# On The Economics of Energy Labels in the Housing Market

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**Abstract**

The 2003 European Performance of Buildings Directive mandated all EU member states to enforce disclosure of building's energy performance. This is the first paper to analyse the introduction, adoption and market implications of energy labels (EPCs) in the housing market. We use a unique dataset on housing transactions in the Netherlands, including 194,000 transactions since the introduction of energy labels in January 2008. The results show that when energy performance certification is not mandatory, adoption rates are low and declining over time. Labels are clustered among post-war, single-family homes in more expensive, low-density neighbourhoods, where competition among buyers is low. This provides an indication that energy labels are adopted as a strategic tool in the transaction process. We also document that adoption rates of energy labels are highest in areas that have a high propensity of 'green' voters during elections, which implies that idealistic motives may also play a role in the decision to adopt an energy label.

The energy label seems to carry a moderately powerful market signal. We analyse the impact of energy labels on the transaction process of homes and find that the label does not affect time on the market. However, within the sample of certified homes, we document a significant price premium for homes with a 'green' energy label. The size of the 'green' increment is positively related to the energy efficiency of a dwelling and this result holds while controlling for various hedonic features, such as quality of insulation and the maintenance of the interior. Even though the label adoption rate is declining, the label premium is rather constant over time. The energy label creates transparency in energy consumption of homes and our analysis shows that consumers capitalize this information in the price of their prospective home.



Keywords: Energy labels, real estate, environmental sustainability

## I. Introduction

The spike in oil prices during the Summer of 2008 once again reinforced the discussion on energy efficiency in our society. Remarkably, with oil prices now falling to a lower level – followed belatedly by consumer prices of gas and electricity – energy efficiency seems to remain on the political agenda. This not only holds for countries traditionally aware of the environmental impact of energy consumption, but also for those countries that were previously not strongly engaged in energy-efficiency measures, like the United States.

One of the crucial differences between the current view on energy efficiency and the situation following the 1973 oil crisis is the increased focus on carbon emissions. Under the 1997 Kyoto protocol, the majority of developed countries and a host of emerging countries already pledged to substantially reduce greenhouse gas emissions. A more specific agreement signed by the members of the European Union in 2007 commits to reducing greenhouse gas emissions even further: at least 20 percent by 2020, compared to 1990 levels. Both agreements include mechanisms that allow for trading of carbon credits. This implies that in the near future, not just the sole use of energy will be costly, but also the extent to which a country, project or firm pollutes. Indeed, initiatives like the EU Emission Trading Scheme (EU ETS), which has been in place since 2005, and the UK Carbon Reduction Commitment, due to start in April 2010, are testimonies to this development.

The real estate sector is responsible for approximately 30 percent of global carbon emissions and 40 percent of global energy consumption (RICS, 2005). Moreover, the built environment offers the largest potential of greenhouse gas abatement (Per-Anders Enkvist et al., 2007, Nicholas Stern, 2008). This makes the sector an easy target of governmental energy-efficiency policies. The European Union has implemented the Energy Performance of Buildings Directive (EPBD) in January 2003, with the explicit goal of promoting the improvement of energy performance of buildings in the European

Union. The Directive, which has been recently recasted, includes an explicit element on the disclosure of energy performance in buildings: Article 7 states that "...Member states shall ensure that, when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant.....".[1] This has lead to implementation of national energy performance certificates (EPCs) for residential dwellings as well as utility buildings (e.g. office, retail, schools and healthcare facilities) across the European Union. The implementation of the EPBD contains various elements and is not synchronized across Europe. The introduction of energy performance certificates is regarded as a first and necessary step to create awareness and enhance the transparency of energy consumption in the housing market.

Creating transparency in energy performance may enable private and corporate occupiers to take energy efficiency into account when making housing decisions. From an economic perspective, the energy performance certificate should have financial utility for both real estate investors and tenants, as the energy savings flowing from higher energy-efficiency scores capitalize in higher values, *ceteris paribus.* The consequent demand-shift can trigger a higher buildings quality and thereby reduce energy consumption and carbon emissions. However, the diffusion and uptake of energy performance certificates across Europe is still limited, and investors as well as consumers are uncertain about the value represented by labels indicating a certain level of energy efficiency.

This paper is the first to empirically address the diffusion of energy performance certificates in the European Union. We study the drivers of the adoption of energy performance certificates and the consequent economic implications in the housing market. We use the Netherlands as a laboratory, as energy performance certification for homes has been introduced in the Netherlands in January 2008, one full year before the introduction date prescribed by the European Union. This makes the Netherlands one of the first countries to introduce the EPC-initiative. However, homebuyers have been allowed to sign a waiver that alleviates the obligation of certifying the dwelling at the

[1] Energy Performance of Buildings Directive, EU, 2009.

expense of the seller. During the first three months of 2008, more than 25 percent of all home transactions carried an energy label, but the adoption rate has decreased monotonically ever since, to less than 7 percent of the 150,000 homes that were for sale in October 2009.

The semi-mandatory choice for energy labeling creates a natural experiment in which we can study the adoption of an innovation in the housing market. Our empirical results show that the choice of certification is driven largely by the quality of a home. We find that row houses, constructed during the seventies and eighties, and located in low-density, relatively expensive suburban areas, are significantly more likely to obtain an energy performance certificate. It is especially in this market segment and at these locations that competition among buyers is very low. Our results also provide some indication of ideology driving the adoption of energy labels: adoption rates are higher among homeowners that voted 'green' during the 2006 national elections.

The energy label also seems to carry a moderately powerful market signal. We track the sales process of some 33,483 certified homes and document a positive relation between the energy efficiency of a dwelling and its transaction price, corrected for location and quality characteristics. Homes with a 'green' label – indicated by the letter A, B, or C – sell at a premium of 2.5 to 2.7 percent, relative to otherwise comparable non-green homes. Time on the market and the discount-to-ask price are not affected by the energy efficiency of a home.

The results of this paper are important for the national governments in EU member states and countries outside the European Union in increasing the effectiveness of policies regarding energy efficiency measures and energy performance certification. The results address two crucial questions regarding the implementation of energy certification in residential markets: who adopts the energy labels when there is a choice, and does energy performance disclosure provide a price signal to the market? Our answer on the second question offers a compelling method to drive the outcome of the first. When offering clear proof on the financial benefits of 'greening' the housing market, homebuyers and sellers will be more willing to adopt the certification and enhance the energy efficiency of their home.

The rest of this paper is organised as follows. The next section reviews the literature on energy efficiency in the built environment. Section III discusses the global implementation of energy performance certification. Section IV describes the data and provides descriptive statistics. Section V shows the empirical results and Section VI concludes the paper.

## II. Literature Review

Following the rise in energy prices in the 1970s, a multitude of energy models has been developed, with Quigley (1984) explicitly taking the real estate sector into account. Indeed, the world has come to realize that the built environment and energy consumption are closely intertwined: residential and commercial buildings account for forty percent of global energy consumption (RICS, 2005). In determining future energy consumption, modern energy models nowadays not only take the housing stock and its projected growth into account, but also demographic, social and behavioural factors of the occupants (P.G.M. Boonekamp, 2007, D.R. Kamerschen and D.V. Porter, 2004).

However, to ultimately reduce the carbon footprint of the real estate sector, demand from occupiers and investors for more energy-efficient real estate is crucial. Evidence on the willingness to pay for energy efficiency in the real estate sector is scant. In a paper studying the willingness to pay for energy efficiency in the US office market, Eichholtz et al. (2009) show that buildings with an Energy Star label – indicating that a building belongs to the top-25 percent of most energy-efficient buildings in the US – have rents that are three percent higher as compared to regular office buildings. Transaction prices for energy-efficient office buildings are even 16 percent higher. Further analyses show that the level of these premiums is strongly related to real energy use, indicating that tenants and investors in commercial real estate seem to capitalize energy savings in their decision-making process.

