Energy Performance Certification in the Housing Market
Implementation and Valuation in the European Union

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Abstract
In this paper, we analyze the adoption and effects of energy performance certification in Europe. We use the Dutch housing market as a laboratory, with a unique data set that covers more than 100,000 dwelling transactions in 2008. Our results show that when energy certification is not mandatory, adoption rates are low and clustered among young, well-kept single-family dwellings, located in regions where competition among buyers is low. Tracking the transaction process of the certified dwellings in our sample, we find a significant price premium for green energy labels. This analysis is robust to the inclusion of various dwelling characteristics, including quality of isolation and maintenance of the interior. Our results provide a first indication that consumers recognize the added value of buying an energy-efficient home.

JEL Codes: G51, M14, D92
Keywords: Energy efficiency, environmental sustainability, real estate

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1. 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 that governments are gradually putting a price on a previously costless externality: carbon emissions. Under the 1997 Kyoto protocol, the majority of developed countries and a host of emerging countries already pledged to reduce greenhouse gas emissions substantially. 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 active since 2005, and the UK Carbon Reduction Commitment, due to start in April 2010, are testimonies to this development.

Being responsible for approximately 30 percent of global carbon emissions and 40 percent of global energy consumption (RICS, 2005), the real estate sector makes for 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 energy performance certification of 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 the implementation of national energy performance certification programs for residential dwellings as well as utility buildings (e.g. office, retail, schools and healthcare facilities) across the European Union.

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 that stem from higher energy-efficiency scores capitalize in higher values, *ceteris paribus*. The consequent demand shift can trigger a higher buildings quality and thereby reduce carbon emissions and energy consumption. 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 investigate the diffusion of energy performance certificates in the European Union. We address the drivers of the adoption of energy performance certificates and the consequent wealth effects on the housing market. To this end, we use the Netherlands as a laboratory, with a sample of more than 100,000 transacted dwellings in 2008, of which a mere 20,000 had an energy performance certificate. The results show that the choice of certification is driven largely by the type, quality and location of a dwelling. We find that dwellings constructed during the seventies and eighties in less attractive regions are significantly more likely to obtain an energy performance certificate. When tracking the sales process within the sample of certified dwellings, we document a positive relation between the energy efficiency of a dwelling and its transaction price, corrected for location and quality characteristics. The results and implications of this paper can be used by the national governments in EU Member states and countries outside the European Union to increase the effectiveness of policies regarding energy-efficiency measures and energy performance certification.

The rest of this paper is organised as follows. The next section briefly reviews the literature on energy efficiency in the built environment, while Section 3 discusses the global

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

implementation of energy performance certification programs. Section 4 describes the data sources and provides some first descriptive statistics. Section 5 discusses the empirical results, while Section 6 concludes the paper.

2. Literature Review

Following the rise in energy prices in the 1970s, a multitude of energy models has been developed, with Quigley (1984) being one of the first to take the real estate sector explicitly 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 (Boonekamp, 2007, Kamerschen and 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 effective rents that are some 10 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 office buildings capitalize energy savings in their decision-making process.

For the residential sector, Glaeser and Kahn (2008) argue that if the cost of 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 up to 51 percent if a dwelling is located in the neighbourhood of 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 (Brounen et al., 2009).

Even though willingness to pay for energy-efficient dwellings 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 (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. Ryghaug and Sorensen (2009) document 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.

3. Energy Performance Certification Programs and the EPBD

To increase consumer and investor awareness regarding carbon emissions and energy use in the built environment, a host of national governments have initiated rating systems measuring the extent to which both dwellings and utility 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 labelling 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." 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, up 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 the implementation of energy performance certification programs obligatory 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 buildings sector and will introduce transparency for prospective owners or users with regard to the energy performance in the Community property market." 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 energy performance certificates 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.[2]

The energy performance certificate has a common base in all member states and is based on the thermal quality of the dwelling, but also on such issues 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.

