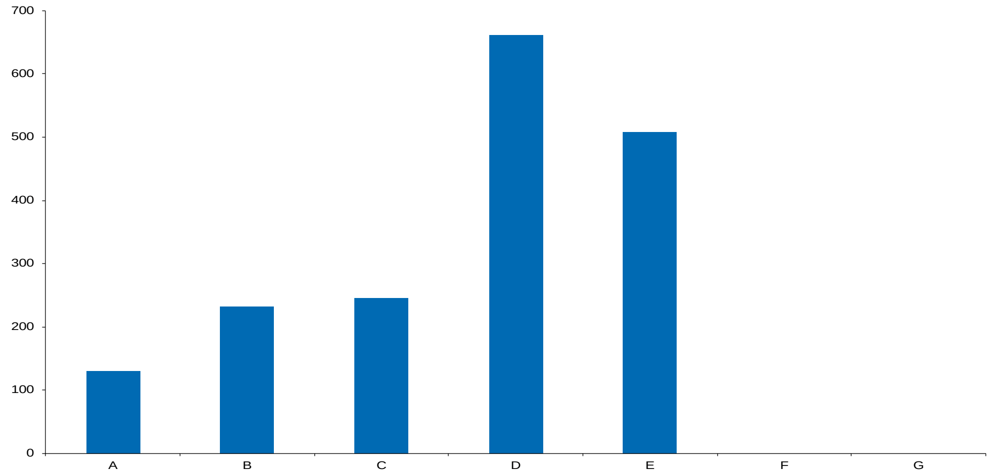
The other two key aspects of Spain’s NEEAP are the following: how mandatory are EPC labels and who is in charge of controlling and monitoring the implementation. In the case of Spain, both are deeply related.

For instance, EPC labels are mandatory for every new building. Hence, a first problem is related to the unit of study: buildings, not dwellings. The incentives to users of each dwelling to improve their habitat in terms of energy efficiency will be lower among other things because of free-riding problems.

However, the issuance and monitoring of labels is delegated to the regional governments. That is to say, each region decides the timing and harshness of the legislation. The basic problem is that implementation through Spain is not even: Cataluña is the most advanced region in terms of labels, but it only has issued near 2,000 labels (see Chart 55). Even worse, many (how many) of these labels enter into the “immediate” issuance category. In Cataluña, there are two categories of labels: “full” study and “immediate” study.

The first one comprises a thorough analysis of the energy efficiency of the building. This analysis takes a few weeks and will result in the exact rating for the building, as is done in most EU15 countries. The later is a bureaucratic mechanism that allows a building to comply with the law (get an EPC), which will reflect the lower possible rating for a new building (“D”). This mechanism saves time to the constructors allowing him to sell the building. However, once again, the real value of the EPC label cannot be determined.

Chart 55. EPC Labels in Spain (Cataluña)



Source: ICAEN

A new decree, incorporating the EPBD recast to the Spain's NEEAP was enacted in September 2011. However, this EPBD recast has not made any considerable advances regarding the implementation of minimum requirements, mandatory EPC labels for existing dwellings, improving the register of EPC labels for new dwellings or setting recycled materials requirements for green public procurement.

Portugal

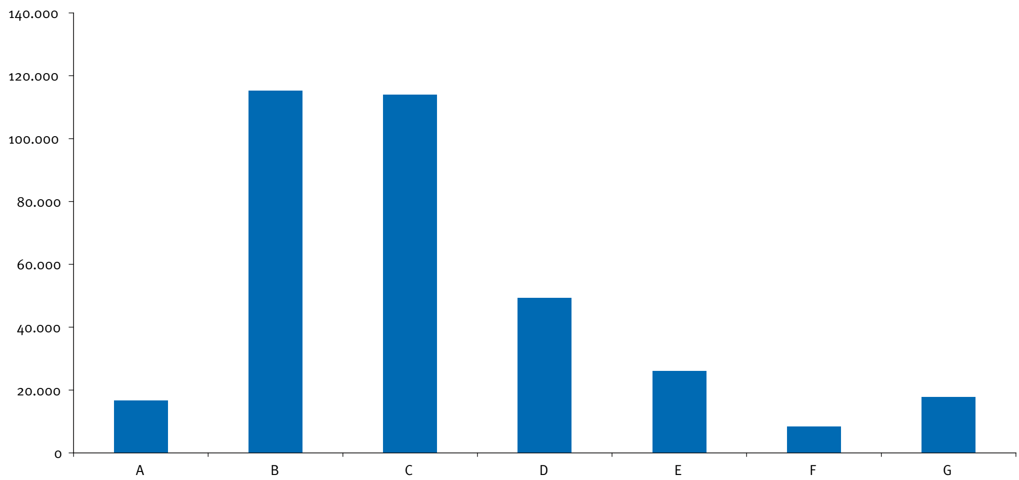
Surprisingly, Portugal is one of the most convergent southern countries in terms of EPBD enforcement. A national certificate registry is in place and information is available publicly.

Also, although the level of adoption of EPCs when compared to the existing dwelling stock is low (see Chart 56), it has been increasing constantly in the last two years. Furthermore, EPCs are distributed along all the Portuguese territory.

Although it does not appear to be a relevant quality factor for buyers or renters (real estate agents do not advertise EPCs, for instance) we expect convergence to occur during 2012.

Finally, the NEEAP responding to the recast is still under debate and analysis by the Portuguese administration. Although the exact measures were not disclosed, an interview with government officials indicated the new NEEAP will include provisions for recycled materials in public tenders, and minimum requirements for existing dwellings.

Chart 56. EPC labels in Portugal



Source: ADENE 2011

Italy

Very little information exists at the national level about the National Energy Efficiency Action Plan in Italy. The NEEAP for Italy is behind in many of the measurements for convergence. Italy not only does not set minimum requirements or establishes provisions for Green Public Procurement. Italy also does not offer enough incentives for Energy Performance Certificates issuance or registry, neither for new nor existing dwellings.

Furthermore, the level of enforcement of the NEEAP at the national and regional level is very small. For instance, no information exists about the energy efficiency of the existing dwelling stock. Finally, even though EPC issuance is enforced regionally (Province level), there is no data or estimates about the total number and the category distribution of EPCs.

The EU is aware of this situation and has asked the Italian Government to upgrade its efforts towards energy certification as well as other provisions on the European Performance of Buildings Directive.

Conclusions

Our National Energy Efficiency Action Plan analysis for the United Kingdom, The Netherlands, Spain, France, Germany, Portugal and Italy provides two interesting tools in order to measure the national efforts to comply with European mitigation regulation. These tools are combined into a Convergence Index that takes into account both the Velocity of adoption of EPBD rules at the National Level and the Convergence of these rules to the EPBD 2010 recast.

These tools show that there are three levels of countries in terms of Velocity of Adoption (Pioneers, Early Movers and Laggards) and other three levels in terms of Convergence to the EPBD (Convergent, Chronic and Non-Convergent).

Countries like the UK, The Netherlands or Portugal are important not only because they have advanced rapidly and are convergent, but also because they provide guidance and experience in terms of enforcement of regulation and on the effects of this regulation on the markets.

In fact, several studies have been conducted regarding the willingness to pay for green dwellings in The Netherlands and our research team conducted similar tests on the Greater London Area. Both studies, presented in Chapters 5 and 6, prove that consumers of dwellings value more energy efficient dwellings.

In a second group we find countries like France or Germany, which have a long history of Energy Efficiency regulation but which history proves to be an obstacle for convergence. In these sense, the national effort seems troubled by pre existing regional and local regulations. More convergence will definitely take place in the next years but it will demand intra convergence too, that is to say, regional and local regulation inside each country will have to be adapted towards a common, unique national regulation that follows the EPBD mandate.

In order to analyse how consumers behave in these countries, we conducted research on France in order to assess the willingness to pay for green dwellings. The results, presented in Chapter 6, were positive and interesting.

Even though the analysis in this chapter can be improved in many aspects as richer data become available, it provides an interesting map of the fields where different countries need to adjust in order to comply with the EPBD and with what other members of the EU are achieving.

Incentives towards convergence can be both positive and negative. Positive incentives are those related to achieving greater energy efficiency, reducing Greenhouse Gases emissions and creating new sources for employment, given the new markets that arise because of the regulation and the needs of the consumers.

Negative incentives will take the form of both sanctions from the EU Commission to the Member States and punishment by voters to national leaders that fail to guide a country into a desired direction: reducing emissions.

It is fair to say, then, that convergence will occur and that countries that lag in terms of policies (Spain, Italy, among others) will have to act rapidly to adjust their policies.

5. Willingness to pay for green dwellings, a meta analysis of the existent evidence

Introduction

This chapter summarizes the results of recent research on the willingness to pay for green buildings, measured by the response of properties' prices and rents to a "green" rating. Given the lack of available and proper data in most countries, a Meta analysis of the existing research can provide important information on the nature of demand and the effects of regulation in the market for buildings. Existing research suggests that buyers of homes are willing to pay more for "greener" properties and companies are willing to pay higher rents for "greener" office spaces. In some cases, home buyers and companies appear to be willing to pay more than the potential economic savings that they would derive from a more energy efficient dwelling or building. This evidence suggests that owners and leasers of buildings may very well be interested in investing in more efficient buildings and this will probably affect the behaviour of constructors, architects and suppliers of construction materials. At the same time, this calls for a detailed analysis of the usefulness of subsidization programs.

Climate Change mitigation is a very important topic for both governments and companies. Targets for reductions of Greenhouse Gases emissions, responsible for global warming, have been set under the Kyoto Protocol and the Lisbon Treaty in Europe. At the same time, energy efficiency has been identified as one of the key vehicles to make these targets reachable.

One of the economic sectors were GHGs reduction and Energy Efficiency are almost identical goals is the building sector. The estimates of GHG emissions by the building sector (residential and commercial) as a proportion of total GHG emissions range between 30% and 40% in regions like North America and Europe. Insulation, refurbishment of dwellings and energy efficiency are considered key factors for reducing the contribution of the building sector to global warming.

Hence, the European Union, in its 20-20-20 targets for 2020 implies the adoption of new standards for energy efficiency for buildings. The Energy Performance of Buildings Directive (EPBD) has set standards and requirements to be adopted by all member states (MS) of the European Union. Adoption comes in the shape of a National Energy Efficiency Action Plan (NEEAP) and the state of implementation varies across the EU. For instance, countries like the United Kingdom, France or The Netherlands are fairly advanced relative to others like Spain or Italy and have already begun to implement the EPBD recast of 2010.

In order to assess the effects of the EPBD on energy efficiency and the markets in Europe, it is necessary to conduct research related to the specific aims of the legislation. One of these aims is the modification of incentives on the demand side of the market: signalling energy efficiency and green characteristics of buildings should influence buyers and renters of buildings. This, it is hoped, would feedback into the incentives of building owners, who would in turn invest more in order to improve the "greenness" of their properties.

However, this aim is tricky. On the one hand, signals in the form of Energy Performance Certificates provide useful information to consumers under the assumption that they do care about these characteristics or ratings. On the other hand, EPC labels are intended to modify the behaviour of consumers. Identifying causality (are EPC labels providing information to "green" aware consumers or are they creating "green" aware consumers?) could be troublesome.

Another potential problem is the fact that most labels in Europe include both an Energy Efficiency rating and a Greenhouse Gases Emission rating (generally CO_2). This could provide another methodological problem: are these results reflecting willingness to pay for green or just for more energy efficiency?

Hence, a first step in our research has been to analyse the existing research on the field of "green" labels. Although, willingness to pay for green buildings is a growing field, specially fuelled by the findings of researchers in The Netherlands and the US, the extent of current research is not vast. We were able to identify only two studies in Europe, one in Australia and two in the United States.

In terms of implementation, LEED and BREAM certificates in the US have led the way since 1997, specially regarding commercial properties, both for rent and sales. The studies conducted by Miller (2008), McAllister & Fuerst (2008, 2009, 2011) and Eichholtz, Kok & Quigley (2009) synthetize the most important results.

In Australia, since 2004 the government committed to mandatory energy efficiency disclosure. The study conducted by the Department of the Environment, Water, Heritage and the Arts on the Australian Capital Territory summarizes the conclusions for 2005 and 2006.

In Switzerland, studies have been conducted around the *Minergieproject*. However, these studies do not seem to have been made public to date, and the lead researchers did not respond to our copy requests.

More recently, a group of researchers based in The Netherlands has analysed the effects of EPC labels on the residential and commercial sectors in The Netherlands and the US. Kok, Brounen, Eichholtz, Menne and Quigley have conducted more than five studies on data from 2008 onwards testing a similar model and obtaining interesting results.

Our Meta analysis begins by describing the existing body of research on this topic follows to the methodology used by existing research, the descriptive statistics and the results obtained by previous researchers. Finally, we enumerate the conclusions on the existing research on the willingness to pay for green buildings.

Existing research

The existing body of research can be subdivided into three groups: residential dwellings for sale, commercial buildings (and dwellings) for rent, and commercial buildings (and dwellings) for sale.

The first group, "Residential dwellings for sale" is analysed by at least four studies. The first one, "Energy Efficiency rating and House Price in the ACT" (2008), is related to the Australian Capital Territory and was conducted by researchers of the "Department of the Environment, Water, Heritage and the Arts". This study takes advantage of the implementation of Energy Efficiency Ratings in Australia since 2004, and analyses results for 2005 and 2006 for detached houses sold in the ACT. The study takes advantage of a unique data set and arrives at interesting conclusions for the five models tested.

The other three studies were conducted primarily by a group of Dutch researchers led by Nils Kok and Dirk Brounen: "Energy Performance Certification in the Housing Market - Implementation and Valuation in the European Union" (Brounen, Kok and Menne -2009-); "The Diffusion of Green Labels in the Housing Market" (Brounen, Kok and Quigley -2009-); and "On the Economics of Energy Labels in the Housing Market" (Brounen and Kok -2010-). These three studies build on data gathered from Agentzshap, SenterNovem and NVM in The Netherlands. An important issue relates to the fact that EPCs are not mandatory for all property transactions in The Netherlands, which could be troublesome from a methodological point of view.

A second group of studies is related to the analysis of labels in the office or commercial buildings for rent and sale, mainly in the US. For simplicity, we will analyse commercial properties for rent as a different group from commercial property for sale.

In the first subgroup, commercial property for rent, there are eight studies; only one of them is not related to the US market for commercial properties.

This is the case of "The Value of Energy Labels in the European Office Market" (Kok and Jennen, -2011-). This study was published on May 2011, based on Dutch commercial properties data and using a model that is a slight variation of the one used in the studies conducted at Berkeley University: "Doing Well by Doing Good? Green Office Buildings" (Eichholtz, Kok and

Quigley -2009-); and "The Economics of Green Building" (Eichholtz, Kok and Quigley -2010-). Fuerst and McAllister conducted the rest of the existing research in this subgroup: "Green noise or Green Value? Measuring the effects of Environmental Certification in Commercial Buildings" (2008); "New Evidence on the Green Building Rent and Price Premium" (2009); and "Green noise or Green Value? Measuring the effects of Environmental Certification on Office Values" (2010).

In the second subgroup we encounter research based on the denominated CoStar Studies, based on data provided by the CoStar Property Database, a private company, to two groups of researchers. First, "Measuring the Green Premium for Office Buildings. Does Green Pay Off?" (Miller, Spivey and Florance -2008-). Second, the aforementioned studies by Fuerst and McAllister.