For the residential sector, Glaeser and Kahn (2008) argue that if the carbon externality were appropriately priced, costs per household would range from $830 to $1410 per household per year, depending on the climatic conditions and more importantly, on a city's population and density. However, when relocating, households do not seem to take carbon emissions or energy efficiency into account, but rather focus on environmental externalities, like pollution, traffic and the availability of nature. Indeed, Bourassa et al. (2004) find price discounts of 50 percent if a dwelling is located near a poor-quality environment. Moreover, the population density of an area and the closeness to nature has been documented to become more important in location decisions (D. Brounen et al., 2008).

Even though willingness to pay for more energy-efficient homes has not been empirically documented, regulation has become more stringent and buildings standards have improved. These mostly supply-side measures have lead to substantial energy savings realized over the past decades (L. Schipper, 1991). However, more recent studies document a stagnating trend in the energy efficiency of buildings in Western economies. Nassen, Sprei and Holmberg (2008) find that energy price elasticity has decreased over time, mainly due to a lack of understanding of the life cycle cost – or, the economic payoff – following investments in energy efficiency. This is in line with Kempton and Layne (1994), who show that inefficient allocation of data on energy use restricts energy savings behaviour of consumers. It is documented that deficiencies in public policies regarding energy efficiency, limited regulation and the conservatism of the buildings industry are to blame for the slow diffusion of energy efficiency measures (M. Ryghaug and K.H. Sorensen, 2009).

## III. Energy Performance Certification and the EPBD

To increase consumer and investor awareness regarding energy consumption and carbon emissions in the built environment, various national governments have initiated rating systems measuring the extent to which both dwellings and commercial buildings adhere to energy efficiency standards. The Energy Star program of the U.S. Department of Energy and the U.S. Environmental Protection Agency is a long-running and notable example. Energy Star started in 1992 as a voluntary labeling program designed to identify and promote energy-efficient products in order to reduce greenhouse gas emissions. Energy Star labels were first applied to computers and were later extended to office equipment and major appliances. The Energy Star label was extended to new homes in 1993 and has been advocated as an efficient way for consumers to identify builders as well as buildings constructed using energy-efficient methods, since it is marketed as an indication of lower ownership costs, better energy performance, and higher home resale values.

Residential buildings can receive an Energy Star certification if they are at least 15 percent more energy efficient than homes built to the 2004 International Residential Code (IRC) and include additional energy-saving features that typically make them 20–30 percent more efficient than standard homes. For consumers, there is a clear relation between investments in energy efficiency and the consequent savings, as stated by EPA "...energy efficiency improvements save homeowners money – about $200 to $400 per year on utility bills. More importantly, monthly energy savings can easily exceed any additional mortgage cost for the energy efficiency improvements, resulting in a positive cash-flow from the first day of home ownership."[2] Hitherto, close to a million dwellings have earned an Energy Star label.

Although numerous countries have introduced comparable initiatives to raise consumer awareness of energy use and carbon emissions resulting from their homes, until recently, none had the scope of the Energy Star program. This changed in December 2002, when the European Parliament ratified Directive 2002/91/EC on the energy performance of buildings, which makes energy performance disclosure mandatory for all member states. The Directive argues that "a common approach [...] will contribute to a level playing field as regards efforts made in member states to energy saving in the

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[2] See http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_index for more information.

buildings sector and will introduce transparency for prospective owners or users with regard to the energy performance in the Community property market."[3] This has lead to the introduction of more or less comparable energy performance certificates (EPCs) across the European Union. The directive should have been formally introduced in all member states in January 2006. However, member states had an additional period of three years to fully adhere to the certification procedures, due to the lack of qualified and/or accredited experts. During this transition period, the existing energy performance certificates have not yet materialized as active energy labels of dwellings in European member states. This is likely to change with the recast of the Directive in 2009. For instance, the certificate will have to be included in all advertisements for selling or renting properties. Moreover, the certificate and its energy saving recommendations have to be part of the sales and renting documents in each transaction.

The energy performance certificate has a common base in all member states and is derived from the thermal quality of the dwelling, but also takes into account elements such as heating installation, (natural) ventilation and indoor air climate, solar systems and built-in lighting. The certificate contains a simple universal indicator of the energy consumption, measured by either actual energy consumption or by calculated energy consumption. As different forms of energy can be delivered to a building, the indicator is a weighted sum of these delivered energies. Besides an energy-efficiency score, the certificate also contains specific advice as how to improve the thermal characteristics of a building. Appendix A provides an example.

The energy performance certificate should increase the transparency in the energy use of a specific dwelling. In turn, one would expect the certificate to represent a certain economic value, as a higher rating represents a revenue stream stemming from future energy savings. However, poorly defined label requirements and insufficient training of official certification agencies characterise the recent introduction of energy performance certificates across the European Union. Moreover, 'escape clauses' have allowed private

[3] Press release MEMO/08/693, Brussels, 13 November 2008.

consumers to circumvent the mandatory disclosure of energy performance certificates in housing transactions. Also, consumers have questioned the reliability of the information provided by energy certificates in housing transactions. The combination of these factors has lead to a slow diffusion of the energy labels in European property markets.

The diffusion of energy labels in the private market creates an interesting laboratory to study the adoption drivers and patterns and the effectiveness of the energy label as a market signal. We empirically address these questions using a large sample of housing transactions in the Netherlands, which was one of the first countries to formally introduce energy performance certification.

## IV. Data

Since January 2008, all transactions in the Dutch housing market need to be accompanied by an energy performance certificate. Professionally trained surveyors issue the certificates. To classify the home into one of the standardized energy classes, an engineer visits a home and combines an inspection of the physical characteristics of the home with information on recent energy bills. The energy performance certificates range from A++, for exceptionally energy-efficient dwellings, to G, for highly inefficient buildings. The energy index measures the energy use per square meter based on thermal characteristics of the building. Obtaining the certificate requires an investment of some €150, which is incurred by the seller of the building. Dwellings that have been constructed after 1999 or that are classified as monuments are exempted from mandatory disclosure of the energy performance certificate. One other important exception is when the buyer of the dwelling signs a waiver, which is typically offered by the sale-side real estate agent.

Senter*Novem*, an agency of the Dutch Ministry of Economic Affairs, exerts quality control and registration of the certificates. We exploit the database of Senter*Novem*, which provides information on the EPC rating, address and building characteristics on all buildings with an energy performance certificate. As of September 2009, a total over 100,000 homes (rental and owned) had been certified.

To obtain information on housing transactions, we use the database of the National Association of Realtors (NVM), which includes information on address, deal characteristics and quality characteristics of each individual transaction. The members of the NVM collectively cover approximately 70 percent of all housing transactions in the Netherlands. As of September 2009, the NVM database contained 194,379 housing transactions since the introduction of energy performance certificates in the Dutch housing market (January 2008).[4]

We match both datasets based on address information. 33,483 sold homes – approximately 17 percent of the transaction sample – had an energy performance certificate. However, these labeled transactions are not evenly distributed over the sample period. Figure 1 presents the total number of transaction per month and the fraction of transacted homes with an energy performance certificate. The graph clearly shows that the fraction of rated homes decreased during the sample period, starting at 25 percent in January 2008 and decreasing to only 7 percent in September 2009. This is mainly due to start-up problems surrounding the implementation of the label: consumer organizations and the real estate industry cried fool on the lack of consistency and reliability of the label. The initial eagerness of consumers to gain insight in energy efficiency of homes, and the transparency that the energy performance certificates created, soon dwindled. However, revisions to improve the label have been announced for January 2010 and it is expected that the label will regain some ground.

Table 1 compares the average characteristics of the certified homes with non-certified dwellings. Labeled homes sell for lower prices and have a longer time on the market. There are substantial quality differences between certified homes and non-certified homes: the former are slightly smaller and are predominantly constructed between 1960 and 1990. Maintenance of the exterior and insulation are of slightly lower

[4] We only include transactions if all necessary data is available and with a value between €10,000 and €10,000,000.

quality when compared to the non-labeled transaction sample. The economic downturn is clearly reflected in the distribution of the transactions over the sample period: more than half of the transactions take place in the first two quarters of 2008, with the housing market virtually grinding to a halt in the third quarter of 2009.