The energy performance certificate should increase the transparency of the energy use of a specific dwelling. In turn, one would expect the certificate to represent a certain economic

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

value, as a higher rating represents a revenue stream stemming from future energy savings. However, poorly defined label requirements, insufficient training of official certification agencies and a slow diffusion of the certificates in the national property markets have characterized the recent introduction of energy performance certificates across the European Union. This leads to the question whether consumers incorporate the information provided by energy certificates in housing transactions. And if yes, does the insight in energy efficiency translate in economic value? In the subsequent sections, we test these hypotheses on a sample of recent housing transactions in the Netherlands, which was one of the first countries to formally introduce energy performance certification.

4. Data

Since January 2008, all transactions in the Dutch housing market need to be accompanied by an energy performance certificate. Exceptions are: dwellings that have been constructed after 1999, and transactions in which the seller and buyer together decide not to apply for an energy performance certificate. Moreover, social housing corporations are obliged to having their complete housing stock rated by January 2009. The energy performance certificate is based on an energy index and ranges 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. The certification process is outsourced to private engineers, realtors or other associations that have been officially certified by the government to assess buildings' thermal quality.

SenterNovem, an agency of the Dutch Ministry of Economic Affairs, exerts quality control and registration of the certificates. We exploit the database of SenterNovem, which provides information on the EPC rating, address and buildings characteristics on all buildings with an energy performance certificate. As of October 2008, a total of 88,000 dwellings had been certified.

To obtain detailed 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 dwelling. The members of the NVM collectively cover approximately 75 percent of all housing transactions. As of October 2008, the NVM database contains 105,560 housing transactions in 2008.[3]

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

We match both datasets based on address information. Of all dwellings transacted in the first nine months of 2008 – and included in the NVM transaction database – 18,190 dwellings had an energy performance certificate. This amounts to approximately 17 percent of the transaction sample. However, the labelled dwellings are not evenly distributed over the sample period. Figure 1 presents the total number of transaction per month and the fraction of transacted dwellings with an energy performance certificate. The graph clearly shows that the percentage of rated dwellings decreased over the course of 2008. This is mainly due to start-up problems in 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 awareness of consumers regarding energy efficiency in dwellings, and the transparency that the EPC created therein, soon dwindled. However, revisions to improve the label have been announced for 2009 and it is expected that the label will soon regain ground.

The geographical dissemination of energy labels is not random either. In Figure 2, the number of certified dwellings as a fraction of total dwellings transacted is presented per province. There seems to be a relation between the state of the local housing market and the likelihood of having a building labelled: distant provinces with a buyers' market rather than a sellers' market, like Zeeland (26 percent) and Limburg (26 percent) have higher rating intensities relative to the more competitive provinces in the centre of the Netherlands, like North-Holland (13 percent) and Utrecht (14 percent).

Table 1 compares the average characteristics of the certified dwellings with the non-certified dwellings. For the certified sample, dwellings are rarely apartments, are mostly constructed between 1945 and 1990 and are slightly larger than non-certified dwellings. Maintenance and isolation is of slightly lower quality.

Within the sample of certified dwellings, only 35 percent has been awarded a green label, where ratings A, B and C are considered to be "green". About a quarter of the certified dwellings 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 – E or lower – which indicates that there are considerable possibilities to increase the energy efficiency in these particular dwellings.

5. Method and Results

5.1 Drivers of Energy Performance Certification

The adoption of an energy performance certificate in a housing transaction is not fully obligatory, so consumers can make a private trade-off between the costs and benefits of acquiring a certificate. This leads to the energy label not being evenly adopted in the different regions and segments of the Dutch property market. Therefore, the labelled sample may not be a representative reflection of all dwellings transacted during the sample period. To gain insight in the drivers of label adoption and whether certain dwelling characteristics affect the likelihood of energy performance certification, we estimate the following model:

$$(1)\quad EPC_{in} = \alpha + \beta_i X_i + \delta_n L_n + \varepsilon_{in}$$

where EPC_i, the dependent variable, is a binary variable with a value of 1 if dwelling i 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 binary location variables, unique for each province n, to control for regional location effects.