Methodology

The basic research strategy of the above mentioned work consists of fitting a model of the demand for buildings to the data: the idea is to look at the determinants of price levels and see if green labels play any significant role. Both for residential properties and for commercial properties, the models follow a simple formulation that can be summarized by the following regression:

$$\text{Log } P_i = \alpha + \beta_i X_i + \delta_n L_n + \rho G_i + \mu M + \varepsilon_i$$

In this model, $Log\ P_i$ is the natural logarithm of the sale price per square meter; X_i is a vector of dwelling characteristics such as (log of) square feet, number of rooms, number of bathrooms, type of dwelling (attached, detached, studio, etc.); G_i is a dummy variable that captures the "greenness" of a property. In some studies, it takes on value 1 if the dwelling has an ABC category on its current Energy Performance Certificate (label), and 0 otherwise. In other studies, G_i takes on a vector of scores from 1 to 7, reflecting the EPC categories, which range from A to G; L_n is a set of variables capturing neighbourhood characteristics such as average household income, housing density, average time on the market, distance to a central location in the neighbourhood, etc.; M is a vector of dummies to control for geographic (provincial) differences that is used in several papers; finally, ε_i is an error term that captures other factors uncorrelated with P_i. The dependent variable is defined as the log of prices (or rents) in order to facilitate the interpretation of some of the coefficients in terms of elasticities.

There is one exception for this formulation. The latest paper by Kok & Jennen uses a continuous energy efficiency index as an independent variable in the model. However, the energy efficiency index is defined inversely as usual: that is, a higher index represents lower energy efficiency. This distinction matters when interpreting their results. Kok & Jennen show that a one-point increase in the energy index results in a rental decrease of about five percent.

The Australian model uses data for type of structure, neighbourhood characteristics, distance, location and several interaction (quadratic) terms. One of the extensions of this study is also of value: they include a "non-thermal characteristics" factor. This factor tries to summarize characteristics of the dwelling not only valued because of energy efficiency but also because of aesthetic reasons. An example is the use of timber in construction; another example is that of double glazed windows, which are used as thermal insulators but that also have value as sound insulators.

In the case of The Netherlands, one of the studies analyses the intention to vote green as a possible source of willingness to pay for green. A first and important shared assumption is that characteristics such as distance or neighbourhood do not significantly contribute to the green rating; otherwise the coefficient ρ would be unidentified.

Summary characteristics of the samples

Table 9 shows average values for certain variables used in a number of studies about the residential housing market. Samples are often big and the data include information such as average price of the transaction, average age of the dwellings in the sample, average income of residents in the area or socioeconomic index, average energy efficiency rating. In line with the fact that energy efficiency regulation has been in place for a relatively short period of time, existing studies often use the same dataset.

Table 9. Sample means for selected variables. Residential dwellings for sale studies

Variable	Brounen & Kok (2010)	Brounen et al (2009)	Brounen et al (2009)	ACT (2008) ^
Observations (dwellings)	31993	18176	18176	5104
Price per square meter	2003	2993	2993	411898 (+)
Age of Dwelling (years)	48.4	51	51	28
Size of dwelling (square meters)	120.2	122	122	142
Time on the Market (days)	129.2	138.8	138.8	n/a
Average Income in Neighborhood	2087.2	n/a	n/a	1120(*)
Average Price in Neighborhood	n/a	n/a	n/a	n/a
Distance to Downtown (km)	n/a	n/a	n/a	11.1
Energy Efficiency rating	C-D	C-D	C-D	1.68

Figures are means for the sample in the study
*Index of relative socio-economic Advantage/Disadvantage (Adv/Dis)
+ Property Valuation

Results

In terms of the results obtained by the existing research on willingness to pay for green buildings, we have separated the results in three groups to ease their understanding: "residential dwellings for sale" (Table 10); "office buildings for rent" (Table 11); and "office buildings for sale" (Table 12).

Group 1: Residential dwellings for sale

The results obtained by both the Australian Government study and the Dutch research group supports the preliminary conclusion that the specified model, including Energy Efficiency Labels and/or Ratings as a characteristic of the dwelling, explains the demand for residential dwellings.

The Australian study (ACT 2008), which includes a more complex formulation of the model due to the availability of data and an organized effort to understand the effect of certificates on property valuation, reaches an explanatory power of 83%, which indicates that the omitted variables should not be very relevant. The results are also very credible given that the coefficients for both the general model and the specific labels are significant at the 98% level at least. In order to compare results across studies, our research team has transformed the EER ratings elaborated by the Australian Government into labels ranging from A to G. This simple and straightforward transformation, which could be improved, produced two null categories: F and G. This simple transformation, that can be improved, allows us to compare the results of the ACT to those in Europe.

The general ACT model predicts a 1% increase in prices due to a better energy efficiency rating (EER) in the Australian Capital Territory for 2005 and 2006. For the specific labels, it appears that the price increase from a label category to another goes down as we move up in the ranking of energy labels (except for the transition from a B label to an A label, which shows a marginally lower price increase). That is to say, results are positive but decreasing: it is more valuable to have an A label than a B label but the increase in value is lower than that when moving from a C label to a B label, which shows that returns to labels are decreasing.

As we mentioned before, the other three studies are based on the Dutch property market and on the data gathered by Brounen, Kok, Menne, Quigley and Jennen. These models have a lower explanatory power (between 51% and 57%), which could indicate that there are important omitted variables. However, the results for both the general model and the specific labels are significant at a 99% level (except in two cases).

The increase in price arising from a better EPC label/rating ranges between 2,5% and 3,6%. In case of the specific labels, an A label is always more valuable than the rest, reaching more than a 10% increase in the price relative to a D label, in line with the idea that an A label indicates a higher quality for the dwelling.

Table 10. Value of Energy Efficiency in Residential Dwellings for sale

	Brounen & Kok (2010)*	Brounen et al (2009)**	Brounen et al (2009)***	ACT (2008) ^
Energy Efficiency or Green Rating	0.037	0.034	0.025	0.010
	0.001	0.001	0.001	0.001
Label Category				
A	0.102	0.121	0.129	0.061
	0.001	0.001	0.001	0.001
B	0.056	0.069	0.073	0.063
	0.001	0.001	0.001	0.001
C	0.022	0.043	0.049	0.059
	0.001	0.001	0.001	0.001
D	benchmark	0.019	0.037	0.030
	benchmark	0.001	0.001	0.001
E	-0.005	0.014	0.027	0.016
	>0.10	0.001	0.001	0.002
F	-0.025	0.000	0.017	n/a
	0.001	>0.10	0.001	n/a
G	0.051	0.593	n/a	n/a
	0.001	0.001	n/a	n/a
Observations	31993	18176	32846	2819
R2	0.527			
Adj. R2	0.527	0.510	0.568	0.830

* Using the result from model 1 and model 2. Green rating in this case refers to the effect of an A, B or C label. Uses Heckman 2 Step estimation
** Using the results from model 2 in Tables 3 and 4 . Brounen, Kok & Menne (2009)
*** Brounen, Kok & Quigley (2009)
^ Using results from model 2 with 2005 data, which includes non thermal characteristics, ratings are "translated" from EER to EPC terms

Group 2: Office buildings for rent

The second group of studies refers to “Office buildings for rent”. This is the group that includes more studies, given the research conducted in the US and the later studies in The Netherlands (see Table 11).

Except for the study by Miller et al. (2008) based on the CoStar Group database, all the studies show a positive influence of labels on prices. In this case, which we separate into ES and LEED to show results for properties with Energy Star label and LEED label, the size of the sample and control group has been signalled as an important methodological problem (Muldavin 2008).

In order to be able to make comparisons, we have mapped LEED categories (certified, silver, gold and platinum) into the D, C, B and A categories used for Energy Performance Certificates in Europe. This has made it possible to compare results from the US and The Netherlands in terms of the effect on rents of moving from one category to another. However, the coefficients for most of the categories fail to be significant at a level larger than 90%.

The latest study conducted by Kok & Jennen (2011) in The Netherlands, shows that as the label rating increases one point (for the general model) rents go down almost 5%. However, the variable of interest is defined in terms of an energy efficiency index where a higher value means lower energy efficiency.

A final note relates to the studies by Fuerst & McAllister. The three studies appear to use the same database: amount of properties is almost identical and the explanatory power of the model very similar. However, the results of the second 2009 paper appear to be a mix between the general result of the 2011 paper and the specific label results from the previous 2009 paper. We therefore warn readers that their results should be revised carefully before extracting general conclusions.

Table 11. Value of Energy Efficiency in Office Buildings for Rent

	Kok & Jennen (2011)*	Fuerst & McAllister (2011)	Eicholtz et al (2010)	Fuerst & McAllister (2009)	Fuerst & McAllister (2009)	Eicholtz et al (2009)	Miller et al. (2008) ES	Miller et al. (2008) Leed
Energy Efficiency or Green Rating	-0.047	0.050	0.026	0.050	0.060	0.033	0.058	0.099
	0.005	0.001	0.001	0.001	0.001	0.001	0.015	0.05
Label Category	0.042	0.160	n/a	0.160	0.160	n/a	n/a	n/a
A	0.042	0.160	n/a	0.160	0.160	n/a	n/a	n/a
	>0.10	0.001	n/a	0.001	0.001	n/a	n/a	n/a
B	0.054	0.030	n/a	0.003	0.004	n/a	n/a	n/a
	0.010	>0.10	n/a	>0.10	>0.10	n/a	n/a	n/a
C	0.097	0.040	n/a	0.004	0.004	n/a	n/a	n/a
	0.001	>0.10	n/a	>0.10	n/a	n/a	n/a	n/a
D	benchmark	0.090	n/a	0.009	0.009	n/a	n/a	n/a
	benchmark	0.005	n/a	0.005	0.005	n/a	n/a	n/a
E	-0.008	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	>0.10	n/a	n/a	n/a	n/a	n/a	n/a	n/a
F	-0.005	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	>0.10	n/a	n/a	n/a	n/a	n/a	n/a	n/a
G	0.023	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	>0.10	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Observations	1057	10970	20801	10969	10969	8182	927	927
R2	0.727	n/a	0.833	n/a	n/a	0.720	0.478	0.478
Adj. R2	0.660	0.630	0.816	0.630	0.610	0.690	0.468	0.468

* Using the result from model 1 for EER and the results of model 4 for the rest

Group 3: Office buildings for sale

Table 12 shows the results obtained by existing research on the effect of labels on the price of Office Buildings for sale. The problem mentioned above for the Fuerst & McAllister studies repeats itself here: the three papers appear to use the same database but the results for ratings in the last study seem too large.

On the other hand, the reports by Eichholtz et al in the US are in line (general model) with the results for rental office buildings, both in terms of explanatory power and effect. However, the last study shows a 13% increase in price due to a better energy rating. This is a remarkable price increase and further analysis is needed before it can be extrapolated to other markets.

Table 12. Value of Energy Efficiency in Office Buildings for Sale

	Fuerst & McAllister (2011)	Fuerst & McAllister (2009)	Fuerst & McAllister (2009	Eicholtz et al (2010)	Eicholtz et al (2009)
Energy Efficiency or Green Rating	0.030	0.3000	0.360	0.133	0.016
	0.001	0.001	0.001	0.001	0.001
Label Category					
A	0.670	0.670	1.000	n/a	n/a
	0.005	0.005	0.001	n/a	n/a
B	0.260	0.260	0.360	n/a	n/a
	0.005	0.005	0.001	n/a	n/a
C	0.330	0.330	0.380	n/a	n/a
	0.005	0.005	0.001	n/a	n/a
D	0.120	0.120	0.200	n/a	n/a
	>0.10	>0.10	0.001	n/a	n/a
E	n/a	n/a	n/a	n/a	n/a
	n/a	n/a	n/a	n/a	n/a
F	n/a	n/a	n/a	n/a	n/a
	n/a	n/a	n/a	n/a	n/a
G	n/a	n/a	n/a	n/a	n/a
	n/a	n/a	n/a	n/a	n/a
Observations	6156	6156	6157	5993	1816
R2	n/a	n/a	n/a	0.662	0.440
Adj. R2	0.420	0.420	0.420	0.616	0.360

Conclusions

The Meta analysis conducted by our research group arrives to the conclusion that Energy Performance Certificates appear to be significantly and positively related to prices in the three markets studied: Residential dwellings for rent, Office buildings for rent and Office buildings for sale.

Interpreting the positive correlation is not easy. On the one hand, one would be inclined to state that there exists a willingness to pay for green buildings *per se*. However, it may simply be the case that consumers are willing to pay for living in houses where energy efficiency is higher and as a result the monthly energy bill lower.

To discern among these two potential explanations, several studies compare the price premium with the estimated energy savings associated to a label. That is to say, some studies estimate the net present value of energy savings of more efficient dwellings or offices and compare it to the price premium borne by home buyers and corporations. This comparison often shows that the price premium for ABC labels is larger than the corresponding savings in energy. However, net present value calculations of the energy efficiency savings rest on a good number of assumptions on issues such as the discount rate, the behaviour of consumers, the future evolution of energy prices, and so on. These assumptions make the "Green Premium" result less credible.

Most of the studies have been conducted for data from The Netherlands and the US. Because in these two markets energy labels have been voluntary adopted until now, methodologically one has the difficulty of handling properly the *endogeneity* problem that arises due to the voluntary nature of the program. If this is not done accurately, estimates are likely to be biased. Therefore, further research is welcome in this area before generalizing their results to other markets.

The study in Australia is far more comprehensive and methodologically complex than the other and could serve as a guide for further research. In this sense, in the next chapters we try to extend this model to two European cases, London and France, in order to further assess the effect of the EPBD when it is of mandatory implementation.

Annex

Table 13. Sample means for selected variables. Commercial buildings for rent studies

Variable	Kok & Jennen (2011)*	Eichholtz et al (2010)	Fuerst & McAllister (2011)	Fuerst & McAllister (2009)	Fuerst & McAllister (2008)
Observations	1057	20801	10969	10970	10969
Rent per square feet	166.3	29.8	19.5	19.5	19.5
Age of Dwelling (years)	13.7	23.9	28.4	28.4	28.4
Size (000s square feet)	10118.19(*)	324.1	52.8	52.8	52.8

Figures are means for the sample in the study

(*) square meters

6. Evidence of Willingness to pay for green dwellings in London and France

Introduction

Climate change mitigation is one of the most important goals of the European Union since the Lisbon Treaty. The 2020 targets imply a significant reduction in Greenhouse Gases emissions to which all sectors in the economy must contribute. One sector that is identified as a big contributor to GHG emissions is that of residential buildings.

According to the EU, Residential Buildings contribute approximately 36% of all GHG emissions and 40% of all Final Energy Consumption. Hence, improving the energy efficiency levels of residential dwellings and office buildings would have a crucial impact on total GHG emissions.

European legislation is directed towards this goal. The Energy Performance of Buildings Directive issued in 2003 and recast in 2010 aims at setting standards that member states should follow in their implementation of national energy efficiency action plans. The EPBD sets two important issues for this paper: the implementation of Energy Performance Certificates and the potential requirement of minimum standards for construction materials, given a target of Near Zero Buildings for 2020.

Even though this paper deals directly with the effect of Energy Performance Certificates on the willingness to pay of home buyers, the general idea is that if consumers want greener buildings and are willing to pay a premium for them, then builders and owners will make the necessary refurbishment and planning in order to get a higher score on the EPC.