Within the sample of certified homes, about one third of the transactions has been awarded a ‘green label’, where ratings A, B and C are considered to be ‘green’. About a quarter of the certified homes have a D rating, where D indicates that there is room for improvement in energy efficiency. 39 percent of the certified sample has a red label, which indicates that there are considerable possibilities to increase the energy efficiency in these particular homes.

## V. Method and Results

### A. The Adoption of Energy Performance Certificates

Although the adoption of the energy performance certificates in housing transactions is mandatory, private consumers can relatively easily avoid this requirement. So, consumers can make a trade-off between the costs and benefits of acquiring a certificate. The costs are clear, given that certification costs on average €150, a price that the seller of the home has to incur. The benefits are more opaque. The most important benefit is that energy labels enhance the transparency of the offer of the seller, since more price relevant information is disclosed when the energy label is issued during the sale. Potential buyers will be able to consider the consequences of energy efficiency, which, in theory, will be capitalized into the price that they are willing to bid. However, during the short period that homebuyers and sellers in the housing market experienced the energy label, it has become clear that not every buyer will voluntarily adopt an energy performance certificate.

To gain more insight in the drivers of label adoption and whether certain dwelling characteristics affect the likelihood of energy performance certification, we estimate the following logit model:

(1) $$\Pr ob(EPC_{ic}) = \alpha + \beta_i X_i + \delta_n L_n + \sum_{C}^{c=1} \lambda_c c_c + \varepsilon_{ic}$$

where $EPC_{ic}$ is a binary variable with a value of 1 if dwelling $i$ in community $c$ has an Energy Performance Certificate and zero otherwise. $X$ represents a vector of quality characteristics of a dwelling, such as size, age and building quality. $L$ is a vector of variables that reflect the neighbourhood characteristics of each individual dwelling, such as density, average household income, and the voting preferences during the most recent national elections. These variables are all on the ZIP-code level and vary per cluster $n$. To further control for locational effects, $c_c$ is a dummy variable with a value of 1 if building $i$ is located in community $c$ and zero otherwise.

Table 2 presents the basic results of the logit estimation of Model (1). Results are provided for five different specifications. The coefficients do not have a straightforward economic interpretation, but the interest is rather in the sign and statistical significance of the coefficients. Controlling for community-fixed effects, the results in the first column clearly show the decrease of label adoption rates over the sample period. Transactions in the latter part of the sample period are significantly less likely to have a label as compared to transaction in the first quarter of 2008, with the likelihood of labeling decreasing over the sample period. Relative to row houses, detached and semi-detached dwellings are significantly less likely to have an energy performance certificate. Also, apartments are significantly less likely to be labeled. The square footage of a dwelling decreases the likelihood of certification. Thus, larger dwellings are less likely to be labeled.

The period of construction has a distinct influence on the odds of certifying energy performance. Relative to the reference period, which consists of all dwelling constructed before 1930, only dwellings constructed after 2000 are significantly less likely to be labeled. For all other periods, dwellings are significantly more likely to have an energy performance certificate. This is in line with the legislation regarding the certification process: dwellings that have been constructed after 1999, or those that are considered as monuments, are exempted from energy performance certification in the transaction process. The coefficients further indicate that buildings constructed between 1970 and 1990 are especially more likely to be certified.

Column (2) adds a series of dwelling amenities to the model. These results are mixed. Overall, it seems that the odds of label adoption are not simply a reflection of this set of quality features of the individual home. For instance, adoption rates rise when the quality of interior maintenance increases, but adoption rates are inversely related to the quality of external maintenance. The presence of central heating and the quality of insulation – two factors that are directly reflected in the energy performance certificate – do no significantly increase the likelihood of a label. Contrasting common believe, the results show that opting for certification is not the same as requesting a formal report that signals that the quality of a home is above average. The physical attributions of the labeled dwellings are not better than those of the dwellings in our non-labeled control group.

For a slightly smaller subset of our sample, we were also able to collect economic data on the direct vicinity of the home. From the Central Bureau of Statistics (CBS) we obtained information on urban density, average home price value, average income, and political voting behaviour. This information is available on a six-digit ZIP code level.[5] This means we have various measures for the quality of the neighbourhood in which dwellings are located. Column (3) of Table 2 includes the neighbourhood factors. The results show that adoption rates are highest among homes that are located in neighbourhoods that are less urbanized, have higher real estate values, and are populated by households that have lower incomes. Anecdotally, the characteristics of these areas coincide with those facing more difficult housing market conditions – more expensive neighbourhoods outside the larger cities.

Last, we include the environmental ideology of homeowners as an explanatory variable for the choice to take out a label. Findings in the literature on ideology and consumer choice provide some indication that 'greens' are more likely to adopt

[5] The six-digit ZIP code covers an area of less than a square mile around a home. Postal codes are of comparable size across our sample, and therefore a useful proxy for the quality of the direct neighborhood.

environmental innovations (M.E. Kahn, 2007). We obtain voting data on the 2006 national elections and calculate the percentage vote for ‘left’ and ‘green’ parties. The 2006 national elections had a turnout of more than 80 percent, and are a reliable indicator of the political balance on a community-level. Columns (4) and (5) present the results on voting preferences and label adoption. The significantly positive coefficients on our measures of voting ‘green’ and voting ‘left’ provide some indication that the choice for adopting the energy label may also be driven by ideological beliefs.[6]

Summarizing, energy performance certificates are adopted at a steadily decreasing rate. However, we find that some drivers significantly influence label adoption. Households living in single-family dwellings (as opposed to apartments) of moderate size and average quality are more likely to have their home certified. The propensity to take out a label also increases in neighbourhoods where density is low, house prices are high and voting for ‘green’ political parties is more common. Some of these dwelling and neighbourhood characteristics coincide with particular housing market conditions. In the current economic downturn, sellers of more expensive, post-war homes, located outskirts of cities rather than in the suburbs, face difficult market conditions. These sellers may use label adoption – regardless of the outcome – as a ‘strategic’ tool in the transaction process.

**B. The Signaling Effects of Energy Performance Certificates**

The premise of energy performance disclosure is that increased transparency through reliable information on energy efficiency has a signaling effect in the real estate market. This should translate in a discount for less energy efficient homes or a premium for more energy efficient homes. We study the effects of energy labels on the transaction process of homes in the Netherlands. First, we concentrate on whether an energy label makes a home easier to sell. As a proxy, we use the time that the dwelling has been on the

[6] We note that we cannot control for the individual demographic characteristics of voters. Also, the voting data provides just a reflection of community political preferences, rather than the political preferences of the individual.

market before the closing of the transaction. Assuming that energy labels contribute to the informational symmetry in the transaction process, we expect that sales with energy labels involve less negotiation time and hence less time on the market. To test this hypothesis we estimate the following regression:

$$(2) \qquad TOM_{ic} = \alpha + \beta_i X_i + \delta_n L_n + \sum_{C}^{c=1} \lambda_c c_c + \rho G_i + \varepsilon_{ic}$$

where the dependent variable is the logarithm of the number of days that dwelling $i$ in community $c$ has been on the market before the transaction was finalized. A vector of dwelling characteristics is represented by $X$, regional variety in demand and supply is controlled for by a vector of location characteristics $L_n$ and the energy certificate is denoted as $G_i$. We estimate Model (2) for the sample that includes all transactions, and separately for the sample that includes just the transactions with an energy label. To further control for locational effects, $c_c$ is a dummy variable with a value of 1 if building $i$ is located in community $c$ and zero otherwise.

Table 3 presents the results, presented for ordinary least squares regression models corrected for heteroskedasticity (Halbert White, 1980). Columns (1) and (2) provide results for the sample including certified and non-certified homes. Row houses sell faster than any other housing type, with semi-detached homes selling fairly slowly. Large, recently constructed homes have longer lead times. Homes that transacted in 2009 were on average 24 to 28 percent longer on the market as compared to homes sold in the first quarter of 2009.