Table 2 presents the logit estimation of Model (1), results are provided for three 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. The results in the first column show that, relative to apartments, all other housing types are significantly more likely to have an energy performance certificate. This holds especially for connected dwelling types, such as row, corner of semi-detached dwellings. The square footage of a dwelling increases the likelihood of certification. Thus, larger dwellings are more likely to be labelled. The period of construction has a distinct influence on energy performance certification. Relative to the reference period, which represents all dwellings constructed before 1906, only dwellings constructed after 2000 are significantly less likely to be labelled. 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 when a dwelling is transacted. The coefficients further indicate that buildings constructed 1945 and 1990 are especially more likely to be certified.

The second column adds a location factor to the specification. Relative to the base province – Limburg – only Zeeland has a positive (though insignificant) coefficient. All other provinces show significantly negative results, although coefficients are smallest for Overijssel, Flevoland and North-Brabant. This is in line with anecdotal evidence that these provinces, together with Limburg and Zeeland, have housing markets that are regarded as less competitive relative to sellers' markets in the centre of the Netherlands, where the main cities are concentrated.

The last column also includes several quality characteristics of dwellings in our sample. The coefficient on the isolation variable shows that better isolated homes are more likely to have an energy performance certificate.[4] This is in line with the result for maintenance of the interior of a dwelling, which indicates that better maintained dwellings are more likely to be labelled.[5] These results appears contradictive to Table 1, where we reported marginally lower average values for isolation and maintenance in the sample of certified dwellings. When controlling for dwelling type, and age – two characteristics that are not equally distributed among the two samples – we find that isolation is in fact of better quality among the certified homes.

Overall, these first results show that the sample of certified dwellings is distinctly different from the sample of non-certified dwellings. Apartments and detached dwellings built before 1906 or after 2000 seem to be considerably less likely to be certified. However, dwellings in regions characterized by little competition among prospective buyers are more likely to be labelled. These dwellings need not necessarily be bad buildings, as quality seems to increase the likelihood of a label. As some of these characteristics influence pricing, it is important to separate certified and non-certified transacted dwellings in the remainder of the analyses.

5.2 The Economic Value of Energy Performance Certification

Next, we use a standard valuation framework to investigate how energy performance certification influences the transaction price of dwellings. 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:

(2a) $$\log P_{in} = \alpha + \beta_i X_i + \gamma_n L_n + \delta g_i + \varepsilon_{in}$$

(2b) $$\log P_{in} = \alpha + \beta_i X_i + \gamma_n L_n + \delta S_i + \varepsilon_{in}$$

[4] Isolation quality of a dwelling is measured on a zero (worst) to five (best) scale.
[5] The maintenance of the interior of a dwelling is measured on a one (worst) to nine (best) scale.

In the formulation represented by equation (2a), the dependent variable is the logarithm of transaction price per square foot of dwelling *i* in province *n.* In different models, we also repeat the analysis using the time on the market of a transacted dwelling as the dependent variable. X_i is a vector of the hedonic characteristics of building *i.* To control for location effects, L_n is a vector of dummy variables that have a value of 1 if building *i* is located in province *n* and zero otherwise. g_i is a binary variable with a value of 1 if building *i* is rated A, B or C, indicating that the home obtained a green energy performance certificate, and a value of 0 otherwise. α, β_i, γ_n and δ are estimated coefficients, and ε_{in} is an error term. Equation (2b) differs from the previous equation by including S, a vector of binary variables, which represents the score of the energy label, which ranges form A to F, and where the G-label serves as reference group. We estimate the Models (2a) and (2b) separately for the complete sample and for apartments only, since there are reasons to assume that certification will have a different effect on the transaction process of standardized dwelling types – such as apartments – as compared to transactions of more heterogeneous dwelling – such as non-detached villas.