A problem that this paper faced was the availability of information regarding transactions and EPC labels. Almost no country in the EU publishes information regarding the price of properties that have an EPC. Furthermore, EPCs as such are not mandatory throughout the EU and the level of adoption and implementation varies greatly.

For instance, The Netherlands is very advanced in terms of EPCs. SenterNovem has developed a database that has been used in conjunction with a database on home transactions in order to assess the effect of EPCs on transaction prices by Eichholtz, Kok & Quigley (2009), Brounen, Kok and Menne (2009), Brounen, Kok and Quigley (2009), Brounen and Kok (2010), or Kok and Jennen (2011).

The case of The Netherlands, however, presents the methodological difficulty that EPCs were not mandatory for every transaction; that is, the parties involved in a transaction could ask for a waiver of the EPC requirement. To the extent that, for home owners, obtaining the waiver not only meant pecuniary savings (that is, savings in the fees for getting an EPC) but also savings in time, the sample of homes with EPCs is not a random sample. This may constitute a problem if there are unobserved variables correlated with the low EPCs and high prices. For example, it could be the case that some unobserved variable makes owners of relatively expensive and inefficient houses to be more prone to apply for EPCs. If this were so, the sample of houses with EPCs would contain a disproportional number of expensive and inefficient houses, which would bias the estimate of the green premium downwards.

In order to avoid this problem, Brounen and Kok (2010) apply the well-known Heckman's two-step estimation procedure. As usual, because datasets are never ideal, one is hardly completely sure the problem has been correctly dealt with. Instead, we propose to look at a case where EPCs are mandatory on every rent or sale transaction, that is, where no waiver exists. Our purpose is to investigate whether a price premium exists for green homes in London and France, and to quantify such premium. We will compare our results with those in existing papers.

Energy Performance Certificates in the United Kingdom

The United Kingdom is one of the leaders (a pioneer and a convergent country, see chapter 4) in terms of energy efficiency regulation in Europe. Before the European Union issued the first EPBD, the United Kingdom required energy certificates for every home, later called Home Information Packages (HIP).

In 2001, the Standard Assessment Procedure (SAP) was the recommended system for home energy rating (see Table 14 for the timeline of energy certification in the UK). The SAP energy cost rating was based on energy costs for space and water heating. The carbon index (CI) is based on the carbon dioxide (CO_2) emissions associated with space and water heating. Both the SAP rating and the CI are adjusted for floor area so that they are essentially independent of dwelling size. The calculation is not affected by factors that depend on the individual characteristics of the household occupying the dwelling at the moment the certificate is granted, for example: household size and composition; ownership and efficiency of particular domestic electrical appliances; individual heating patterns and temperatures; nor geographical location.

The procedure used for the calculation was based on the BRE Domestic Energy Model (BREDEM), which provides a framework for the calculation of energy use in dwellings. The Standard Assessment Procedure was first published by the DOE (now the Department of Environment, Food and Rural Affairs (DEFRA)) and BRE in 1993 and in amended form in 1994, and conventions to be used with it were published in 1996 and amended in 1997. A consolidated edition was published as SAP 1998.

This first legislation was not mandatory and evolved into what was called a Home Information Package, which since 2007 must include an EPC. The Directive is implemented in England and Wales by means of the Energy Performance of Buildings (Certificates and Inspections) Regulations 2007/991 in April 2007 (EPB Regulations). Scotland and Northern Ireland are making separate arrangements for implementation.

Table 14. Timeline of Energy Certification in the UK

TIMELINE FOR ENERGY CERTIFICATION IN THE UK	
2001	Standard Assessment Procedure (used for EPCs)
01/08/07	HIP PROGRAM ROLLED OUT
22/11/07	HIP REQUIRED IN 1G2 BEDROOM HOMES
06/04/08	HIP REQUIRED IN DWELLINGS > 10000 M2 (FLOOR)
01/07/08	HIP REQUIRED IN DWELLINGS > 2500 M2 (FLOOR)
01/10/08	EPC REQUIRED ON ALL TO BE SOLD

The Regulations created duties for sellers and landlords to produce and provide EPCs to prospective buyers and tenants. The requirements apply to all buildings, whether commercial or domestic, when sold, rented out or newly constructed.

To comply with the HIP requirements, a home owner may choose to commission a stand-alone EPC, prepared by a Domestic Energy Assessor or a Home Inspector, or to commission a HCR which incorporates the EPC. The marginal cost of the EPC may be lower in the latter case. The integration of the EPC with the HIP has three consequences:

- The requirement for EPCs for private marketed sales would be introduced from 1 June 2007, to coincide with the introduction of the HIP requirements;

- The EPC can be produced as a stand-alone document, or in conjunction with an HCR;

- For a HIP to be a reliable basis upon which to make a purchasing decision, the EPC must be less than 3 months old at the first point of marketing.

The average cost per dwelling for an EPC and recommendations report is expected to be £95.50. EPCs are valid for ten years and can be reused for new tenants as many times as wished within that period.

The regulation regarding mandatory EPCs for dwelling transactions has evolved since 2003. For instance, since October 2008 an EPC is mandatory for every new rented dwelling. Today, however, an EPC is mandatory for every sale or rent transaction for new or existing dwellings.

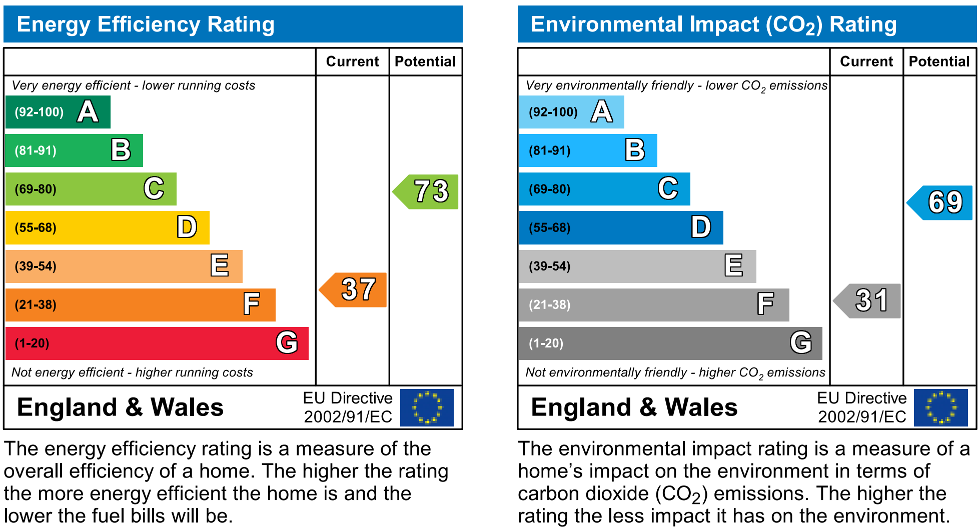
A typical Energy Performance Certificate shows 'fridge style' ratings for the Energy Efficiency and the Environmental Impact of a dwelling (see Table 16). Its purpose is to indicate how energy efficient a building is. The certificate provides an energy rating of the building from A to G, where A is the label granted to the most efficient buildings and G to the least efficient ones. The better the rating, the lower the energy bills are likely to be (see Table 15). The energy performance of the building is shown as a Carbon Dioxide (CO_2) based index. Each energy rating is based on the characteristics of the building itself and its services (such as heating and lighting). Hence this type of rating is known as an asset rating.

Table 15. England & Wales Grade Equivalences for Energy consumption and CO_2 emissions

	kWh/m2/y		CO_2/tonnes	
RANGE	MIN	MAX	MIN	MAX
A		100		1
B	122	125	1,3	1,4
C	200	249	2,1	2,5
D	268	394	2,6	4,4
E	450	531	4,1	6,7
F	568	639	5,5	12
G	650	932	12	19

An accompanying Recommendations Report is included on the following page of the EPC report. The EPC also includes both Energy and Environmental current and potential scores. The potential score is the maximum score a dwelling could reach if it conducts the required refurbishment. Scores and grades for both ratings are shown in Table 16.

Table 16. Sample EPC label for England & Wales



The energy performance of existing dwellings is determined using a government approved domestic energy model known as Reduced data Standard Assessment Procedure (RdSAP). This is a streamlined version of the Standard Assessment Procedure (SAP) into which data for new build dwellings is entered based on drawings and specifications.

The legislation also provides authorities the means for enforcement. For instance, if a landlord has failed to provide an EPC to a tenant, or fails to show an EPC to an enforcement officer when it is requested, Trading Standards can issue a notice with a penalty charge of £200 per dwelling. In addition to paying the penalty notice, the landlord will still have to provide an EPC to the person who has become the tenant.

Energy Performance Certificates in France

France was one of the first countries in Europe to implement an energy efficiency certification system for buildings, back in the 1980s. Although the focus of the EPBD is different (information about the contribution to Climate Change by the residence or dwelling), energy efficiency certifications could be a proxy for green certification. That is to say, consumers of dwellings looking for information about how green a dwelling is will usually find great correlation with energy efficiency: if the dwelling is energy efficient, then it is green.

Even though this has created many problems in terms of convergence to the EPBD, the experience with certification systems provides a great terrain for analysis. France is a country where consumers have been exposed to EPC like certificates for a long time now. Hence, consumers will probably be less subject to a "green" fashion and the willingness to pay for green could be tested on a larger territory.

Also, the different climatic regions existing in France will add relevant information about the nature of this willingness to pay: is it uniform across provinces in France? How does it compare to the willingness to pay in one capital city with cold climate, such as London?

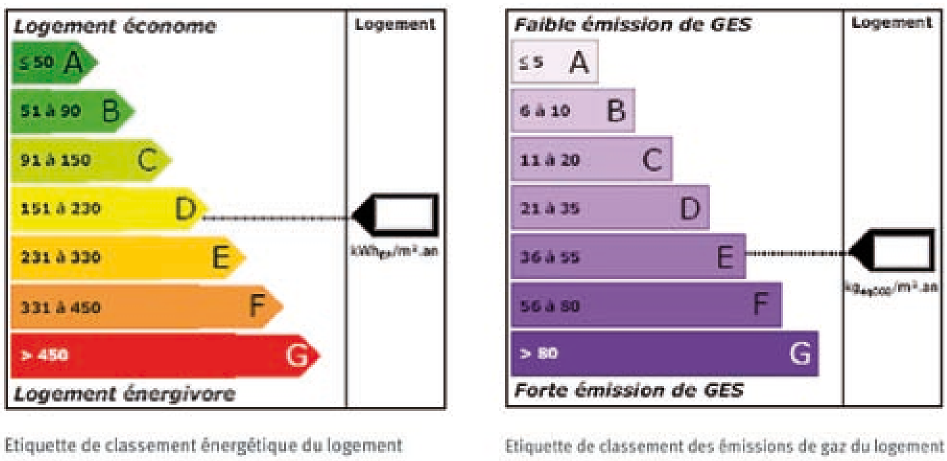
An interesting hypothesis would be that home buyers in a colder city would have a larger willingness to pay for green than French home buyers in general. A counter hypothesis would state that this would only be if EPCs reflected energy efficiency (savings in energy costs) and not only green qualities.

France is a country that falls into the *early adopter chronic* category of convergence we developed in chapter 4. As such, its consumers of dwellings have been exposed to energy efficiency certification for a number of years, but the level of adoption is not uniform because of enforcement problems at the national level. This case provides a good framework for comparing against the results of London, a capital city of a *pioneer convergent* country.

Energy Performance Certificates in France are called *Diagnostique de la Performance Energetique* (DPE). These labels work in a similar fashion as those in England & Wales or The Netherlands, setting grades from A to G for both energy efficiency and GHG emissions (see Table 17).

However, a major distinction is that grades or scores are opposite. That is to say, a lower EPC (DPE) means more energy efficiency.

Table 17. Sample Diagnostique Performance Energetique (DPE)



This distinction is crucial in order to interpret the results obtained by the model. A negative coefficient for the EPC score would mean a positive influence of labels on the price of dwellings. That is to say, a negative EPC coefficient means that consumers of dwellings are willing to pay more for more energy efficient dwellings.

Finally, France presents a suitable sample because it has issued close to four million EPCs. The dwelling stock is also very old in average age, which gives us the possibility of modelling age as a factor in the real estate demand model.

Our ultimate aim, again, is to find a model of real estate demand that finds evidence for a willingness to pay for green dwellings (better EPC ratings) both in London and France.

Methodology

Building on the demand model developed by Eichholtz, Kok & Quigley (2010) and Brounen & Kok (2010), we test the following specification:

$$\text{Log } P_i = \alpha + \beta_i X_i + \delta_n L_n + \rho G_i + \varepsilon_i$$

where *Log* P_i is the natural logarithm of the posted sale price; X_i is a vector of dwelling characteristics such as square foot, number of rooms, number of bathrooms, age of property, type of dwelling (attached, detached, studio, etc.); G_i is a vector of scores in the energy label, ranging from A to G; L_n is a set of variables capturing neighbourhood characteristics such as average household income, average household price, average house age, distance to Trafalgar square in the city of London, etc. More refinement would come from actual sale data and from completing dwelling characteristics with information such as age of building.

Methodology for London

In the case of London, in order to be able to evaluate this model, we gathered a sample of posted dwellings on real estate websites. Given that not every real estate agent in the United Kingdom made all the necessary information available on the web, we decided to circumscribe to the information available on Hamptons Real Estate (http://www.hamptons.co.uk/) to the London Area. This real estate agent provided information about EPCs for each posted property. We manually downloaded data for 2,354 dwellings that included EPC label and rating, both current and potential, and GHG emissions label and rating, both current and potential. The information downloaded also included: posted sale price, postal code for the property, total internal square feet, type of dwelling (attached, detached, suite, flat), number of rooms per dwelling, bathrooms per dwelling, whether the dwelling had a reception or not, among other important information.

However, the data gathered did not contain two important pieces of information: the age and the exact location of the dwellings. The age of the dwelling provides helpful information. First, it helps to identify neighbourhood characteristics, given that real estate studies of the city of London suggest that neighbourhoods tend to be uniform in this aspect. Second, failing to control for age might be problematic if it is the case that home buyers prefer older houses over newer houses. Since age is probably negatively correlated with the environmental performance of buildings, older houses commanding higher prices may obscure the estimation of the price premium for greener houses. The exact location of a house would provide information about the neighbourhood characteristics and could be useful in order to analyse a cluster of dwellings. It is then not surprising that when we first tested the model excluding this information, the results were non-significant: the model did not explain well the real estate market in London and EPCs had no effect on the price of the dwelling.

To solve this problem originating from lack of data, we constructed a series of proxies. The first one was a variable measuring “distance from a dwelling to Trafalgar square.” Since we did not have data on the exact location of a home, we took the distance from the centre of the postal code where the house was located to London downtown. We used the most ample definition of the postal code available. The idea for this proxy was that it could help separate post code effects from price premium originating from the proximity of the home to the centre of the city.

The second idea was to use a proxy for the age of the dwellings in a postal code. However, we could not find this information anywhere mainly due to the fact that London is organized administratively in terms of Boroughs, which often comprise more than one postal code. We conducted research on the characteristics and available information (public) of Boroughs in London and we found that several boroughs published information about the evolution of the dwelling stock in their territories. This would certainly suggest that a database with dwelling stock evolution and information on home characteristics such as age would exist. We obtained such database upon request to different departments of the UK government.