Most importantly, the results give little reason to believe that energy performance certification decreases the time on the market of transactions: homes with a ‘green’ label are approximately 8 percent longer on the market as compared to non-certified homes. Also, column (2) shows that the outcome of a label does not consistently change the time on the market.

Columns (3) and (4) show the effect of a ‘green’ label and label level on the time on the market, for the sample of certified dwellings. Within this sample of labeled transactions, we find that the coefficient for green-labeled dwellings is negative, indicating that carrying a green energy label reduces the time on the market, but this results lacks any statistical significance. A 'greener' label does not reduce the transaction period.

Next, we use a standard valuation framework to investigate whether the information that is signaled by the energy performance certificate is capitalized into the transaction price of a dwelling. We focus on the sample of certified dwellings and estimate a semi-log equation relating selling price per square meter to the hedonic characteristics of the buildings (e.g., age, size, etc.), the location of each building, and the score of the energy performance certificate:

$$(3) \qquad \log P_{ic} = \alpha + \beta_i X_i + \delta_n L_n + \sum_{C}^{c=1} \lambda_c c_c + \rho G_i + \varepsilon_{ic}$$

In the formulation represented by equation (3), the dependent variable is the logarithm of the transaction price per square foot of dwelling *i*. $X_i$ is a vector of the hedonic characteristics of building *i*. To control for local economic characteristics, $L_n$ is a vector of variables that capture the attributes of the neighbourhood in which a dwelling is situated. $G_i$ is a dummy variable with a value of 1 if building *i* is rated A, B or C, indicating that the home obtained a green energy label, and a value of 0 otherwise. Alternatively, $G_i$ represents the score of the energy label, which ranges form A to F, and where the G-label serves as reference group. To further control for locational effects, $c_c$ is a dummy variable with a value of 1 if building *i* is located in community *c* and zero otherwise.

Table 4 presents the results, in which the logarithm of transaction price per square foot is related to a set of hedonic characteristics. Results are corrected for heteroskedasticity (Halbert White, 1980). The basic model in column (1) explains some 57 percent of the natural logarithm of the transaction price, based on 32,851 observations. Selling prices are higher in smaller dwellings and among homes that are either relatively new (post 2000) or very old – monuments sell at a premium of 5 percent. House prices have been falling mildly over the sample period: transaction prices are 8 percent lower in the third quarter of 2009 as compared to the average transaction price in the first quarter of 2008.

Most importantly, for the sample of homes with energy labels, we document homes with an energy label class A, B or C – which we refer to as 'green' – transacted at an average price premium of 2.7 percent, *ceteris paribus*.

Columns (2) and (3) more explicitly control for differences in dwelling quality and local economic characteristics. The presence of central heating – now prevalent in most homes in the Netherlands – is positively related to the transaction price. Surprisingly, good interior maintenance negatively affects property prices. The variables reflecting local economic characteristics all show the expected signs: house prices are higher in high-density, urban areas, where the average income is relatively high.

The coefficient on the 'green' energy label shows that the price premium is not just a reflection of potential quality differences among green versus non-green dwellings: when explicitly accounting for specific dwelling amenities, the price premium for green dwellings, remains both economically and statistically significant. Considering that the average transaction price in our sample is equal to €230,000, the euro value of the 'green' price premium amounts to almost €6,000.

The fourth column of Table 4 presents the results when the specific score for energy efficiency is included in the model. We document that the premium for energy efficiency constitutes a series of positive price effects, which correspond to implications of the different label categories. We find that A-labeled homes transacted at a price premium of almost 12 percent as compared to similar homes with a G-label. The premium is positively related to the outcome of the label. These results provide some indication that private consumers take the energy efficiency of their prospective home into account when making investment decisions.

Finally, we test for the robustness of the 'green' transaction premium during the sample period. With decreased consumer confidence in the energy performance certificate, the signaling value of the label may well be negatively affected. We replicate the analysis for three subperiods. The results are summarized in Appendix B. Controlling for differences in location and quality, we find that the average price premium for homes with an A, B or C energy label drops slightly in 2009. However, the number of labeled homes is small during that period, and we do not further account for the differences in composition of the 'green' indicator (i.e. the fraction of A or B-labeled homes may well be smaller in the last period).

## VI. Conclusions

This paper reports the first evidence on the implementation and valuation of energy performance certificates in the European Union. We use the residential sector in the Netherlands as a laboratory, as the Dutch housing market was one of the first to experience formal introduction of the implementation of energy performance certificates in January 2008. Using a dataset of 194,000 transactions, we empirically address the diffusion of green labels in the housing market. First, we study which homeowners adopt the energy label when there is a choice. We find that energy labels are adopted at a declining rate over time. Single-family dwellings of moderate size and average quality are more likely to be labeled. Locational characteristics have a distinct influence on the labeling propensity: labeled dwelling are mostly located in neighbourhoods where density is low, house prices are high and voting for 'green' parties is more common. The results show that the initial lack of transparency of labeling practices, in combination with the current legislation regarding energy performance certification, hinder a complete uptake by the market. Our results also show that adopting an energy performance certificate is not just a tactical tool to formally communicate the high quality of the dwelling. Labeled dwellings are not of higher physical quality, judging by amenities, insulation and maintenance level.

Second, we study the effects of labeling a home on the outcome of the sale process. Although we find no evidence for the hypothesis that increased informational transparency materializes in a higher speed of sale, we document that homebuyers are willing to pay a premium for homes that have been labeled as ‘green’. Our results show that this price premium of around 2.5 percent varies with the outcome of the energy performance certificate and is robust to variations in housing quality.

These findings are important information for homeowners – private as well as institutional. In ‘greening’ a dwelling, there is not only an immediate financial benefit from lower energy expenses, but the increased energy efficiency also leads to a higher transaction price. The energy performance certificate is instrumental in creating transparency in the energy efficiency of a dwelling. However, we are not able to distinguish between the intangible effects of labeling itself and the actual effects of energy savings. Information on energy consumption would allow us to further disentangle these effects.

For policy makers, the results may help in further refining national energy performance certification programmes and in stimulating more extensive dissemination of the certificates. First, current legislation regarding uptake of the label is not strong enough. The numerous opt-outs allow homeowners to circumvent certification of dwellings. For the energy performance of the complete residential stock to improve, all homes should have an energy performance certificate. Second, the case of the Netherlands shows that start-up problems surrounding the energy performance certificate were neither adequately tackled, nor clearly communicated. This leads to negative publicity surrounding energy performance certification, which hinders the uptake and consequent lack of confidence in the certificate is costly to repair. National governments should learn from these mistakes.

## References

**Boonekamp, P.G.M.** "Price Elasticities, Policy Measures and Actual Developments in Household Energy Consumption – a Bottom up Analysis for the Netherlands " *Energy Economics*, 2007, *29*(2), pp. 133-57

**Bourassa, S.C.; Hoesli, M. and Sun, J.** "What's in a View." *Environment and Planning*, 2004, *36*(8), pp. 1427-50.

**Brounen, D.; Neuteboom, P. and Xu, J.** "Countryside Living: Pricing Preference Perfectly " RSM Erasmus, 2008.

**Eichholtz, P.M.A.; Kok, N. and Quigley, J.M.** "Doing Well by Doing Good: Green Office Buildings." *American Economic Review*, 2009, *forthcoming*.

**Enkvist, Per-Anders; Naucler, Thomas and Rosander, Jerker.** "A Cost Curve for Greenhouse Gas Reduction." *The McKinsey Quarterley*, 2007, *1*, pp. 35-45.

**Glaeser, E.L. and Kahn, M.E.** "The Greenness of Cities: Carbon Dioxide Emissions and Urban Development," National Bureau of Economic Research, 2008.

**Kahn, M.E.** "Do Greens Drive Hummers or Hybrids? Environmental Ideology as a Determinant of Consumer Choice." *Journal of Environmental Economics and Management*, 2007, *54*, pp. 129-45.

**Kamerschen, D.R. and Porter, D.V.** "The Demand for Residential, Industrial and Total Electricity, 1973–1998." *Energy Economics*, 2004, *26*(1), pp. 87-100.