Table 3 presents the results, in which the logarithm of transaction price per square foot is related to a set of hedonics. Results are corrected for heteroskedasticity (White, 1980). Column (1) reports the results for all dwelling types. The regression explains about 50 percent of the logarithm of transaction prices, based on 18,176 observations. Dwelling size is strongly and negatively related to the transaction price per square foot, which can be interpreted as an indication of the fact that beyond a certain dwelling size, buyers tend to appreciate extra floor space to a lesser extent. Row dwellings transact for 9 percent more relative to apartments, *ceteris paribus,* and there seems to be a premium for tenure if dwellings have been constructed before the 20^{th} century: dwellings constructed between 1906 and 2000 trade at a significantly lower price. This holds especially for those dwellings constructed between 1945 and 1970, for which dwellings transact at prices that are 15-18 percent lower relative to pre-1906 constructed dwellings. In line with the old adage in real estate, 'location location location', the region of transaction plays an important role. Relative to Limburg, dwellings in the economic center of the Netherlands – Utrecht, South- and North-Holland transact at a premium of 44, 29 and 39 percent, respectively. The Northern provinces – Groningen and Friesland – have substantially lower prices, of 10 percent and 12 percent respectively. Most importantly, holding other factors constant, the estimated transaction premium for dwellings with a green label is about 5.4 percent, a premium that is both economically and statistically significant.

In column (2), we extend the model by adding more specific quality characteristics. This slightly increases the explanatory power of the model. Better isolation is positively related to the transaction price, although economic effects are small – a one point increase in isolation quality leads to a 0.7 percent increase in transaction price. For dwelling maintenance, results are economically stronger. A one point increase in the maintenance of interior and exterior leads to an increase of 3.8 percent and 2.7 percent, respectively.

Column (3) restricts the sample to apartments with an energy performance certificate. The size of the coefficients on age and location changes, but the signs remain largely the same. Most notable, apartments in the Northern province of Groningen seem to be in stronger demand as compared to apartments in the Southern province of Limburg, which is contrasting results for the full sample. Importantly, when the specification of hedonic variables and the sample is changed in various ways, the magnitude and statistical significance of the green label remains approximately the same. Ceteris paribus, the transaction price of a dwelling with an A, B or C label is significantly higher by 3.4 to 6.6 percent than of a dwelling with a D label or less.

Table 4 presents the results when the specific score for energy efficiency is included in the model as a set of binary variables. For all dwelling types, the results in column (1) suggest that an A-label is associated with an increase in transaction price of some twenty percent, relative to dwellings of the same type and quality, but with a G-label. In line with expectations, the size of the coefficient on the label dummies is positively related to the level of energy efficiency. The more elaborate model specification in column (2) shows no statistically significant positive effect for energy performance certificates up to D. The premium for an A-labeled dwelling is 12 percent.

For apartments results presented in columns (3) and (4) show a similar positive relation between the level of an energy efficiency rating and the associated premium in transaction price. These effects seem to materialize starting at label rating D. The transaction prices for transacted apartments with an A-label are, *ceteris paribus*, 7.9 to 14.7 percent higher than in G-labeled apartments. Summarizing, it seems that a higher energy score pays off in the transaction process.

Finally, we repeat the analysis to explain a dwellings' time on the market. Table 5 presents the results, in which the time on the market is related to a set of hedonics. The different model specifications explain only 4 to 6 percent of the variation in the dependent variable. For each of the specifications, the variable reflecting a green certification is negative, indicating that dwellings that are more energy efficient, sell faster, also when controlling for quality and location characteristics. In all cases, however, these results lack statistical significance. This relationship may be troubled due to the fact that homeowners may obtain an energy performance certificate at any point during the period that a dwelling is on the market. To illustrate, Figure 3 shows the time difference between the date that a dwelling is first offered on the market and the date that an energy performance certificate is obtained. In more than 80 percent of all transactions, sellers only obtained an energy performance certificate after the first date that a dwelling was offered on the market. In the first month that a dwelling is on the market, another 21 percent of the dwellings were labeled, whereas some 60 percent of the certified and transacted building only obtained a label after two months ore more. This may imply that in some cases, the energy performance certificate is used as a transparency tool with which the unsuccessful transaction gets an exogenous stimulus. Consequently, this reduces the impact of the label rating on the speed of the transaction, since in these cases the sale period is already partially predetermined, and the certificate can no longer influence the total time on the market. Therefore, the transaction-triggering effect of an energy label may be stronger in case all transactions are obliged to being accompanied by an energy performance certificate from the first day on the market onwards.