Finally, the Valuation Office Agency of the UK government provided us with a more complete version of the "Property data attribute" database, which is used to calculate property taxes in the United Kingdom. This file has information of the dwelling stock distribution by Borough and by Age group. Fourteen groups have been defined from A to N plus O and X categories, being A the category were the older dwellings are comprised. Further description of these age groups can be found in the annex to this chapter. This database enabled us to construct the exact distribution of dwellings per construction year in each borough.

Our next step was to define two age ratings for each borough. The first was a grade system from 1 to 10, being 10 the grade for older dwellings, according to the distribution of dwellings. The second was an average age system, according to the definitions of the VOA groups from 110 years old to new dwellings. With minor exceptions, both ratings gave consistent ages for the dwelling stock in the London Boroughs. We decided to use the second one in our model.

To further add information about the dwelling stock on each borough we gathered information on the average income and the average price per square foot of each borough. This information is valuable, because it is often related to the price of an individual dwelling in a certain area.

In order to determine the average age of the dwellings on our database, we conducted an analysis comparing postal codes in London and Boroughs in London. As mentioned before, Boroughs often comprised more than one postal code. We devised a weighted average for each postal code that summarized information about the quantity of dwellings in the sample on that borough. This proxy was used to assess dwelling age, average income and average price per square foot.

A final depuration of the sample involved eliminating those dwellings were a potential mistake in reporting occurred in terms of EPCs and GHGs: 15 dwellings presented incompatible ratings. The most common case occurred when the potential rating was smaller than the current rating, which would mean that refurbishing an existing dwelling would worsen its environmental and/or energy efficiency situation.

In the next section, we provide a description of the final sample of dwellings of the London area that we used to test the model.

Methodology for France

In the case of France, in order to be able to evaluate the model, we gathered a sample of posted dwellings on a real estate agent website. We chose to circumscribe to the information available on Century 21 (http://www.century21.fr/) for the France national territory, given that not every real estate agent in France made available all the information necessary for this model. This real estate agent provided information about EPCs for each posted property. We used a software tool called Mozenda to download data for 5,120 dwellings that included EPC label and rating and GHG emissions label and rating. This original sample was analysed thoroughly in order to construct a database for testing the model.

The information downloaded also included: age of dwelling, posted sale price, postal code for the property, total internal square feet, type of dwelling (attached, detached, suite, flat), number of rooms per dwelling, bathrooms per dwelling, whether the dwelling had a reception or not, French department, among other important information.

Samples

The London Sample

From an original sample of 2500 dwellings, we eliminate those with problems in the data, such as missing information. Then we divide dwellings among those on the London Postal District (624), the London Postal Region (127) and those outside of these two (1604 dwellings). We focus on those dwellings on the London Postal District (624) because we are able to build variables for age, average income and average price of dwellings for the London Boroughs included in the LPD. After eliminating those dwellings with obvious errors in the information about EPCs or ENVs, we end up with 598 dwellings in total.

Table 18 describes basic statistics for our London sample of homes. The price per square feet ranges from 180 to 1644 sterling pounds, with an average of 577. The variation in the price per square meter is enormous and a large part of this variation has to be related to house characteristics. The size of houses, with an average of 1161 square feet varies quite a lot, namely, from 269 to 5834 square feet. Our sample does not really contain new houses. The youngest house is 55 years old and the oldest is 91. Finally, we observe houses that are very close to the center, while other houses are located in boroughs relatively far away from Trafalgar Square.

Table 18. Average characteristics of the London sample

	Price p/dwelling	Square Foot	P/Sq Ft	Dist Trafalgar	Age 2	Avg Price	Avg Income
Average	£573.741	1.161	£577	56	76,105	£355.283	£33.959
Maximum	£2.850.000	5.834	£1.664	157	91,233	£675.000	£53.604
Minimum	£155.000	269	£180	1	55,437	£195.608	£27.242

Table 19 shows the distribution of EPC labels in our London sample. We observe a somewhat skewed distribution towards more efficient types. Most of the houses, about 31%, have D-labels. Houses with the best ABC labels sum up to 42%, while houses with the worst type of labels, EFG, represent a 26% of the total.

Table 19. Distribution of EPC and ENV grades in the London sample

	EPC CUR	%	ENV CUR	%
A	0	0.00%	0	0.00%
B	73	12.21%	54	9.03%
C	179	29.93%	164	27.42%
D	188	31.44%	154	25.75%
E	116	19.40%	170	28.43%
F	36	6.02%	54	9.03%
G	6	1.00%	2	0.33%
Total	598	100.00%	598	100.00%

Table 20 gives the distribution of dwellings across house types. Most of the homes in our data are flats (about 65%), which can be explained by the fact that London is a rather urbanized area. However, a good number of houses are detached (about 17%). The rest of the houses are attached, semi-detached or studios. The last category is almost inexistent in our sample.

Table 20. Sample distribution by dwelling type in the London sample

Type	#	%
Detached	101	16,9%
Attached	53	8,9%
Semidetached	50	8,4%
Flat	388	6 4,9%
Studio	6	1,0%
Total	598	100,0%

In Table 21 we provide the age distribution of homes in our London sample. The majority of the houses, about 65%, are between 70-79 years old. Younger houses are less frequent, about 11%, than older houses, about 25%.

Table 21. Age of dwellings in the London sample

Age	#	%
50	52	8,7%
60	14	2,3%
70	389	65,1%
80	105	17,6%
90	38	6,4%
Total	598	100,0%

Table 22 shows the distribution of homes over the post codes. The SW post code is overrepresented, with a 39% of the total number of houses. The next well represented post codes follow at distance, with 12% of the homes or less. One potential reason is that Hamptons Real Estate has more influence in the SW postcode, perhaps due to the current or earlier location of its offices. There is also substantial variation across Boroughs in the London area, which we account for by using the average house price and the average income in the Borough.

Table 22. Sample distribution by Postal Code of the Greater London Area

Postal Code	#	%
E	13	2,2%
EC	20	3,3%
N	38	6,4%
NW	27	4,5%
SE	51	8,5%
SW	233	39,0%
W	73	12,2%
WC	2	0,3%
KT	68	11,4%
CR	73	12,2%
Total	598	100,0%

The France Sample

We excluded dwellings that were built before 1900. These dwellings, sometime small palaces, are luxury objects, highly priced, monumental in nature and, as it is the case in many countries, they are protected by regulation. These buildings are probably valued precisely because of their age, which usually comes along with energy inefficiency and this potentially distorts the analysis. Moreover, regulation limits considerably refurbishment possibilities. These consideration lead us to believe these dwellings do not belong in our model of demand. After eliminating these buildings from the database, we circumscribed the model to 4,661 dwellings.

Unfortunately our data for France did not comprise one important piece of information: the exact location of the dwellings. Such data would provide information about the neighbourhood or region of the city and could be useful for the analysis. However, the average age of the dwelling in a neighbourhood was available. Although quite imperfectly, this can help proxy for neighbourhood characteristics. We first tested the model excluding this information, but the results were non significant: the model did not explain well the real estate market in France and EPCs had no effect on the price of the dwelling. Then, we included the new Average Age variable and excluded those departments where data was not available or where there were very few dwellings, getting a final sample of 4,646 dwellings.

Our next step was to define two age ratings for each department. The first was a grade system from 1 to 10, being 10 the grade for older dwellings, according to the distribution of dwellings. The second was an average age system from 110 years old to new dwellings.

To further add information about the dwelling stock on each department we gathered information on the average income and the average price per square foot of each department. This information is valuable, because it is often related to the price of an individual dwelling in a certain area (see Table 23).

Once we finished all this depuration processes we tested the model with very positive results.

We now provide a description of the final sample of dwellings for France that we used to test the model. Table 24 describes basic statistics for France and a selection of the departments in our sample of dwellings.

Table 23. Descriptive statistics for the Departments of France in the sample

Departments de France	Foyers fiscaux en 2008	Revenu net déclaré foyers fiscaux en 2008 (€)	Total Pop	Avg. Income	Pr SqMt	GDP par habitant (en €)	GDP (en millions d'euros)
Paris	1.441.319	53.828.995.691	2.211.297	24.343	7.780	75.439	164.214
Seine-et-Marne	701.692	18.225.233.846	1.303.702	13.980	2.740	23.480	29.755
Yvelines	742.068	25.733.144.454	1.406.053	18.302	3.760	30.507	42.485
Essonne	648.606	18.189.598.242	1.205.850	15.084	2.700	26.718	31.883
Hauts-de-Seine	890.375	32.008.120.650	1.549.619	20.655	5.250	73.277	111.975
Seine-Saint-Denis	824.291	16.279.081.306	1.506.466	10.806	3.110	27.420	40.676
Val-de-Marne	753.273	20.048.262.712	1.310.876	15.294	4.100	29.250	37.816
Val-d'Oise	625.609	15.815.835.268	1.165.397	13.571	2.790	25.765	29.705

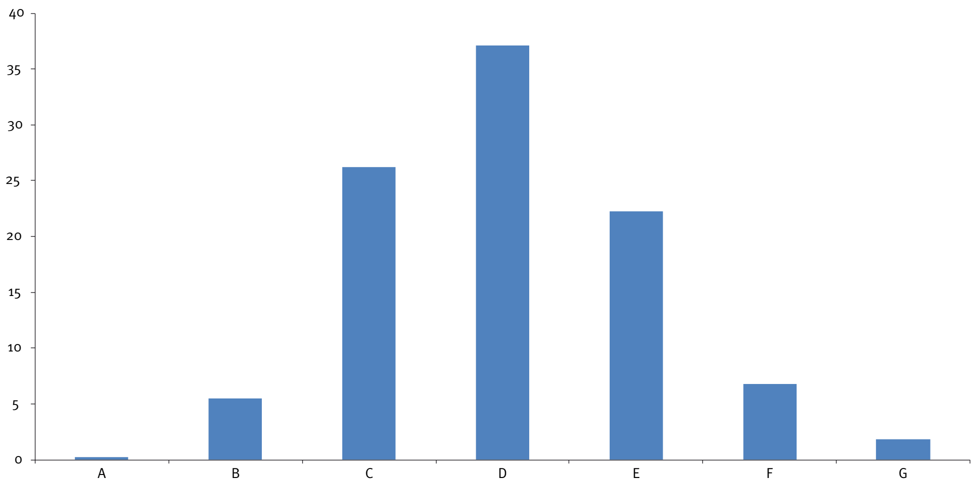
The price ranges from 450,000 euros to 520,000 euros, with an average size of 150 meters. The price per square meter, hence, varies between 2,500 and 4,200 euros, with an average of 3,000 euros. The variation in the price per square meter is quite big and a large part of this variation has to be related to house characteristics. Our sample contains both new and old houses. The youngest average age is 6.5 years old (Essone) and the oldest average age is 89 (Val de Marne).

Table 24. Descriptive statistics for France and a selection of Departments (average data)

		Vicinity of Paris			Rest of Ile de France Region				
Sample	Dept All	92 Hauts De Seine	75 Paris	93 Seine StDenis	94 Val de Marne	95 Vel D'Oise	78 Yvelines	91 Essone	77 Seine et Marne
# OF PROPERTIES	4.646	113	144	127	158	309	176	195	261
AVG. PRICE	462.363	459.665	450.054	499.183	520.059	471.380	548.078	457.734	460.548
AVG. AGE	35,7	16,8	23,0	40,4	89,8	56,9	152,1	6,5	33,0
AVG. NRG.	206,1	197,4	236,5	254,7	270,2	279,4	279,5	168,8	33,0
AVG. GHG	33,3	22,8	21,2	57,0	58,0	63,6	54,4	24,6	44,8
AVG. SIZE	5,8	134,2	129,5	125,3	124,8	115,9	141,6	126,7	133,6
NRG=GHG	519,0	14,0	12,0	17,0	25,0	58,0	30,0	15,0	26,0
NRG>GHG	1971,0	58,0	98,0	18,0	31,0	32,0	41,0	89,0	83,0

Other relevant characteristics are energy consumption and GHG emissions. On the first category, energy consumption varies between 33 and 500 kWh/m^2/y, the average energy consumption is 206 kWh/m^2/y, which results in an average D rating for the dwellings in the sample. This is consistent with the information in Chart 57, where we can see the very low number of A or B labels, as well as F or G. This could indicate either that dwellings are more energy efficient or that the certification process has problems.

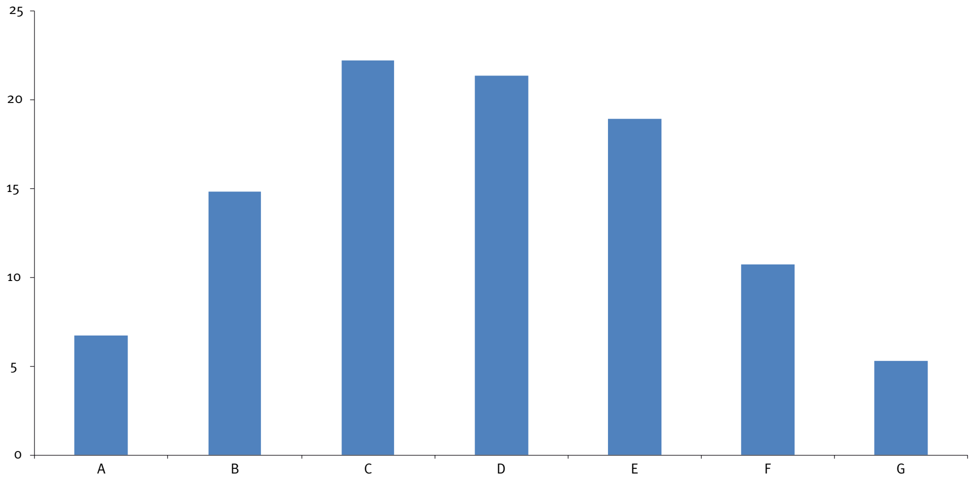
Chart 57. Distribution of EPC ratings in the France sample (%)



Source: authors' own elaboration

This last conclusion gains strength when we compare these results with those of GHG labels, which should be highly correlated with EPC labels. We can see in Chart 58 that the distribution is more "normal" with a higher number of A, B, F and G GHG labels, as in other European cases. In this regard, we find it somewhat strange that 7% of the dwellings have an A GHG label while almost no home has an A EPC label.

Chart 58. Distribution of GHG ratings in the France sample (%)



Source: authors' own elaboration

Chart 59 is a depiction of the distribution of labels (EPC) by department in the Century 21 sample. There are only eight departments, for example, with a noticeable proportion of green labels, none of them in the city of Paris.