**Kempton, W. and Layne, L.L.** "The Consumer's Energy Analysis Environment." *Energy Policy*, 1994, *22*(10), pp. 857-66.

**Nässén, J.; Sprei, F. and Holmberg, J.** "Stagnating Energy Efficiency in the Swedish Building Sector - Economic and Organisational Explanations " *Energy Policy*, 2008, *36*(10), pp. 3814-22.

**Quigley, J.M.** "The Production of Housing Services and the Derived Demand for Residential Energy." *The RAND Journal of Economics*, 1984, *15*(4), pp. 555-67.

**RICS.** "Green Value," London and Vancouver: RICS, 2005.

**Ryghaug, M. and Sorensen, K.H.** "How Energy Efficiency Fails in the Building Industry." *Energy Policy*, 2009, *37*(3), pp. 984-91.

**Schipper, L.** "Improved Energy Efficiency in the Industrialized Countries: Past Achievements, Co2 Emission Prospects " *Energy Policy*, 1991, *19*(2), pp. 127-37.

**Stern, Nicholas.** "The Economics of Climate Change." *American Economic Review: Papers and Proceedings*, 2008, *98*(2), pp. 1-37.

**White, Halbert.** "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica*, 1980, *48*(4), pp. 817-38.

**Figure 1**
**Market Volumes versus Adoption Rates**
**(January 2008 – September 2009)**

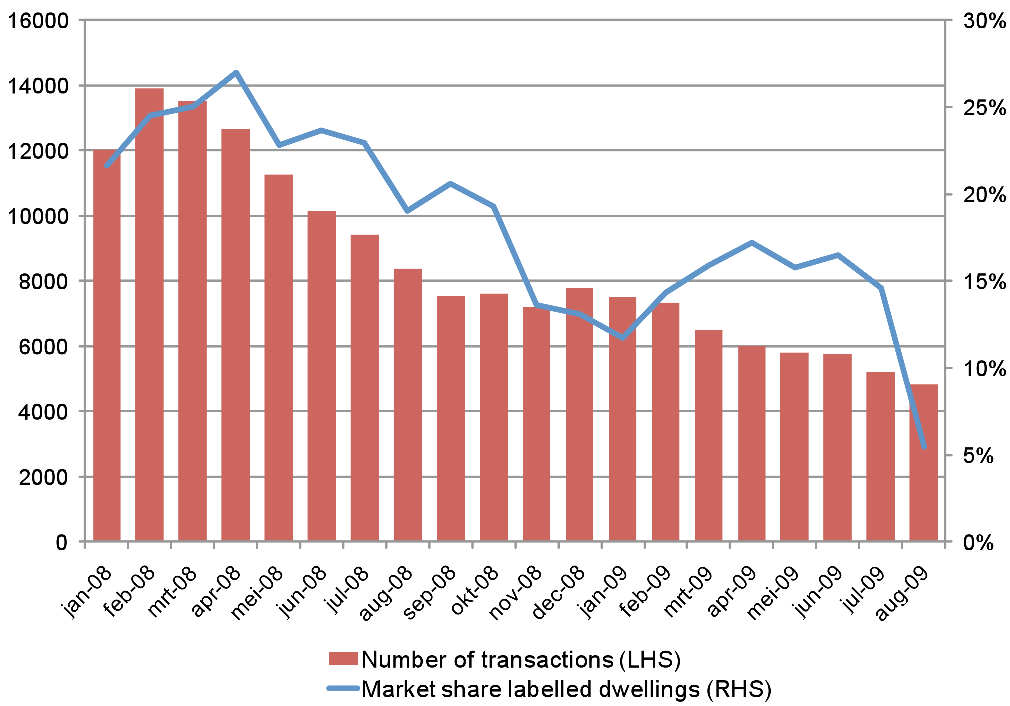


**Table 1**
**Comparison of Certified and Non-Certified Dwellings**
**(Period: January 2008 – September 2009)**

| | Certified Dwellings | | Non-Certified Dwellings | |
|---|---|---|---|---|
| Sample Size | 33,483 | | 160,996 | |
| | Mean | St.dev. | Mean | St.dev. |
| Transaction Price (euros/sq.m) | 2011.53 | 702.14 | 2222.15 | 863.29 |
| Time on Market (days) | 139.86 | 161.59 | 137.00 | 166.62 |
| Discount to Asking Price (percent) | -3.73 | 3.94 | -4.17 | 4.24 |
| Size (square meters) | 114.81 | 48.17 | 121.62 | 57.30 |
| Housing Type (percent) | | | | |
| Apartment | 30.35 | 45.98 | 31.99 | 46.64 |
| Detached | 10.71 | 30.93 | 12.90 | 33.52 |
| Terraced | 1.83 | 13.42 | 1.94 | 13.80 |
| Semi-Detached | 13.37 | 34.03 | 13.56 | 34.24 |
| Corner | 13.22 | 33.88 | 11.67 | 32.11 |
| Duplex | 30.51 | 46.05 | 27.93 | 44.87 |
| Period of Construction (percent) | | | | |
| 1500 – 1905 | 3.32 | 17.90 | 5.73 | 23.24 |
| 1905 – 1930 | 9.61 | 29.47 | 11.95 | 32.44 |
| 1931 – 1944 | 6.24 | 24.18 | 7.75 | 26.73 |
| 1945 – 1960 | 9.82 | 29.76 | 7.12 | 25.71 |
| 1960 – 1970 | 18.52 | 38.85 | 14.53 | 35.24 |
| 1971 – 1980 | 22.04 | 41.45 | 14.66 | 35.37 |
| 1981 – 1990 | 17.62 | 38.10 | 11.94 | 32.42 |
| 1991 – 2000 | 11.83 | 32.29 | 13.52 | 34.20 |
| > 2000 | 0.99 | 9.91 | 12.53 | 33.10 |
| Technical Characteristics (percent) | | | | |
| Central Heating Dummy | 91.04 | 28.56 | 90.92 | 28.74 |
| Interior Maintenance Dummy (fraction 'Good') | 9.71 | 29.60 | 8.74 | 28.24 |
| Exterior Maintenance Dummy (fraction 'Good') | 5.71 | 23.21 | 5.82 | 23.42 |
| Insulation Dummy (fraction 'Good') | 26.87 | 44.33 | 30.81 | 46.17 |
| Local Economic Characteristics | | | | |
| Housing Density | 1941.02 | 1727.01 | 2069.65 | 1979.31 |
| Urbanization (1 - 5) | 2.69 | 1.34 | 2.69 | 1.40 |
| Average House Value (in €1000) | 130.38 | 64.29 | 142.07 | 72.90 |
| Average Household Income (euros) | 2088.97 | 616.41 | 2202.85 | 660.94 |
| Voting Behavior (percent) | | | | |
| Voting Left | 24.09 | 5.68 | 24.15 | 6.03 |
| Voting Green | 6.96 | 3.18 | 7.33 | 3.47 |

**Table 1**
**Comparison of Certified and Non-Certified Dwellings**
**(continued)**

| | | | | |
|---|---|---|---|---|
| Energy Label (percent) | | | | |
| A | 0.67 | 8.19 | | |
| B | 8.46 | 27.83 | | |
| C | 24.10 | 42.77 | | |
| D | 26.76 | 44.27 | | |
| E | 19.12 | 39.33 | | |
| F | 13.20 | 33.85 | | |
| G | 7.52 | 26.38 | | |
| | | | | |
| Period of Transaction (percent) | | | | |
| Q1 2008 | 28.05 | 44.93 | 17.71 | 38.17 |
| Q2 2008 | 25.03 | 43.32 | 19.09 | 39.30 |
| Q3 2008 | 15.85 | 36.52 | 17.40 | 37.91 |
| Q4 2008 | 10.34 | 30.45 | 13.05 | 33.69 |
| Q1 2009 | 8.87 | 28.43 | 12.04 | 32.54 |
| Q2 2009 | 8.67 | 28.14 | 14.57 | 35.28 |
| Q3 2009 | 3.19 | 17.56 | 6.14 | 24.00 |