6. Conclusions

This paper reports the first evidence on the implementation and valuation of energy performance certificates in the residential sector of Europe. Using the Netherlands as a laboratory, we are able to identify some 18,000 dwellings with an energy performance certificate, in a unique dataset of more than 100,000 dwellings transacted in 2008.

The results show that the initial intransparency of labelling practices, in combination with the currently weak legislation regarding energy performance certification, hinder a complete uptake by the market. This leads to the label being mostly in demand in less competitive regions and for dwellings that are more difficult to sell. However, within the sample of 18,000 certified dwellings, our results clearly indicate the importance of an energy performance certificate in affecting market values. The results suggest that an otherwise identical dwelling with an A-rating transacts for about 12 percent more relative to a dwelling with a G-rating; the difference for dwellings with a green label is four percent. The economic significance of these premiums is substantial. For example, the average selling price of certified buildings with a

G-rating is €2167 per square meter. *Ceteris paribus*, the incremental value of an A-rated dwelling is estimated to be about €31,522 at the average size of these dwellings. Comparing dwellings with a green rating (i.e. A, B or C) to dwellings with a D-rating or lower, the incremental value is about €8,395 more.

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 operation expenses following energy savings, but the increased energy efficiency also leads to a higher transaction price. Thus, 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 labelling 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 programs and in stimulating more extensive dissemination of the certificates in the housing markets. 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 existing 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, not 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. Policy makers could learn from these mistakes.

This study has some limitations. The transaction database not fully covers all transactions that took place in the Netherlands during the sample period. Moreover, 2008 was characterized by a strongly changing economic environment and some first signs of a downturn in the housing market. It remains to be seen how the changing economic climate affects the valuation of energy efficiency in the housing market.