Chart 59. EPCs by Department in the France sample

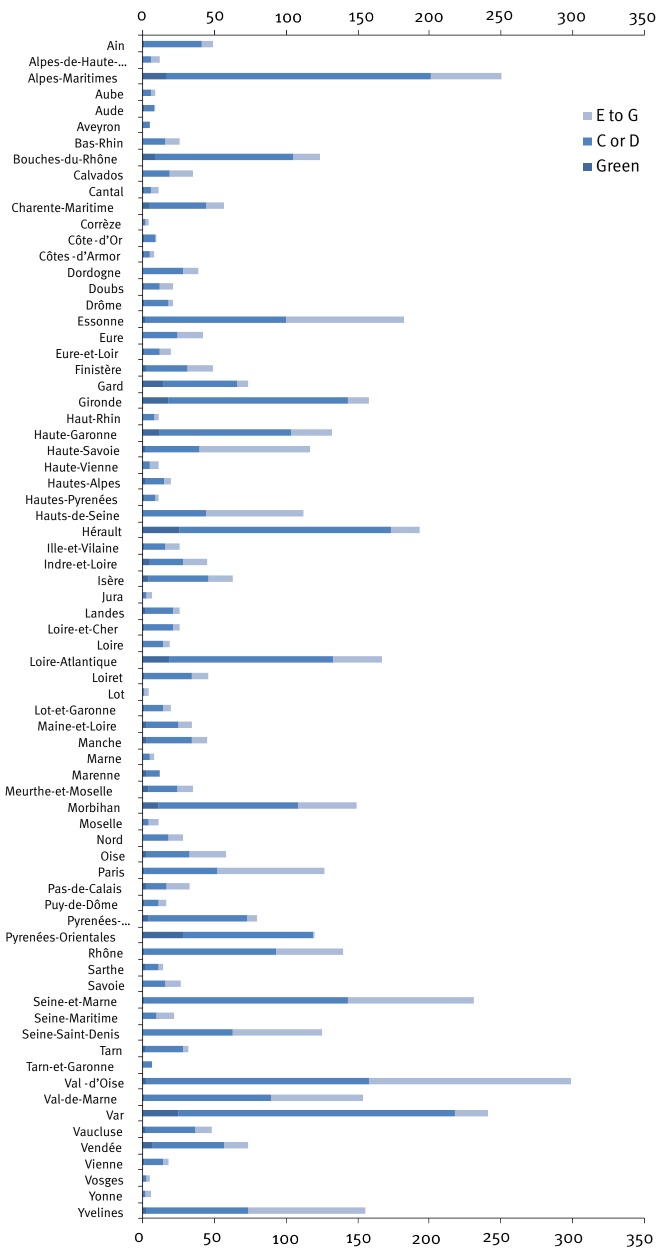


Chart 60. Energy consumption and age of dwellings by departmental average in the Sample

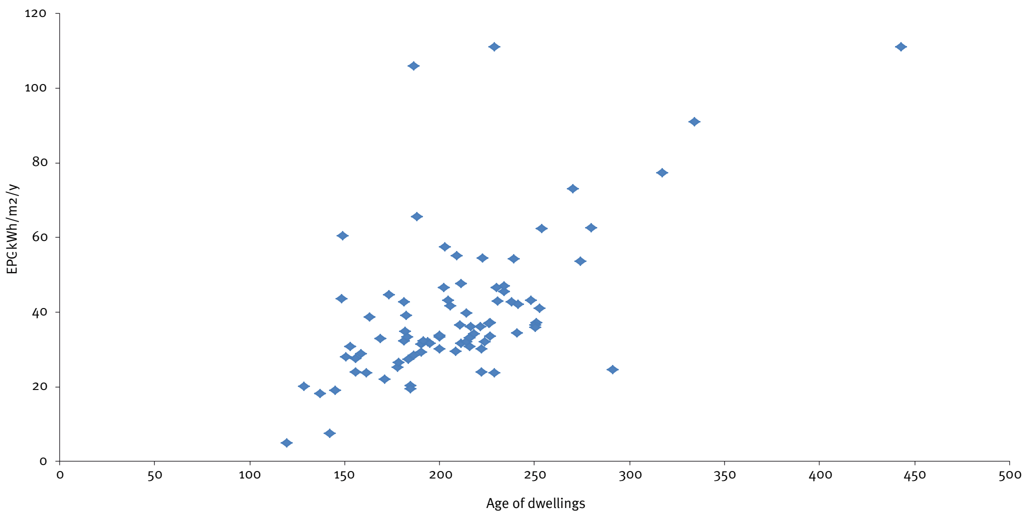


Chart 60 shows how EPC energy scores relate to the Age of Dwellings. As we can see in several cases, as the age increases, the EPC increases. That is to say, the energy efficiency of the dwelling is lower.

Results

The results are based on a simple scores model, that is to say, a model that takes into account the scores that the Energy Performance Certificates allocate to each dwelling. We could use instead the grades the EPC gives. The EPC score is a continuous variable and using the grades instead has the disadvantage that we need to estimate many more parameters.

As mentioned before, the final sample used for this analysis includes a total of 598 properties for London, and a total of 4661 for France. We eliminated those properties with potential problems such as an EPC potential (the maximum EPC score that the dwelling could reach after necessary refurbishment) or Environmental score potential that is lower than the current EPC or ENV score, monumental dwellings, observations for which we did not have necessary demographic information, etc.

The model uses the following independent variables *lepcscore*, *lage2*, *lintsqft* (could be used as a proxy for type of bldg.), *lavgprice*, *lavgincome* and *ldist* as regressors, where the dependent variable is *lpricesqft*. The variable *lepcscore* is the natural logarithm of the EPC score for each of the dwellings in the sample, *lage2* or *lage* is the natural logarithm of an age variable for each postal code that we described in methodology section, *lintsqft* is the natural logarithm of the size of the dwelling in square foot, *lavgprice* and *lavgincome* are the natural logarithms of the average price and average income for each Borough or Department in the sample, and *ldist* is the natural logarithm of the distance from Trafalgar square for each dwelling in the sample (*ldist* is not defined in the case of France).

London results

The model has an R-square of 0.75. In terms of coefficients, our results are in line with those reflected by similar models in the literature (see Table 25). A 1% increase in the EPC score accounts for a 0,073% increase in the price per square foot of the dwelling. That is to say, for example that the difference between an average D score (61) and an average Green label (85) represents a 2,87% change in the price per square foot. This compares with a 3,7% increase in Brounen & Kok (2011) for the same range. Put differently, passing from a D label to a B label means around 17 GBP more per square foot for a given dwelling.

Table 25. Coefficients for the model based on the London sample

Coefficients [a, b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-46588.021	11769.148		-3.958	.000
	lepcscore	-.073	0.028	.057	2.613	.009
	lintsqft	-0.35	.024	-.434	-14.554	.000
	lage2	.560	.116	.151	4.824	.000
	lavgprice	.460	.037	.388	12.602	.000
	lavgincome	.473	.080	.191	5.907	.000
	Idist	-.041	.008	-.120	-5.334	.000

a. Dependent Variable: lpricesqft
b. R-square = 0,75 (0,000)

Source: authors' own elaboration

The rest of the results are in line with what is expected and the obtained estimates are highly significant. First, the size of the dwelling affects prices: as the size increases, the price per square meter diminishes, even if the total price rises. Second, age has a positive effect on prices. Demand in London values more a more antique dwelling. Also, average income in the neighbourhood and average price of properties in the neighbourhood are important factors for determining the price of a dwelling. Finally, the distance of the dwelling to downtown London affects its price: a longer distance means a lower price in this case.

France results

We test the same model for the France sample. Results are based on a simple scores model, that is to say, a model that takes into account the scores that the Energy Performance Certificates allocate to each dwelling, instead of the grades the EPC gives. In the case of France, this means using the Energy Consumption score, opposite to the Energy Performance score in the UK: higher energy consumption indicates lower efficiency, a higher rating/score means lower efficiency. We also use the same indicator for Greenhouse Gases emissions, also devised by French authorities in the same way as EPC scores.

As mentioned before, the final sample used for this analysis includes a total of 4646 dwellings, after eliminating those properties with potential problems. The estimation of the model gives an R-square of 0.67. In terms of coefficients, our results are, at least qualitatively, again in line with those reflected by similar models in the literature (see Table 26). A 1% increase in the EPC score accounts for a 0,022% decrease on the price per square meter of the dwelling. That is to say, for example that the difference between an average D score (190) and an average Green label (72) represents a 0,014% change in the price per square meter. This compares with a 4,7% increase in Kok & Jennen (2011) for the same range in commercial rentals in The Netherlands. Put differently, passing from a D label to a B label means around 0,4 Euros more per square meter for a given dwelling. Possible reasons for this lower effect are related to a National more diverse sample, a more benign weather, or the lower convergence to the EPBD by France.

The rest of the results are in line with what is expected. First, the size of the dwelling affects prices: as the size increases, the price per square meter diminishes, even if the total price rises.

Table 26. Coefficients for the model based on the France sample

Coefficients [a, b]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	71.112	1.777		40.014	.000
	lepcscore	-0,022	0,009	-0,024	-2,513	.012
	lintsqmt	-0,007	0,004	-0,017	-1,79	.074
	lage	-0,582	0,011	-0,548	-55,062	.000
	lavgprice	0,459	0,015	0,385	30,397	.000
	lavgincome	0,34	0,019	0,022	1,827	.068

a. Dependent Variable: lprsqmt

b. R-square = 0,67 (0,000)

Source: authors' own elaboration

Second, age has a negative effect on prices. Demand in France values less a more antique dwelling. Finally, average income in the neighbourhood and average price of properties in the neighbourhood are important factors for determining the price of a dwelling.

Annex

Table 27. Table of Correlations for the London model

		Ilpricesqft	lepcscore	lenvscore	lintsqft	lage2	lavgprice	lavgincome	ldist
Pearson Correlation	Ilpricesqft	1	.256	.290	-.735	.280	.765	.446	.040
	lepcscore	.256	1.	.779	-.305	-.69	.134	.205	.116
	lenvscore	.290	.779	1	-.338	-.008	.198	.219	.146
	lintsqft	-.735	-.305	-.388	1	-.163	-.561	-.431	-.337
	lage2	.280	-.069	-.008	-.163	1	.381	-.462	-.024
	lavgprice	.765	.134	.198	-.561	.381	1.	.351	-.013
	lavgincome	.765	.134	.198	-.561	.381	1.	.351	-.013
	ldist	.446	.205	.219	-.431	-.462	.351	1.	.83
Sig. (1-tailed)	Ilpricesqft	0	.00	.00	.00	.00	.00	.00	.166
	lepcscore	.00	.	.00	.00	.045	.000	.00	.02
	lenvscore	.00	.00	.	.00	.424	.00	.00	.00
	lintsqft	.00	.00	.00	.	.00	.00	.00	.00
	lage2	.00	.045	.424	.00	.	.00	.00	.282
	lavgprice	.00	.00	.00	.00	.00	.	.00	379
	lavgincome	.00	.00	.00	.00	.00	.00	.	.021
	ldist	.166	.002	.00	.00	.282	.379	.021	.
N	Ilpricesqft	598	598	598	598	598	598	598	598
	lepcscore	598	598	598	598	598	598	598	598
	lenvscore	598	598	598	598	598	598	598	598
	lintsqft	598	598	598	598	598	598	598	598
	lage2	598	598	598	598	598	598	598	598
	lavgprice	598	598	598	598	598	598	598	598
	lavgincome	598	598	598	598	598	598	598	598
	ldist	598	598	598	598	598	598	598	598

Table 28. Mean and standard deviation of variables in the London sample

	Mean	Std. Deviation	N
Ilpricesqft	62775.66	4099.285	598
lepcscore	41073.0736	3188.22535	598
lenvscore	40622.6254	3089.21481	598
lintsqft	69242.7140	5080.56290	598
lage2	43261.7258	1106.05718	598
lavgprice	127187.088	3449.62621	598
lavgincome	104181.757	1653.24148	598
ldist	35469.6806	11994.2691	598

Chart 61. Map of London Boroughs

Table 29. Table of Correlations for the France model

		Iprsqmt	lepcscore	lenvscore	lage	Iintsqmt	lavgpr	lavginc
Pearson Correlation	Iprsqmt	1	.127	.013	.017	-.743	.665	.500
	lepcscore	.127	1.00	.461	.442	-.186	.137	.179
	lenvscore	.013	.461	1.00	.523	-.008	-.090	.191
	lage	.017	.442	.523	1.00	.024	.139	.191
	Iintsqmt	-.743	-.186	-.008	.024	1.00	-.493	-.388
	lavgpr	.665	.137	.090	.139	-.493	1.	.707
	lavginc	.500	.179	.191	.191	-.388	.707	1.
Sig. (1-tailed)	Iprsqmt	.	.00	.182	.130	.00	.00	.00
	lepcscore	.00	.	.00	.00	.00	.00	.00
	lenvscore	.182	.00	.	.00	.291	.00	.00
	lage	.130	.00	.00	.	.051	.00	.00
	Iintsqmt	.00	.00	.291	.051	.	.00	.00
	lavgpr	.00	.00	.00	.00	.00	.	.00
	lavginc	.00	.00	.00	.00	.00	.00	.
N	Iprsqmt	4646	4646	4646	4646	4646	4646	4646
	lepcscore	4646	4646	4646	4646	4646	4646	4646
	lenvscore	4646	4646	4646	4646	4646	4646	4646
	lage	4646	4646	4646	4646	4646	4646	4646
	Iintsqmt	4646	4646	4646	4646	4646	4646	4646
	lavgpr	4646	4646	4646	4646	4646	4646	4646
	lavginc	4646	4646	4646	4646	4646	4646	4646

Table 30. Mean, standard deviation and number of items in the sample

	Mean	Std. Deviation	N
Iprsqmt	80726.4684	4122.42410	4646
lepcscore	52299.3465	4573.76753	4646
lenvscore	31125.7957	9113.24513	4646
lage	31784.2746	10103.9135	4646
Iintsqmt	49267.3706	3884.89246	4646
lavgpr	78827.6337	3460.64357	4646
lavginc	101975.662	2660.62530	4646

Chart 62. Departments of France

7. European regulation impact on the market for construction materials: Doors and Windows

Introduction

One of the most important goals of this project is to assess the effects of energy efficiency regulation on the behavior of markets for construction materials. Besides understanding that willingness to pay for green creates incentives for owners of dwellings to refurbish and build with greener construction materials, we want to analyze the exact impact of the regulation in place.

For instance, does the consumer ask for greener products (i.e.: recycled material)? Has the demand of a certain product changed since the implementation of the regulation?

With partial data provided by ALCOA on sales of Building & Construction Aluminum, we were able to identify potential patterns of consumption in European countries regarding the use of aluminum. However, we warn the reader that an important problem with deriving general conclusions from these data lies with the fact that the only information about aluminum demand was sales from ALCOA. Though we tried to find better data, unfortunately this task has proven unsuccessful to date. There seem to exist very few sources of reliable data for construction materials for Europe and we have unable to obtain data upon request.

A potential source of information about the impact of European climate mitigation regulation such as the EPBD on the construction material market is the market for windows and doors.

Market researchers indicate that overall European demand for windows has fallen significantly in 2009, although the decline was not felt to the same extent in all countries.

In France, Spain, the United Kingdom and The Netherlands, market demand for windows declined sharply in 2009, following the downward trend in overall construction activity. However sales of windows in Germany increased by at least 2% in 2009 due to state funding and public commitment for energy-efficiency measures.

Total market volume in the EU27 reached around 158.9 million window units in 2007. This figure increased by 2.7 million units in 2008 to 161.6 million. PVC windows accounted for by far the largest share in 2008 at approximately 93.6 million window units. This compares to 35.7 million aluminum units, 27.5 million wood units, and 4.8 million units combining wood and aluminum.

Our focus has been to gather information about this market in countries with a deeper commitment to the EPBD. The UK (England and Wales) was one of the first choices due to its situation as a pioneer and a convergent country in regards to the EPBD.

Information regarding demand for door & windows of different materials was difficult to gather in England. Changes in the statistical methodologies and on the authorities gathering the information were coupled with incomplete public sources. Our team contacted several UK government branches in order to build a complete database for both quantities and prices of windows and doors units in England.

Our ultimate aim is to build a model of the demand for Windows and Doors for England in order to understand own- and cross-price elasticities. This would enable us to study how markets reacted to EPDB the regulation. Insufficient information has not yet allowed us to complete this task.