**Table 2**
**Drivers of Label Adoption – Transacted Dwellings**
**Logit Regression**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Housing Type | | | | | |
| Apartment | -0.206*** | -0.209*** | -0.168*** | -0.172*** | -0.170*** |
| | [0.0204] | [0.0204] | [0.0216] | [0.0208] | [0.0207] |
| Detached | -0.0985*** | -0.0974*** | -0.0368 | -0.00256 | -0.00648 |
| | [0.0258] | [0.0258] | [0.0298] | [0.0283] | [0.0282] |
| Semi-Detached | -0.0862* | -0.0847* | -0.0194 | 0.00501 | 0.00210 |
| | [0.0484] | [0.0485] | [0.0498] | [0.0493] | [0.0493] |
| Duplex | -0.0328 | -0.0331 | 0.0111 | 0.0422* | 0.0420* |
| | [0.0224] | [0.0224] | [0.0236] | [0.0228] | [0.0227] |
| Corner | 0.0165 | 0.0161 | 0.0229 | 0.0288 | 0.0296 |
| | [0.0210] | [0.0210] | [0.0213] | [0.0211] | [0.0211] |
| Size (log) | -0.403*** | -0.404*** | -0.324*** | -0.329*** | -0.336*** |
| | [0.0236] | [0.0236] | [0.0271] | [0.0262] | [0.0262] |
| Period of Construction | | | | | |
| 1931 – 1944 | 0.0306 | 0.0300 | 0.0288 | 0.0692** | 0.0690** |
| | [0.0299] | [0.0299] | [0.0306] | [0.0300] | [0.0300] |
| 1945 – 1960 | 0.525*** | 0.523*** | 0.499*** | 0.552*** | 0.554*** |
| | [0.0274] | [0.0274] | [0.0286] | [0.0279] | [0.0279] |
| 1960 – 1970 | 0.497*** | 0.494*** | 0.482*** | 0.495*** | 0.500*** |
| | [0.0236] | [0.0237] | [0.0253] | [0.0246] | [0.0246] |
| 1971 – 1980 | 0.668*** | 0.666*** | 0.686*** | 0.724*** | 0.727*** |
| | [0.0234] | [0.0235] | [0.0250] | [0.0242] | [0.0241] |
| 1981 – 1990 | 0.629*** | 0.628*** | 0.634*** | 0.674*** | 0.674*** |
| | [0.0241] | [0.0243] | [0.0257] | [0.0248] | [0.0248] |
| 1991 – 2000 | 0.121*** | 0.123*** | 0.180*** | 0.232*** | 0.227*** |
| | [0.0257] | [0.0260] | [0.0280] | [0.0271] | [0.0271] |
| > 2000 | -2.297*** | -2.295*** | -2.077*** | -1.984*** | -1.989*** |
| | [0.0588] | [0.0590] | [0.0744] | [0.0741] | [0.0741] |
| Monument | -0.153** | -0.153** | -0.108 | -0.0754 | -0.0748 |
| | [0.0777] | [0.0777] | [0.0798] | [0.0788] | [0.0788] |
| Period of Transaction | | | | | |
| Q2 2008 | -0.222*** | -0.222*** | -0.215*** | -0.205*** | -0.206*** |
| | [0.0180] | [0.0180] | [0.0183] | [0.0181] | [0.0181] |
| Q3 2008 | -0.607*** | -0.607*** | -0.603*** | -0.583*** | -0.583*** |
| | [0.0200] | [0.0200] | [0.0203] | [0.0201] | [0.0201] |
| Q4 2008 | -0.781*** | -0.781*** | -0.796*** | -0.763*** | -0.764*** |
| | [0.0228] | [0.0228] | [0.0233] | [0.0230] | [0.0230] |
| Q1 2009 | -0.870*** | -0.871*** | -0.882*** | -0.849*** | -0.849*** |
| | [0.0239] | [0.0239] | [0.0244] | [0.0241] | [0.0241] |
| Q2 2009 | -1.082*** | -1.083*** | -1.091*** | -1.056*** | -1.056*** |
| | [0.0238] | [0.0239] | [0.0243] | [0.0240] | [0.0240] |
| Q3 2009 | -1.212*** | -1.212*** | -1.208*** | -1.155*** | -1.156*** |
| | [0.0354] | [0.0354] | [0.0361] | [0.0357] | [0.0357] |
| Central Heating | | 0.0202 | -0.00155 | -0.0155 | -0.0153 |
| | | [0.0229] | [0.0234] | [0.0230] | [0.0230] |
| Maintenance Interior | | 0.176*** | 0.160*** | 0.151*** | 0.152*** |
| | | [0.0282] | [0.0287] | [0.0283] | [0.0283] |

**Table 2**
**Drivers of Label Adoption – Transacted Dwellings**
**(continued)**

| | | | | | |
|---|---|---|---|---|---|
| Maintenance Exterior | | -0.207*** | -0.189*** | -0.169*** | -0.170*** |
| | | [0.0351] | [0.0357] | [0.0353] | [0.0353] |
| Insulation | | -0.00753 | -0.000151 | 0.00151 | 0.00243 |
| | | [0.0150] | [0.0153] | [0.0151] | [0.0151] |
| Housing Density | | | -9.85e-06 | -1.73e-05*** | -1.79e-05*** |
| | | | [7.49e-06] | [6.49e-06] | [6.26e-06] |
| Urbanization | | | -0.0103 | -0.0303*** | -0.0159* |
| | | | [0.0102] | [0.00815] | [0.00837] |
| Average House Value | | | 0.000495** | 0.000323* | 0.000525*** |
| | | | [0.000195] | [0.000179] | [0.000179] |
| Income | | | -0.000251*** | -0.000262*** | -0.000268*** |
| | | | [1.64e-05] | [1.59e-05] | [1.59e-05] |
| Voting Green | | | | 1.236*** | |
| | | | | [0.306] | |
| Voting Left | | | | | 1.291*** |
| | | | | | [0.148] |
| Constant | -16.35*** | -16.36*** | 1.281** | 0.920*** | 0.692*** |
| | [1.037] | [1.038] | [0.584] | [0.136] | [0.139] |
| Community-Fixed Effects | Y | Y | Y | N | N |
| Province-Fixed Effects | N | N | N | Y | Y |
| Sample Size | 194379 | 194379 | 177610 | 175875 | 175875 |
| Pseudo $R^2$ | 0.103 | 0.103 | 0.0904 | 0.0617 | 0.0621 |

Notes:

Base dummy building period is ‘< 1930’
Base dummy house type is ‘row house’
Standard errors are corrected for heteroskedasticity and stated in brackets.
Significance at the 0.10, 0.05, and 0.01 levels indicated by *, **, and ***, respectively