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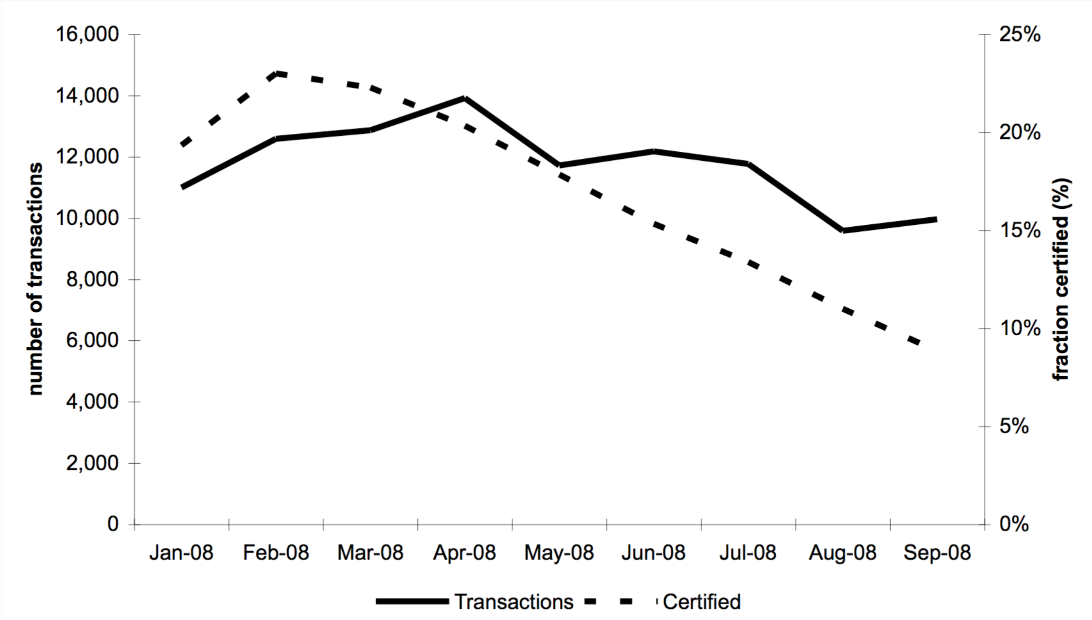
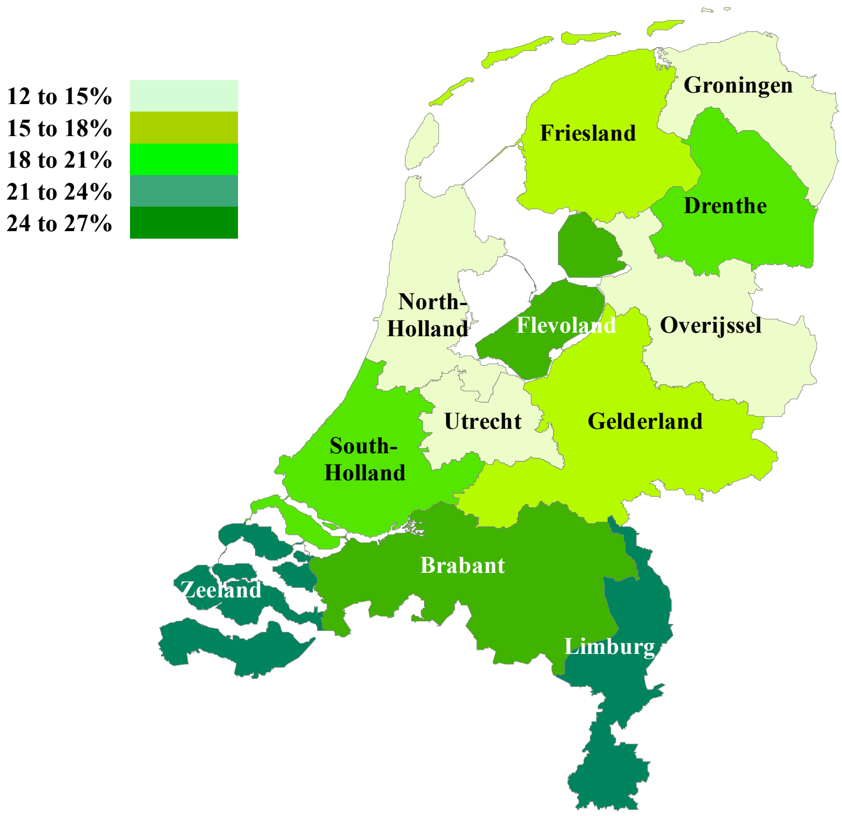
Figure 1
Transactions and Adoption Rate of Energy Performance Certificates