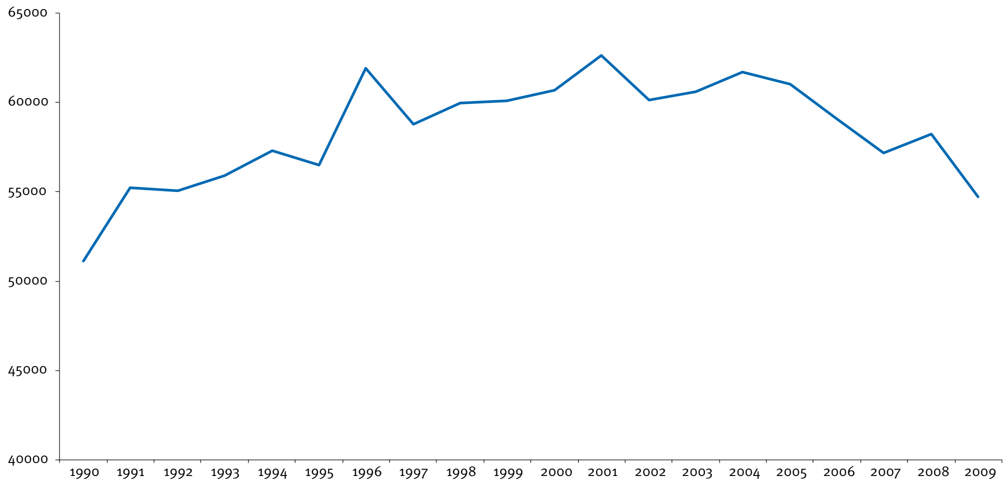
A second possibility laid in relating Demand of different Doors and Windows with Refurbishment expenditures in England. Doors and Windows have been identified in several studies as sources of energy efficiency for a dwelling. Refurbishing Doors and Windows has been a usual recommendation by these reports.

Our research team gathered information from the Communities Department about Refurbishment expenditures in England since 1990 in order to assess how it was related to sales of Doors and Windows sales. In what follows, we enumerate our main conclusions about this issue.

Energy consumption in the United Kingdom

The evolution or energy consumption by the Building sector in the United Kindom is shown in the Chart 63. As we can see, from 2002 onward the trend has been towards a reduction in energy consumption that does not seem to be correlated with the economic cycle.

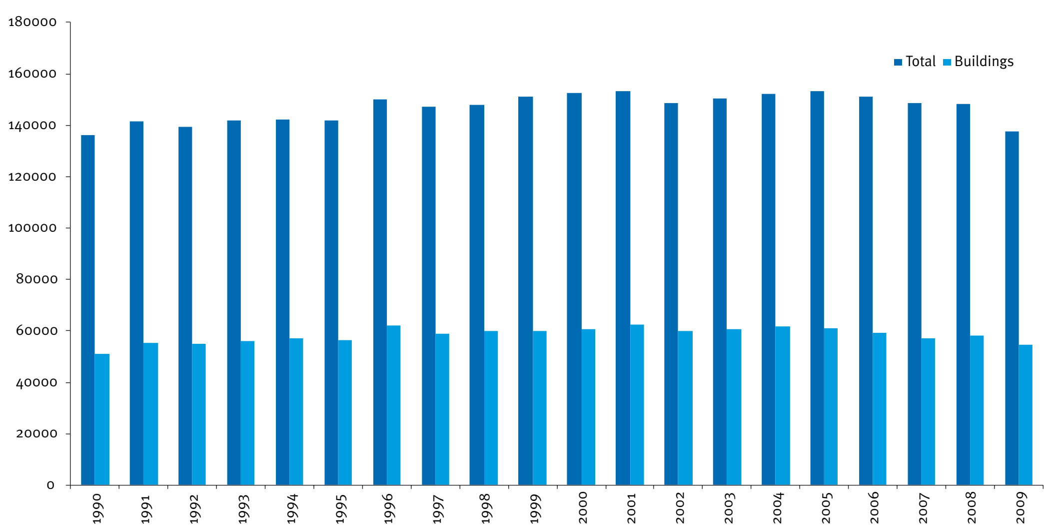
Chart 63. Energy consumption by Buildings in the UK



Source: Eurostat

In Chart 64 we also can compare the evolution of Total Energy consumption with that of the Building sector. Total Energy consumption appears to be highly correlated with the economic cycle. Also, Buildings have lowered its share of Total Energy consumption.

Chart 64. Buildings and total energy consumption in the UK



Source: Eurostat

Refurbishment expenditures in England

The following Charts (65 and 66) show the evolution of Refurbishment Expenditures in England since 1990. Our aim is to identify trends and changes in trends in order to explain the effect of mitigation regulation (subsidies and other incentives such as labels) on repairs in the dwelling stock. We analyze both Public and Private expenditures in order to identify any possible difference in patterns of behavior.

Chart 65. Annual evolution of Refurbishment Demand

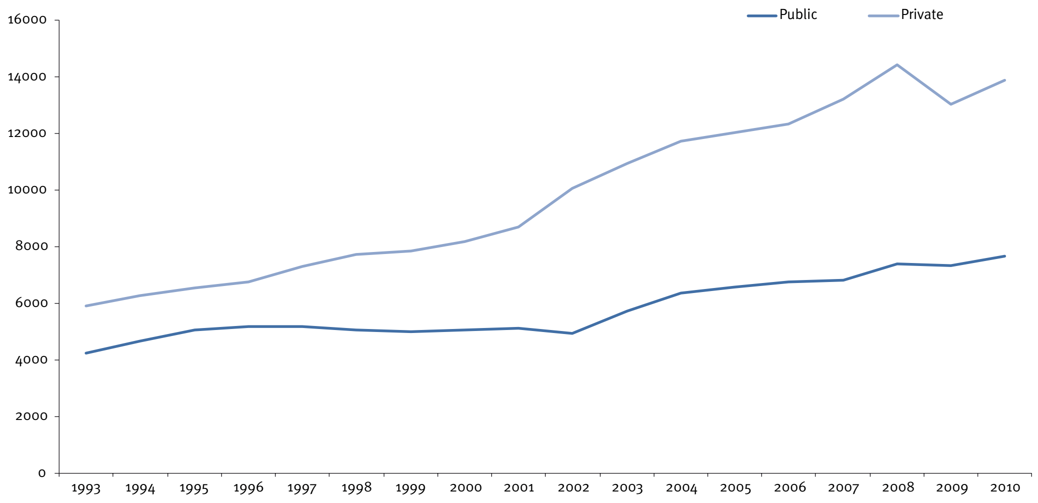
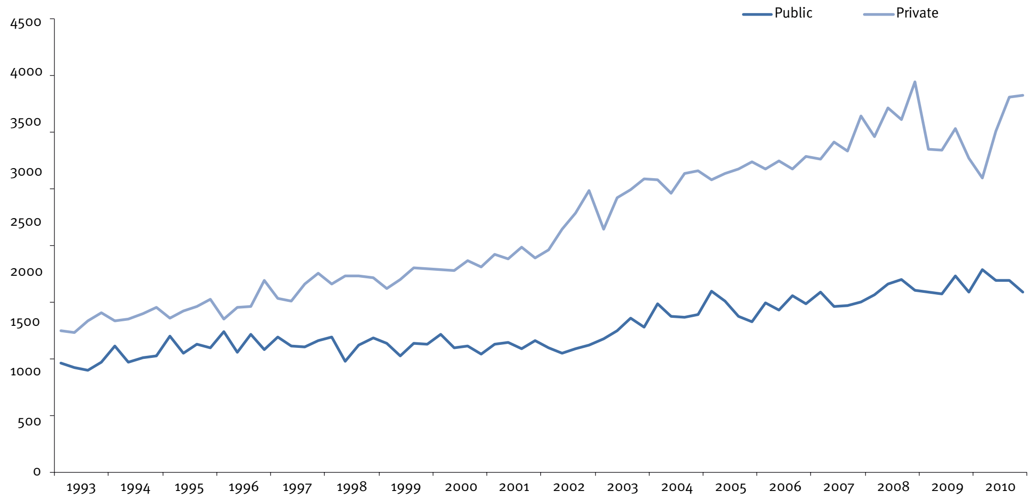


Chart 66. Quarterly evolution of Refurbishment expenditures in England



We identify a change in the trend of refurbishment expenditures (private and public) since 2002. After 2007, trend growth diminishes as is shown by the change in the slope.

Finally, we note that total refurbishment expenditures grew by 60% since the enactment of the European Performance of Buildings Directive. This represents an annual 7% increase in refurbishment expenditures and an acceleration of these expenditures, probably caused by new economic incentives and more information.

Refurbishment expenditures and the market for Doors and Windows

Though there are various types of repairs one can make in a dwelling, because of available data, we next focus on upgrades of doors and windows. The share of doors and windows sales of distinct materials in England can be seen in Chart 67. The corresponding graph for quantities in in Chart 68. Wooden windows and doors are clearly the most popular, probably due to their low prices. The next most popular type of material is plastic, followed by aluminum and steel, which command higher prices. This pattern is more or less a constant over time (see Chart 69).

Chart 67. Share of Doors & Windows Sales in England (2010)

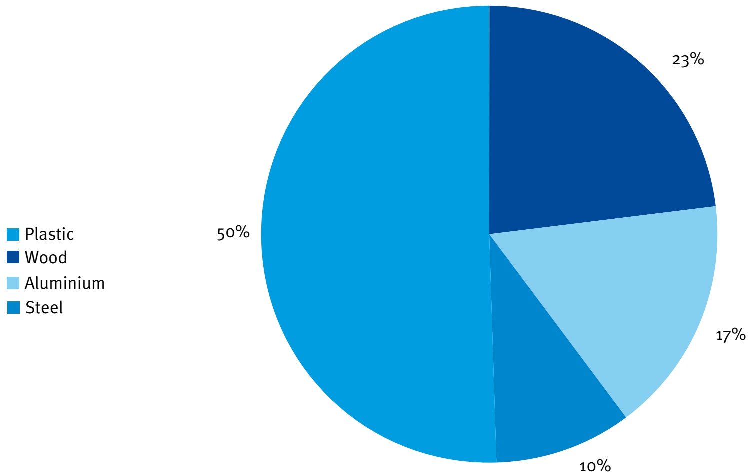


Chart 68. Share of Units of Doors & Windows sold in England (2010)

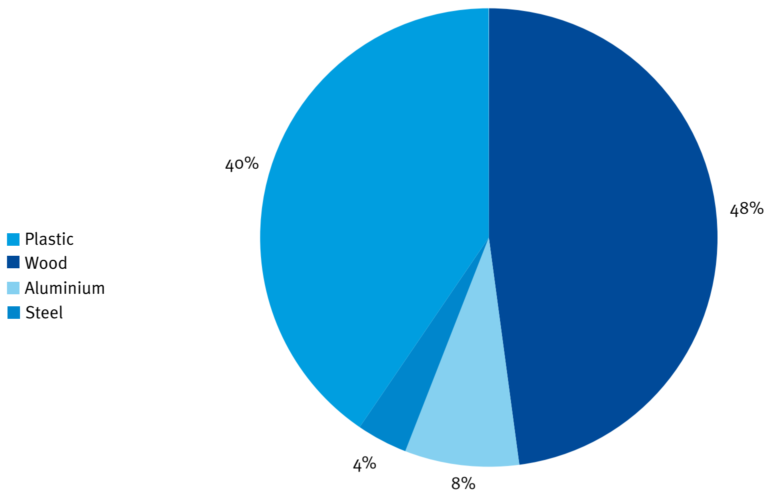
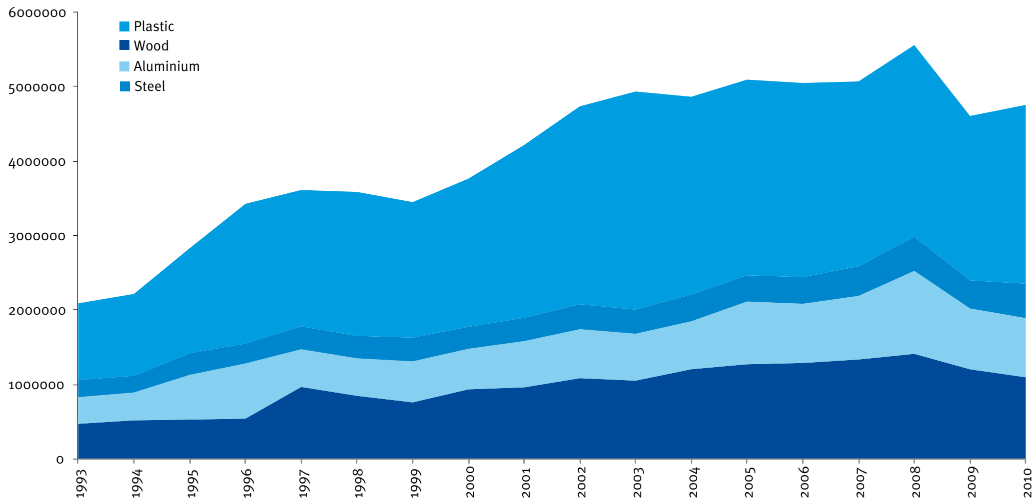


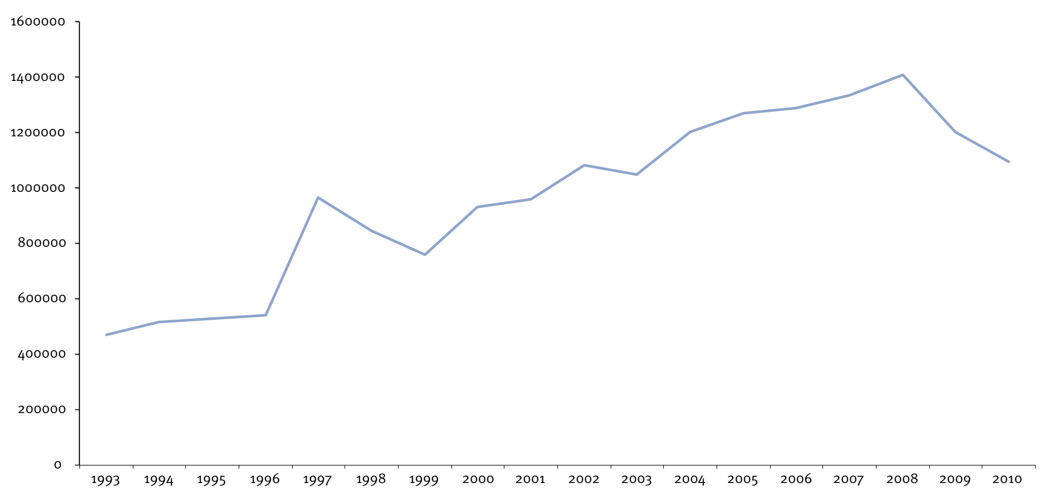
Chart 69. Evolution of Doors & Windows shares in England (Sales GBP 000s)



Wood Doors and Windows

Recent evolution of sales and prices for Wood Doors & Windows has followed an increasing path between 1993 and 2008. However, sales of Wood Doors and Windows present a decrease during the recent economic recession, from 2008 to 2010.