**Table 3**
**Regression Results**
**Time on the Market and Energy Performance Certification**

| | All Transactions | | Labeled Transactions | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Green Energy Label | 0.0799*** | | -0.00672 | |
| | [0.0113] | | [0.0168] | |
| Energy Label Score | | | | |
| A | | 0.126 | | 0.00712 |
| | | [0.0841] | | [0.0914] |
| B | | 0.125*** | | 0.0205 |
| | | [0.0212] | | [0.0356] |
| C | | 0.0741*** | | 0.0107 |
| | | [0.0131] | | [0.0293] |
| D | | 0.0590*** | | 0.0187 |
| | | [0.0124] | | [0.0272] |
| E | | 0.0742*** | | 0.0256 |
| | | [0.0149] | | [0.0277] |
| F | | 0.0735*** | | 0.0206 |
| | | [0.0178] | | [0.0289] |
| Housing Type | | | | |
| Apartment | 0.170*** | 0.171*** | 0.160*** | 0.160*** |
| | [0.00865] | [0.00865] | [0.0216] | [0.0216] |
| Detached | 0.131*** | 0.132*** | 0.111** | 0.111** |
| | [0.0204] | [0.0204] | [0.0473] | [0.0473] |
| Semi-Detached | 0.421*** | 0.422*** | 0.509*** | 0.510*** |
| | [0.0122] | [0.0122] | [0.0292] | [0.0293] |
| Duplex | 0.146*** | 0.146*** | 0.188*** | 0.189*** |
| | [0.00980] | [0.00980] | [0.0229] | [0.0230] |
| Corner | 0.0534*** | 0.0537*** | 0.0155 | 0.0161 |
| | [0.00907] | [0.00907] | [0.0206] | [0.0207] |
| New Construction | 0.124*** | 0.124*** | 0.0157 | 0.0157 |
| | [0.0171] | [0.0170] | [0.0451] | [0.0451] |
| Size (log sq. m.) | 0.226*** | 0.228*** | 0.340*** | 0.340*** |
| | [0.0109] | [0.0109] | [0.0279] | [0.0279] |
| Number of Rooms | -0.00102 | -0.00108 | -0.00324 | -0.00322 |
| | [0.00146] | [0.00145] | [0.00396] | [0.00396] |
| Period of Construction | | | | |
| 1931 – 1944 | -0.0255** | -0.0266** | -0.0278 | -0.0281 |
| | [0.0114] | [0.0114] | [0.0304] | [0.0305] |
| 1945 – 1960 | 0.00910 | 0.00466 | -0.0534* | -0.0543* |
| | [0.0119] | [0.0119] | [0.0282] | [0.0283] |
| 1960 – 1970 | 0.0910*** | 0.0860*** | 0.00927 | 0.00701 |
| | [0.0102] | [0.0102] | [0.0250] | [0.0252] |
| 1971 – 1980 | 0.0805*** | 0.0756*** | -0.0444* | -0.0467* |
| | [0.0103] | [0.0103] | [0.0245] | [0.0249] |
| 1981 – 1990 | 0.0586*** | 0.0599*** | -0.0169 | -0.0183 |
| | [0.0106] | [0.0106] | [0.0255] | [0.0262] |
| 1991 – 2000 | 0.147*** | 0.150*** | 0.0843*** | 0.0806*** |
| | [0.0108] | [0.0109] | [0.0296] | [0.0306] |
| > 2000 | 0.328*** | 0.333*** | 0.179** | 0.177** |
| | [0.0141] | [0.0141] | [0.0814] | [0.0836] |
| Monument | 0.0263 | 0.0272 | 0.00296 | 0.00335 |
| | [0.0306] | [0.0306] | [0.0837] | [0.0837] |

**Table 3**
**Time on the Market and Energy Performance Certification**
**(continued)**

| | | | | |
|---|---|---|---|---|
| Central Heating | -0.0132 | -0.0134 | -0.00799 | -0.00885 |
| | [0.00976] | [0.00976] | [0.0227] | [0.0227] |
| Maintenance Interior | -0.0761*** | -0.0771*** | -0.127*** | -0.127*** |
| | [0.0122] | [0.0122] | [0.0267] | [0.0267] |
| Maintenance Exterior | -0.00693 | -0.00543 | 0.0191 | 0.0197 |
| | [0.0149] | [0.0149] | [0.0347] | [0.0347] |
| Insulation | -0.00940 | -0.00911 | -0.00571 | -0.00565 |
| | [0.00624] | [0.00624] | [0.0148] | [0.0149] |
| Period of Transaction | | | | |
| Q2 2008 | -0.0752*** | -0.0737*** | 0.0298* | 0.0298* |
| | [0.00847] | [0.00847] | [0.0167] | [0.0167] |
| Q3 2008 | -0.0379*** | -0.0340*** | 0.130*** | 0.130*** |
| | [0.00875] | [0.00878] | [0.0192] | [0.0192] |
| Q4 2008 | 0.0558*** | 0.0610*** | 0.204*** | 0.204*** |
| | [0.00950] | [0.00954] | [0.0228] | [0.0228] |
| Q1 2009 | 0.236*** | 0.241*** | 0.353*** | 0.354*** |
| | [0.00971] | [0.00975] | [0.0243] | [0.0243] |
| Q2 2009 | 0.265*** | 0.272*** | 0.355*** | 0.355*** |
| | [0.00937] | [0.00943] | [0.0253] | [0.0253] |
| Q3 2009 | 0.278*** | 0.285*** | 0.360*** | 0.360*** |
| | [0.0130] | [0.0130] | [0.0387] | [0.0387] |
| Housing Density | -3.67e-05*** | -3.67e-05*** | -3.64e-05*** | -3.65e-05*** |
| | [2.61e-06] | [2.61e-06] | [6.65e-06] | [6.66e-06] |
| Urbanization | 0.00165 | 0.00167 | -0.00608 | -0.00622 |
| | [0.00406] | [0.00406] | [0.0100] | [0.0100] |
| Average House Value | -0.000340*** | -0.000343*** | -0.000592*** | -0.000589*** |
| | [7.29e-05] | [7.29e-05] | [0.000206] | [0.000206] |
| Income | 6.05e-07 | 1.87e-06 | 7.97e-05*** | 7.97e-05*** |
| | [5.99e-06] | [5.99e-06] | [1.55e-05] | [1.55e-05] |
| Constant | 3.188*** | 3.161*** | 3.933*** | 3.773*** |
| | [0.120] | [0.122] | [0.140] | [0.150] |
| Sample Size | 174930 | 174930 | 31771 | 31771 |
| $R^2$ | 0.120 | 0.121 | 0.144 | 0.144 |
| $R^2$-adj | 0.118 | 0.118 | 0.131 | 0.131 |

Notes:

Base dummy building period is '< 1930'
Base dummy house type is 'row house'
Standard errors are corrected for heteroskedasticity and stated in brackets.
Significance at the 0.10, 0.05, and 0.01 levels indicated by *, **, and ***, respectively.

**Table 4**
**Regression Results**
**Transaction Prices and Energy Performance Certification**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Green Energy Label | 0.0266*** | 0.0252*** | 0.0245*** | |
| | [0.00318] | [0.00318] | [0.00269] | |
| Energy Label Score | | | | |
| A | | | | 0.117*** |
| | | | | [0.0171] |
| B | | | | 0.0767*** |
| | | | | [0.00661] |
| C | | | | 0.0578*** |
| | | | | [0.00525] |
| D | | | | 0.0456*** |
| | | | | [0.00496] |
| E | | | | 0.0377*** |
| | | | | [0.00492] |
| F | | | | 0.0212*** |
| | | | | [0.00521] |
| Time on the Market (Days) | -0.00855*** | -0.00894*** | -0.00863*** | -0.00868*** |
| | [0.00116] | [0.00116] | [0.000993] | [0.000990] |
| Housing Type | | | | |
| Apartment | -0.00179 | -0.00274 | -0.0166*** | -0.0157*** |
| | [0.00484] | [0.00484] | [0.00423] | [0.00423] |
| Detached | 0.168*** | 0.168*** | 0.0847*** | 0.0845*** |
| | [0.00913] | [0.00913] | [0.00717] | [0.00712] |
| Semi-Detached | 0.420*** | 0.420*** | 0.273*** | 0.274*** |
| | [0.00660] | [0.00660] | [0.00644] | [0.00643] |
| Duplex | 0.203*** | 0.203*** | 0.117*** | 0.119*** |
| | [0.00395] | [0.00394] | [0.00383] | [0.00383] |
| Corner | 0.0603*** | 0.0603*** | 0.0546*** | 0.0567*** |
| | [0.00322] | [0.00321] | [0.00271] | [0.00271] |
| New Construction | 0.00211 | -0.00248 | -0.00376 | -0.00275 |
| | [0.00920] | [0.00936] | [0.00830] | [0.00829] |
| Size (log sq. m.) | -0.190*** | -0.192*** | -0.382*** | -0.384*** |
| | [0.00902] | [0.00903] | [0.00877] | [0.00878] |
| Number of Rooms | 0.00330*** | 0.00333*** | 0.00263*** | 0.00266*** |
| | [0.000857] | [0.000834] | [0.000685] | [0.000683] |
| Period of Construction | | | | |
| 1931 – 1944 | -0.0436*** | -0.0440*** | -0.0340*** | -0.0325*** |
| | [0.00712] | [0.00709] | [0.00597] | [0.00594] |
| 1945 – 1990 | -0.109*** | -0.108*** | -0.0719*** | -0.0727*** |
| | [0.00584] | [0.00581] | [0.00502] | [0.00500] |
| 1960 – 1970 | -0.149*** | -0.149*** | -0.101*** | -0.104*** |
| | [0.00524] | [0.00522] | [0.00458] | [0.00456] |
| 1971 – 1980 | -0.125*** | -0.126*** | -0.0976*** | -0.105*** |
| | [0.00518] | [0.00516] | [0.00451] | [0.00453] |
| 1981 – 1990 | -0.0852*** | -0.0869*** | -0.0681*** | -0.0774*** |
| | [0.00535] | [0.00534] | [0.00457] | [0.00469] |
| 1991 – 2000 | -0.0133** | -0.0158** | -0.0398*** | -0.0529*** |
| | [0.00624] | [0.00626] | [0.00551] | [0.00571] |
| > 2000 | 0.00564 | 0.00265 | -0.0291 | -0.0518** |
| | [0.0171] | [0.0171] | [0.0236] | [0.0245] |