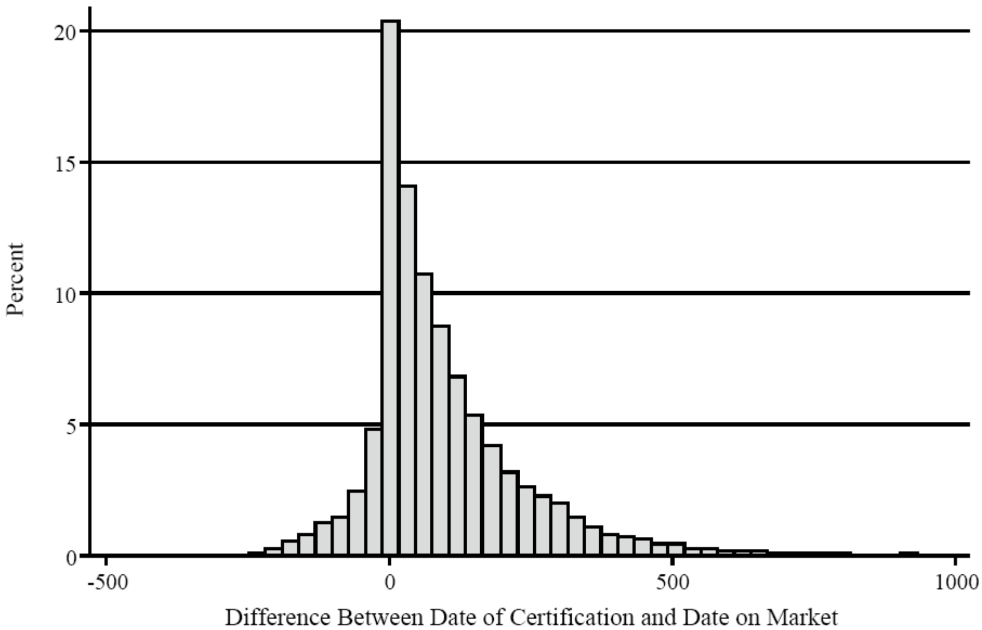
Notes: In this figure, we present both the monthly number of transactions, and the fraction of labelled transaction in every month during the period from January 2008 through September 2008. The fraction of labelled dwellings is computed as the proportion of transactions with an energy certificate to the total number of transactions in the NVM database.

Figure 2
Adoption of Energy Performance Certificates Across Regions



Notes: In this figure, we present the regional variation in adoption rates of energy performance certificates. The adoption rate is computed as the proportion of transactions with an energy performance certificate to the total number of transactions in the NVM database.

Figure 3
Distribution of Label Adoption versus Date on the Market



Notes: In this figure, we present the distribution of the number days between label adoption and date on the market.

Table 1
Comparison of Certified and Non-Certified Dwellings
(Period: Jan 2008 – Oct 2008)

Sample Size	Certified Dwellings N = 18,176		Non-Certified Dwellings N = 87,255	
	Mean	St. Dev.	Mean	St. Dev.
Sales Price (euros/sq. m.)	2993.08	21409.44	3170.79	21480.01
Time on Market (days)	138.75	150.60	122.37	159.07
Housing Type (percent)				
Apartment	21.96	41.40	32.04	46.66
Corner	13.89	34.59	11.54	31.95
Detached	13.15	33.80	13.57	34.25
Semi-Detached	16.38	37.01	13.25	33.90
Row	32.36	46.78	27.78	44.79
Period of Construction (percent)				
< 1500	0.03	1.66	0.03	01.59
1500 – 1905	3.59	18.60	6.01	23.76
1906 – 1930	9.79	29.72	12.26	32.80
1931 – 1944	7.23	25.91	7.72	26.69
1945 – 1959	8.35	27.66	7.46	26.28
1960 – 1970	17.68	38.15	15.04	35.74
1971 – 1980	20.80	40.59	15.58	36.27
1981 – 1990	17.57	38.06	12.47	33.03
1991 – 2000	14.45	35.16	14.31	35.02
> 2000	5.11	7.13	9.13	28.81
Maintenance Interior (1 – 9)	6.98	0.89	7.03	1.10
Maintenance Exterior (1 – 9)	7.00	0.74	7.07	0.95
Size (sq. m.)	121.98	49.74	120.17	56.47
Isolation (0 – 5)	2.19	1.68	2.22	1.81
Energy Performance Certificate (percent)				
Label A	0.83	9.08		
Label B	9.36	29.13		
Label C	25.12	43.37		
Label D	26.18	43.96		
Label E	18.54	38.86		
Label F	12.84	33.45		
Label G	7.12	25.72		

Notes: In this table, we compare the summary statistics of our two sub samples; the set of transactions with an energy performance certificate (certified dwellings) versus the set of non-certified transactions. For each sample we provide information with respect to the average sale price in euros per square meter, the average time on the market measured in days, the type and age of the house, the level of maintenance scored from low to well, the size of the dwellings in each sample, the quality of isolation, and the rating of the energy label, ranging from good (A) to poor (G).