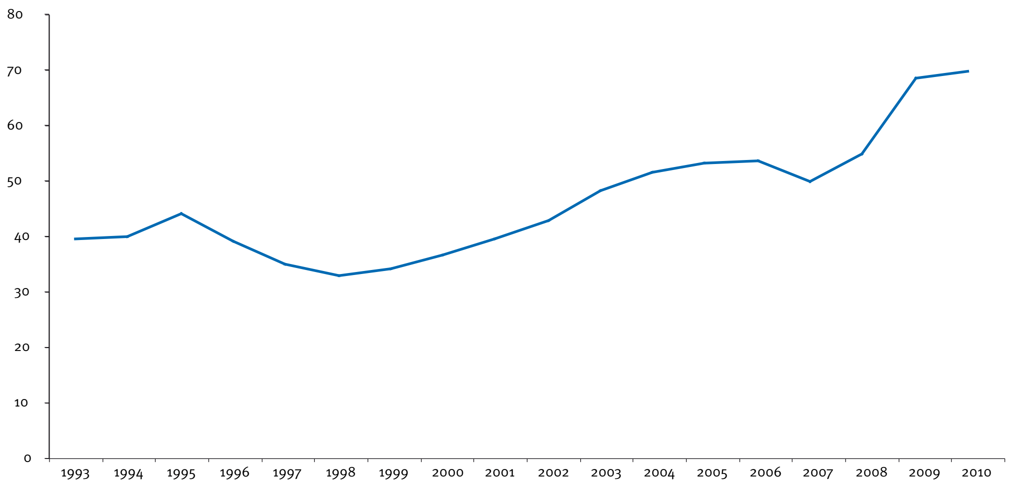
Chart 70. Sales of Wood Doors & Windows



Source: authors' own elaboration (Sales GBP 000s)

At the same time, prices for Wood Doors & Windows present an upward trend that continues to increase (even with a steeper slope) after 2008.

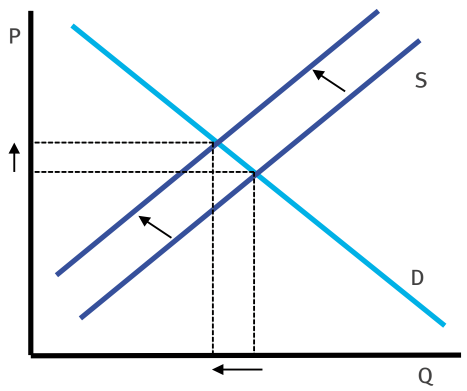
Chart 71. Price per item evolution for Wood Doors & Windows



Source: authors' own elaboration (GBP)

How can we rationalize these late events using economic theory? Though it is very likely that there has been an important demand shock due to the fall in economic activity during the recent recession, the observed price increase points towards there being a dominant supply shock in the Wood Doors & Windows market. This shift in supply was probably due to an increase in the costs of raw materials, lack of credit and the exit of producers of this product from the market (later we provide evidence pointing towards a shake-out process). Chart 72, abstracting from the fall in demand during the recession, shows the effect of a supply contraction on sales, which decrease, and prices, which increase.

Chart 72. Shifts in Supply of Wood, Aluminum and Plastic Doors & Windows



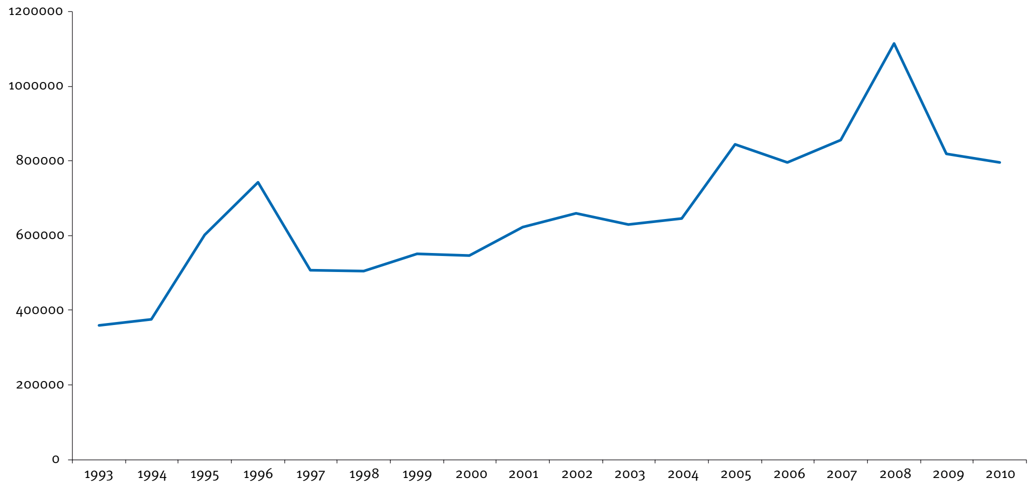
Source: authors' own elaboration

Aluminium Doors and Windows

Aluminum Doors and Windows sales and prices follow a similar path to that of Wood Doors & Windows. The upward trend in sales stops in 2008, coincidentally with the beginning of the economic crisis. The fall in sales in 2008 is very severe though it seems to level-off again in 2009 (see Chart 73).

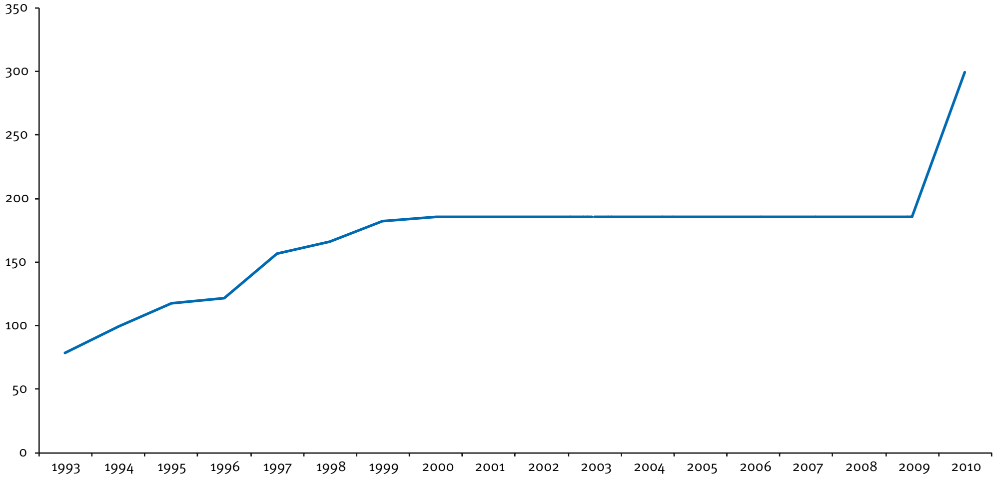
Despite not being able to gather a complete series of data for the period, we can see in Chart 74 that prices for Aluminum Doors & Windows sharply jump in 2009, not following the path that we perceive until 2001. This conclusion is supported by two related issues: total units sold drop in this period while market share (sales) remains at 17%, the same level as in 1993.

Chart 73. Sales of Aluminum Doors & Windows



Source: authors' own elaboration

Chart 74. Price per item evolution for Aluminum Doors & Windows



Source: authors' own elaboration

The observed pattern can again be explained by the existence of a supply contraction that has a dominating influence over the likely demand contraction occurred during the recent economic crisis (Chart 72). We expect the reasons for this supply shock to be similar to the ones underlying the supply contraction of wood doors and windows, including the exit of a good number of producers (again, later we provide evidence on this).

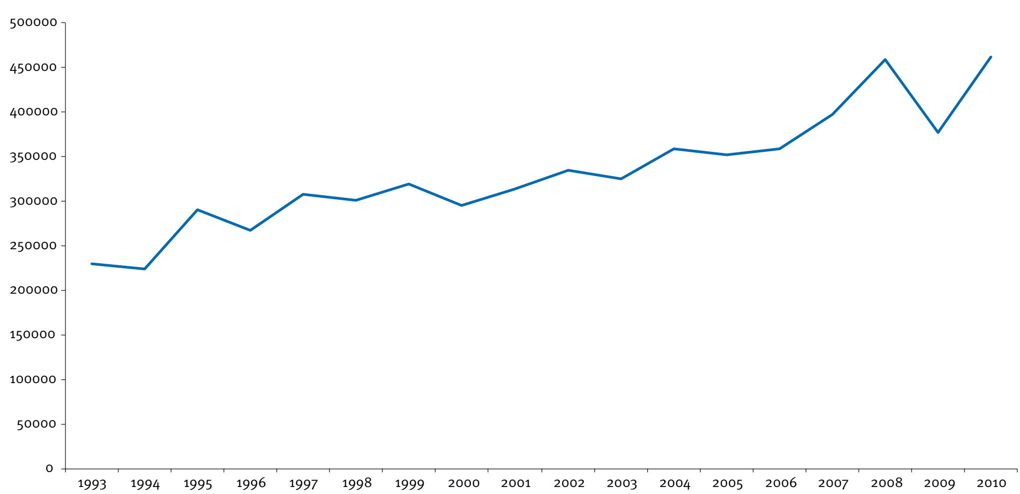
Steel Doors and Windows

In the case of Steel Doors & Windows, the evolution follows a slightly different path from the two previous cases. For instance, sales of Steel Doors & Windows follow an upward trend almost uninterruptedly since 1993; they fall abruptly in 2009 but recover steeply in 2010 (see Chart 75).

Prices, however, follow an opposite path to that in the case of Wood and Aluminum items: an upward trend until 2008, when prices begin a continued fall (see Chart 76).

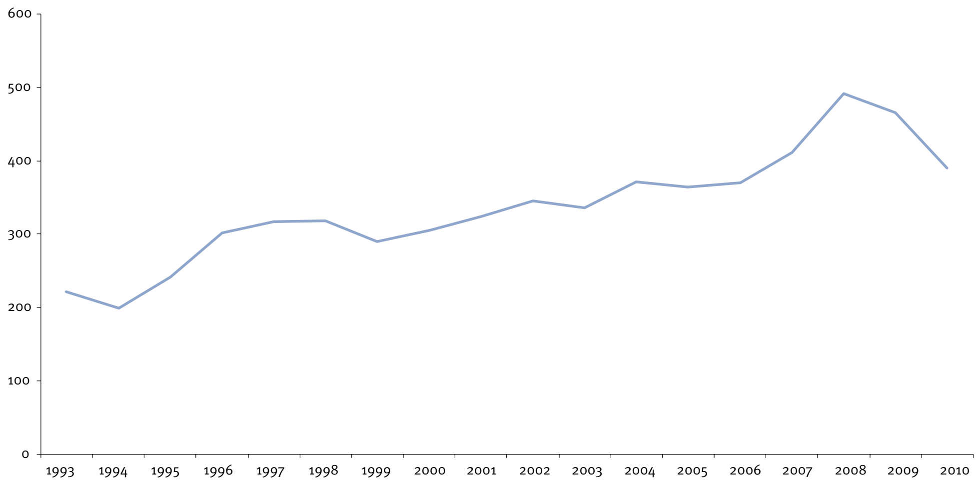
Finally, we record a drop in unit sales that results in a loss of 1% of the market compared to 1993, because prices went up during this period.

Chart 75. Sales of Steel Doors & Windows



Source: authors' own elaboration

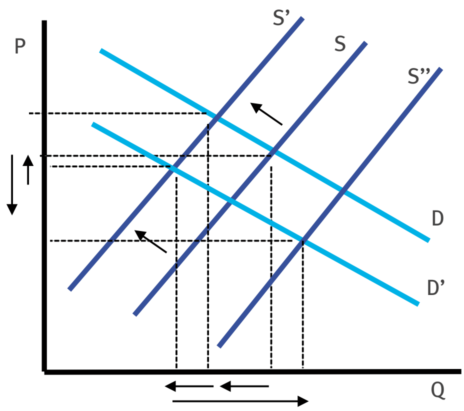
Chart 76. Price per item evolution for Steel Doors & Windows



Source: authors' own elaboration

The economic interpretation is somewhat more complicated in this case. It is likely that there has been a substitution effect whereby consumers have substituted away steel doors and windows in favor of wood and aluminum ones. This, added to the downturn, may have shifted the demand for steel products leftward. Like in the previous cases, we expect the supply to have shifted upwards. These two effects would have led to a decrease in prices and a fall in sales in 2008. The immediate recovery of sales and a further price fall from 2009 to 2010 probably has to do with a supply shift. Chart 77 depicts a plausible explanation for the recent trends observed in the market for Steel Doors and Windows.

Chart 77. Potential shifts in Supply & Demand of Steel Doors & Windows

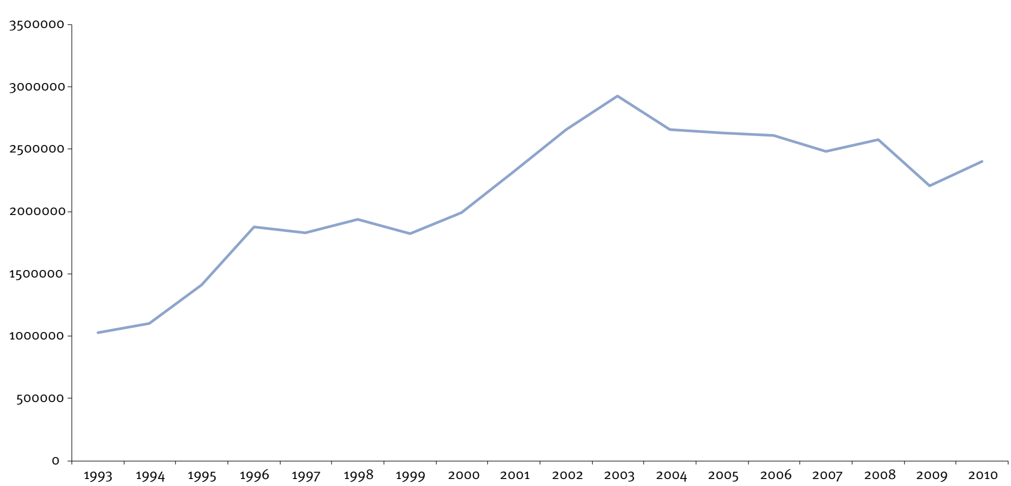


Source: authors' own elaboration

Plastic Doors and Windows

Sales of Doors and Windows made of Plastic, which maintain the larger market share in the whole period (50%) go up in the period under study (see Chart 78). However, we have been unable to find suitable and complete data for prices and units sold of Plastic Doors and Windows.

Chart 78. Sales of Plastic Doors & Windows



Source: authors' own elaboration

Analyzing the market for plastic doors and windows in light of the recent evolution of market shares in the other products leads to three potential hypotheses. First, prices of plastic doors and windows went down, compensating an increase in units sold. The first part of this premise looks suspicious because oil based products, such as PVC and Plastic, have shown an increase in their prices due to higher than ever commodity prices.

Second, prices of plastic doors and windows went up. However, this does not seem possible due to the increase in refurbishment expenditures and the increase in the dwelling stock we have witnessed in this period. A more probable scenario is one where both prices and units sold went up at the same time. In terms of the analysis for the last couple of years, this would entail that the demand shock due to the economic crisis was dominated by a supply contraction, as explained above.

Evidence on exit of firms during 2008-2010

We found some relevant evidence for the hypothesis that firms left the market of doors and windows after 2008 provoking a shock in supply (contraction) that resulted in higher prices despite the deep economic crisis we are in. We conducted an analysis of the data that the Communities Department of England publishes about the contractor market.