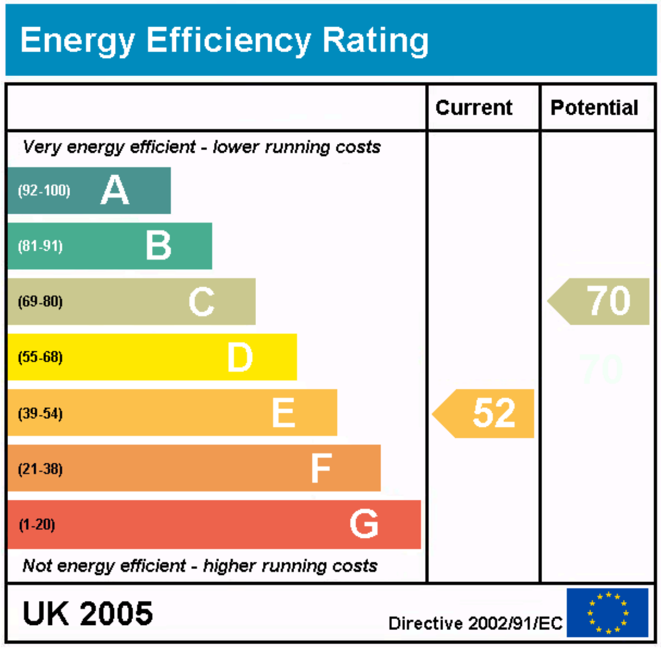
**Table 4**
**Transaction Prices and Energy Performance Certification**
**(continued)**

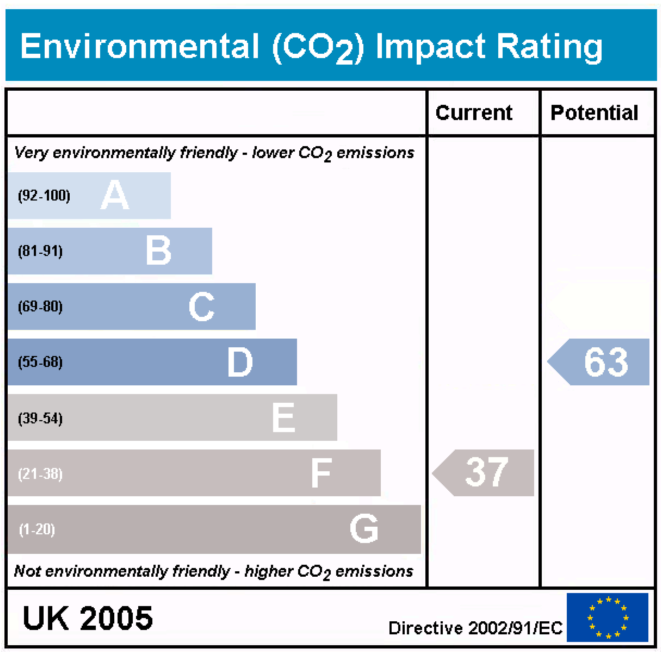
| | | | | |
|---|---|---|---|---|
| Monument | 0.0506*** | 0.0543*** | 0.0430*** | 0.0424*** |
| | [0.0169] | [0.0169] | [0.0133] | [0.0131] |
| Period of Transaction | | | | |
| Q2 2008 | 0.00484 | 0.00484 | -0.000542 | -0.000800 |
| | [0.00325] | [0.00324] | [0.00274] | [0.00273] |
| Q3 2008 | -0.0166*** | -0.0164*** | -0.0167*** | -0.0170*** |
| | [0.00372] | [0.00372] | [0.00311] | [0.00311] |
| Q4 2008 | -0.0527*** | -0.0521*** | -0.0448*** | -0.0447*** |
| | [0.00427] | [0.00426] | [0.00361] | [0.00360] |
| Q1 2009 | -0.0730*** | -0.0722*** | -0.0598*** | -0.0595*** |
| | [0.00435] | [0.00434] | [0.00364] | [0.00362] |
| Q2 2009 | -0.0690*** | -0.0678*** | -0.0623*** | -0.0617*** |
| | [0.00474] | [0.00472] | [0.00414] | [0.00413] |
| Q3 2009 | -0.0785*** | -0.0768*** | -0.0738*** | -0.0727*** |
| | [0.00718] | [0.00717] | [0.00623] | [0.00624] |
| Central Heating | | 0.0126*** | 0.0125*** | 0.0104*** |
| | | [0.00449] | [0.00376] | [0.00374] |
| Maintenance Interior | | -0.0389*** | -0.0361*** | -0.0350*** |
| | | [0.00525] | [0.00427] | [0.00427] |
| Maintenance Exterior | | -0.00752 | -0.00789 | -0.00640 |
| | | [0.00685] | [0.00565] | [0.00563] |
| Insulation | | 0.00354 | 0.00491** | 0.00476** |
| | | [0.00280] | [0.00240] | [0.00239] |
| Housing Density | | | 2.86e-05*** | 2.79e-05*** |
| | | | [1.27e-06] | [1.27e-06] |
| Urbanization | | | 0.00355** | 0.00283 |
| | | | [0.00174] | [0.00174] |
| Average House Value | | | 0.00211*** | 0.00213*** |
| | | | [7.84e-05] | [7.89e-05] |
| Income | | | 6.79e-05*** | 6.74e-05*** |
| | | | [4.15e-06] | [4.16e-06] |
| Constant | 8.504*** | 8.507*** | 9.264*** | 8.303*** |
| | [0.0327] | [0.0340] | [0.0386] | [0.0420] |
| Sample Size | 32851 | 32851 | 31771 | 31771 |
| $R^2$ | 0.571 | 0.573 | 0.695 | 0.697 |
| $R^2$-adj | 0.565 | 0.566 | 0.690 | 0.692 |

Notes:

Base dummy building period is ‘< 1930’
Base dummy house type is ‘row house’
Standard errors are corrected for heteroskedasticity and stated in brackets.
Significance at the 0.10, 0.05, and 0.01 levels indicated by *, **, and ***, respectively.

**Appendix A**
**Energy Performance Certificate**
**Example United Kingdom**



## Appendix B
## Transaction Prices and Energy Performance Certification
## Time Variation in ‘Green’ Increment

| | 2008<br>January - June | 2008<br>July - December | 2009<br>January - September |
|---|---|---|---|
| Green Energy label | 0.0280*** | 0.0235*** | 0.0175*** |
| | [0.00369] | [0.00527] | [0.00628] |
| Constant | 8.847*** | 8.672*** | 8.905*** |
| | [0.0684] | [0.0989] | [0.0991] |
| Control Variables Included | Y | Y | Y |
| Sample Size | 17012 | 8247 | 6512 |
| R-squared | 0.700 | 0.711 | 0.702 |
| $R^2$-adj | 0.692 | 0.694 | 0.680 |