The analysis of the contractor market shows very interesting results. First, the number of firms drops in 2009, with the exit of 8,000 companies. Small firms were the ones that got the hardest hit by the crisis (limited maneuverability, lack of credit, etc.), and this made it that this type of firms left the market more frequently than their bigger counterparts.

Second, the number of joinery firms, which specialize in Doors and Windows, drops in 2009 after the exit of 1,200 companies. At the same time, “Liquidations” raise to a highest since 1996 rate of almost 20%. Both these facts support our hypothesis of a supply contraction.

However, in 2010, Communities registers 62,000 entries in the contractor market with Joinery firms up 3,600, also, in line with our after crisis hypothesis for the Steel market.

Finally, the number of insulation firms raises in 2009, the only segment that presents a higher number of companies. This hints a higher effort towards energy efficiency in England after the EPBD and despite the crisis.

Results of our analysis

Given the rather incomplete set of data we have been able to assemble, and the information restrictions we encountered, our analysis is unfortunately limited to identify potential patterns of behavior and changes in these patterns over time in order to derive some conjectures that could be tested in the future with better data.

A very simple tool we find useful in this case is the study of the correlations between public and private refurbishment expenditures and the sales of Doors and Windows of different materials. Table 31 presents these correlations for the period 1993-2010, while Table 33 does it for the period after the EPDB, i.e. 2002-2010. The hypothesis is that Refurbishment is often focused on these products and that, if refurbishment has increased since the EPBD, a change in the pattern of consumption could indicate that certain materials are identified as "greener" than others.

Table 31. Correlations of Refurbishment and Sales of Doors & Windows (1993-2010)

Correl. 93-10	Manuf Sales	Net Supply	Wood	Aluminum	Steel	Plastic
Total Ref	0,8906	0,8721	0,8965	0,8559	0,9336	0,7673
Public Ref	0,7930	0,7661	0,8037	0,8504	0,9088	0,6412
Priv Ref	0,9123	0,8972	0,9164	0,8444	0,9280	0,8014

Although we cannot infer causation, these correlations show interesting results. First, between 1993 and 2010, sales of Doors & Windows are highly correlated with Refurbishment expenditures, both public and private.

Also, since the EPBD (2002-2010), Aluminum and Steel Doors & Windows seem to be preferred for refurbishment. This is shown by higher correlations of expenditures for these products, especially with private refurbishment.

Finally, public refurbishment, which can be related to Green Public Procurement since 2002, reduces expenditures in Doors and Windows. This could signal future expenditures on this segment by public procurement.

Table 32. Correlations of Refurbishment and Sales of Doors & Windows (2002-2010)

Correl. 02-10	Manuf Sales	Net Supply	Wood	Aluminum	Steel	Plastic
Total Ref	0,5473	0,1039	0,5785	0,7711	0,8763	-0,6475
Public Ref	0,6098	-0,0185	0,4989	0,6722	0,8009	-0,6854
Priv Ref	0,6006	0,1779	0,6168	0,8176	0,9062	-0,6114

As we mentioned before, constructing a complete database of units, sales, and prices of construction materials and being able to compare these data to databases of energy consumption, direct expenditures on these goods, and other effects of the European mitigation regulation.

On a final note, we point out that very short time has elapsed since the enactment of the EPBD and the enforcement of NEEAPS, even in pioneer-convergent countries such as England. We intend to complete these data and develop new models of demand in the years to come.

8. Conclusions

This project represents one of the few existing attempts to measure the effect of policies and regulations regarding climate change mitigation in the markets they attempt to regulate. We focus on the analysis of the effects of European Union policies regarding energy efficiency, which are mostly aimed towards residential dwellings due to the identification of this sector as one of the main sources of energy inefficiency and, hence, of Greenhouse Gases emissions.

First, we develop an overview of the situation in Europe regarding 2020 targets. Our conclusion is that these targets are still far from being reached. Even though recent economic activity has resulted in lower GHG emissions and Energy consumption, this situation is temporary and growth in emissions and energy consumption will resume once the recession is over. If the current targets are far in this situation, efforts towards energy efficiency will have to be renewed.

We continue with the analysis of Energy Efficiency regulation at the European level and we focus on the European Performance of Buildings Directive and its recast of 2010. The recast leaves many issues unresolved which will need to be addressed either by National Energy Efficiency Action Plans (by Member States) or by the European Commission. Hence, we continue analysing the state of NEEAPs in seven European countries.

Our National Energy Efficiency Action Plan analysis for the United Kingdom, The Netherlands, Spain, France, Germany, Portugal and Italy provides two interesting tools in order to measure the national efforts to comply with European mitigation regulation. These tools are combined into a Convergence Index that takes into account both the Velocity of adoption of EPBD rules at the National Level and the Convergence of these rules to the EPBD 2010 recast.

These tools show that there are three levels of countries in terms of Velocity of Adoption (Pioneers, Early Movers and Laggards) and other three levels in terms of Convergence to the EPBD (Convergent, Chronic and Non-Convergent).

Countries like the UK, The Netherlands or Portugal are important not only because they have advanced rapidly and are convergent, but also because they provide guidance and experience in terms of enforcement of regulation and on the effects of this regulation on the markets.

We analyse these studies in a Meta Analysis of Willingness to Pay for Green Dwellings that comprises all the studies on this issue so far. Our intention is to understand the results, but also the methodologies employed and their soundness. We find that there are three different groups of analysis from a conceptual point of view (residential dwellings for sale, commercial buildings for sale, and commercial buildings for rent) and that studies have been conducted in Australia, The Netherlands, US and Switzerland. The methodologies and samples differ in many aspects, but also the results obtained appear to be more credible in some cases than others due to problems with the methodology, the sample or the methodology.

In fact, only the study in Australia and the studies that have been conducted regarding the willingness to pay for green dwellings in The Netherlands (or the ones conducted by the mentioned Dutch researchers on the US) seem conclusive.

Knowing this, our research team conducted similar tests on the Greater London Area, which prove that dwelling buyers value more energy efficient dwellings. We found that energy efficient (i.e., "green") dwellings are valued 0,073% more than non-efficient dwellings. This results in an increase of 2,87% in price when a dwelling is converted from a D label into a Green Label (average). That is to say, 17 GBP more per square foot.

In a second group we find countries like France or Germany, which have a long history of energy efficiency regulation. History proves, however, that such regulation is an obstacle for convergence. In this sense, the national effort seems troubled by pre-existing regional and local regulations. More convergence will definitely take place in the next years but it will demand intra-convergence too, i.e., regional and local regulation inside each country will have to be adapted towards a common, unique national regulation that follows the EPBD mandate.

In order to analyze how consumers behave in these countries, we conducted research on France in order to assess the willingness to pay for green dwellings. The results were positive and interesting: green dwellings were valued more than non-green dwellings. If a dwelling that had a D label becomes Green it will increase its price per square meter in 0,4 Euros.

Even though these tools can be improved in many aspects, they provide an interesting map of the fields where different countries need to adjust in order to comply with the EPBD and with what other members of the EU are achieving.

Incentives towards convergence are also both positive and negative. Positive incentives are those related to achieving larger energy efficiency, reducing Greenhouse Gases emissions and creating new sources for employment, given the new markets that arise because of the regulation and the needs of the consumers.

Negative incentives will take the form of both sanctions from the EU Commission to the Member States and punishment by voters to national leaders that fail to guide a country into a desired direction: reducing emissions.

It is fair to say, then, that convergence will occur and that countries that lag in terms of policies (Spain, Italy, among others) will have to act rapidly to adjust their policies.

9. References

"Environmental Policy in a Green Market"; Moraga & Padrón (2001)

"Determinants of demand for green products: an application to eco-label demand for fish in Europe"; Brecard et al. (2009)

"Policy options towards an energy efficient residential building stock in the EU-27"; Uilhein & Eder (2009)

"Options to reduce the environmental impacts of residential buildings in the European Union-potential and Costs"; Nemry et al. (2009)

"Economic analysis of the profitability of energy saving architectural measures for the achievement of the EPB-standard"; Audenart, Boeck & Roelants (2009)

"Sustainability in the construction industry: a review of recent developments based on LCA"; Ortiz, Castells and Sonemann (2007)

"Transforming The Market" by the World Business Council for Sustainable Development.

"Pathways to a low carbon economy" by McKinsey 2010

"Impact of the financial crisis on carbon economics" by McKinsey 2010.

"Energy Efficiency: Accelerating the Agenda" by the World Economic Forum and Accenture

"Sustainability of Aluminium in Buildings"; European Aluminium Association (2010)

BuildUp - Energy solutions for better Buildings - http://www.buildup.eu

ILCD Handbook. International Reference Life Cycle Data System.General guide for Life Cycle Assessment. Detailed guidance. European Commission - Joint Research Centre - Institute for Environment and Sustainability (2010).

World Business Council for Sustainable Development - http://www.wbcsd.org

European Commission Environment http://ec.europa.eu/environment/gpp/what_en.htm http://rhein.blogactiv.eu/2009/04/27/zero-energy-buildings-in-the-eu-by-2019/

European Environment Agency, "Tracking progress towards Kyoto and 2020 targets in Europe" (2010)

European Environment Agency Technical report No 6/2010, "Annual European Union greenhouse gas inventory 1990–2008 and inventory report 2010 Submission to the UNFCCC Secretariat" (2010)

"Directive 2009/28/EC on the promotion of the use of energy from renewable sources". The European Parliament and the Council (2009).

"Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products (recast)". The European Parliament and the Council (2009).

"Decision No 406/2009/EC on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020". The European Parliament and the Council (2009).

"Directive 2010/31/EU on the energy performance of buildings (recast)". European Parliament and the Council (2010).

"Communication on Green Public Procurement". The European Commission (2008).

Energy Efficiency National Action Plans:

Germany: Bericht der Arbeitsgruppe 3 "Forschung und Energieeffizienz". BundesministeriumfürUmwelt, Naturschutz Und Reaktorsicherheit, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of Germany (2006).

UK: "Energy Efficiency: The Government's Plan for Action". Department for Environment, Food and Rural Affairs of United Kingdom (2004).

Ireland: "Maximising Ireland's Energy Efficiency. The National Energy Efficiency Action Plan 2009 – 2020". Department of Communications, Energy and Natural Resources of Ireland.

France: "Energy efficiency action plan for France". Note from the French Authorities (2008).

Near Zero Buildings National Action Plans:

Spain: "Acuerdo de Consejo de Ministros por el que se aprueba el Plan de Ahorro y Eficiencia energética en los edificios de la Administración General del Estado". Consejo de Ministros del Gobierno de España (2006). "Real Decreto 47/2007 por el que se aprueba el Procedimiento básico para la certificación de eficiencia energética de edificios de nueva construcción". Ministerio de la Presidencia del Gobierno de España (2007).

Greece: "Last update of status quo in Greece regarding EPBD adaptation". RURASU, Rural Advice and Support Units for integrated energy management in buildings, a project supported by the European Commission (www.rurasu.info). http://goo.gl/7PCFK

The Netherlands: "Criteria for the Sustainable Public Procurement of Office Buildings to be newly built". Environment and Spatial Planning. Ministry of Housing, Spatial Planning and the Environment (2010).

International Energy Agency: http://www.iea.org/subjectqueries/buildings.asp

"Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings". IEA (2008).http://www.iea.org/subjectqueries/buildings.asp

"Energy Efficiency Policy, recommendations.". IEA (2008). http://www.iea.org/subjectqueries/buildings.asp

Environmental Improvement Potentials of Residential Buildings (IMPRO-Building). European Commission. Joint Research Centre. Institute for Prospective Technological Studies (2008).

Housing Statistics in the European Union 2004. National Board of Housing, Building and Planning, Sweden and Ministry for Regional Development of the Czech Republic (February 2005).

TrendanalyseHochbaubis 2012. Expertise. Dr. Wolfgang Amann (2006).

"The Diffusion of Green Labels in the Housing Market". Brounen, Kok & Quigley (2009).

"Energy Performance Certification in the Housing Market Implementation and Valuation in the European Union". Brounen, Kok & Menne (2009).

"Energy Efficiency Rating and House Pricing in the Act". Australian Government. Department of the Environment, Water, Heritage and the Arts (2008).

"Willingness to Pay for Energy-Saving Measures in Residential Buildings". Banfi, Farsi, Filippini & Jakob (2005).

"Doing Well By Doing Good? Green Office Buildings". Eichholtz, Kok & Quigley (2009).

"Energy Efficiency: A recipe for success"; World Energy Council; 2009.

"Energy Performance Certificates across Europe. From design to implementation". Buildings Performance Institute Europe; 2010.

Andaloro, A.; Salomone, R.; Ioppolo, G. and Laura Andaloro."Energy certification of buildings: a comparative analysis of progress towards implementation in European countries". Energy Policy 38 (2010) 5840-5866

Ministry Council Resolution 80/2008 - PNAEE

Council of Ministers Resolution 80/2008 - PNAEE

2015 Portugal Energy Efficiency - Summary Version

2015 Portugal Energy Efficiency - Public Consultation Attachments

Portugal Energy Efficiency Plan 2015 - Support

"Energy Efficiency Rating and House Price in the Act. Modelling the relationship of energy efficiency attributes to house price: the case of detached houses sold in the Australian Capital Territory in 2005 and 2006", Department of the Environment, Water, Heritage and the Arts, Australian Government, 2008.

"New Evidence on the Green Public Rent and Price Premium", F. Fuerst and P. McAllister, 2009.

"Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values", F. Fuerst and P. McAllister, 2011.

"Green Noise or Green Value? Measuring the Price Effects of Environmental Certification in Commercial Buildings", F. Fuerst and P. McAllister, 2008.

"Quantifying "Green" Value: Assessing the Applicability of the CoStar Studies", S. Muldavin, 2008.

"Willingness to pay for energy-saving measures in residential buildings", S. Banfi, M. Farsi, M. Filippini and M. Jakob, 2006.

"Measuring the Green Premium for Office Buildings. Does Green Pay off?", N. Miller, J. Spivey and A. Florance, 2008.

"Doing Well by Doing Good? Green Office Buildings", P. Eichholtz, N. Kok and J. Quigley, 2009.

"The Economics of Green Building", P. Eichholtz, N. Kok and J. Quigley, 2010.

"The Value of Energy Labels in the European Office Market", N. Kok and M. Jennen, 2011.

"The diffusion of Green Labels in the Housing Market", D. Brounen, N. Kok and J. Quigley, 2009.

"Energy Performance Certification in the Housing Market. Implementation and Valuation in the European Union", D. Brounen, N. Kok and J. Menne, 2009.

"On the Economics of Energy Labels in the Housing Market", D. Brounen and N. Kok, 2010.

"The Government's Standard Assessment Procedure for Energy Rating of Dwellings". DEFRA, March 2001.

"STATUTORY INSTRUMENTS. 2007 No. 991. BUILDING AND BUILDINGS, ENGLAND AND WALES." The Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007.

"Regulatory Impact Assessment Energy Performance of Buildings Directive Articles 7-10. The Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007". Department for Communities and Local Governments; March 2007.

"Improving the energy efficiency of our buildings. A guide to energy performance certificates for the construction, sale and let of non-dwellings". Department for Communities and Local Governments; January 2008.

"Recast of the Energy Performance of Buildings Directive". Department for Communities and Local Governments; July 2009.

"Revisions to the Code for Sustainable Homes. Impact assessment". Department for Communities and Local Governments; November 2010.

"Energy performance certificates for dwellings in the social and private rented sectors. A guide for landlords". Department for Communities and Local Governments; February 2011.

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