Table 2
Drivers of Label Adoption in Dwelling Transactions

	(1)	(2)	(3)
Housing Type			
Corner	0.419	0.421	0.408
	[0.029]***	[0.029]***	[0.030]***
Detached	0.293	0.296	0.279
	[0.031]***	[0.033]***	[0.033]***
Semi-Detached	0.500	0.490	0.470
	[0.028]***	[0.030]***	[0.030]***
Row	0.420	0.418	0.407
	[0.023]***	[0.024]***	[0.024]***
Size (sq. m.)	0.073	0.043	0.023
	[0.022]***	[0.022]*	[0.022]
Period of Construction			
1906 – 1930	0.291	0.291	0.295
	[0.049]***	[0.049]***	[0.049]***
1931 – 1944	0.436	0.411	0.417
	[0.051]***	[0.052]***	[0.052]***
1945 – 1959	0.636	0.567	0.576
	[0.051]***	[0.051]***	[0.051]***
1960 – 1970	0.706	0.649	0.650
	[0.046]***	[0.047]***	[0.047]***
1971 – 1980	0.764	0.712	0.687
	[0.046]***	[0.046]***	[0.046]***
1981 – 1990	0.808	0.751	0.655
	[0.046]***	[0.047]***	[0.048]***
1991 – 2000	0.469	0.415	0.252
	[0.047]***	[0.047]***	[0.050]***
> 2000	-2.374	-2.430	-2.628
	[0.112]***	[0.113]***	[0.114]***
Province			
Groningen		-0.695	-0.713
		[0.061]***	[0.061]***
Friesland		-0.594	-0.621
		[0.062]***	[0.062]***
Drenthe		-0.713	-0.746
		[0.056]***	[0.056]***
Overijssel		-0.294	-0.323
		[0.059]***	[0.059]***
Flevoland		-0.139	-0.159
		[0.065]*	[0.065]*
Gelderland		-0.449	-0.480
		[0.049]***	[0.049]***
Utrecht		-0.626	-0.655
		[0.052]***	[0.052]***
Noord-Holland		-0.653	-0.685
		[0.048]***	[0.048]***
Zuid-Holland		-0.238	-0.249
		[0.047]***	[0.047]***
Zeeland		0.102	0.084
		[0.072]	[0.072]
Noord-Brabant		-0.207	-0.233

Table 2
Drivers of Label Adoption in Dwelling Transactions
(continued)

Isolation			0.054
			[0.006]***
Maintenance Interior			0.048
			[0.013]***
Maintenance Exterior			-0.018
			[0.015]
Constant	-2.701	-2.112	-2.264
	[0.107]***	[0.114]***	[0.129]***
Pseudo R^2	0.039	0.046	0.047
Model Chi^2	3790.07	4498.95	4603.94
Sample Size	105431	105431	105431

Notes: In this table, we present the results from Model (1). In these logit regressions, the dependent binary variable is energy performance certificate – yes/no. This is related to the type of house (reference group is apartment), the size of the dwelling, the age of the house (reference group is home build before 1906), the region (reference group is the province of Limburg), and to the level of maintenance and isolation. Standard errors are corrected for heteroskedasticity and stated in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

Table 3
Regression Results Transaction Prices and Energy Performance Certification

	All Segments		Apartments	
	(1)	(2)	(3)	(4)
Green Label	0.054	0.034	0.066	0.047
	[0.006]***	[0.006]***	[0.010]***	[0.010]***
Size (log sq. m.)	-0.579	-0.592	-0.316	-0.323
	[0.006]***	[0.006]***	[0.013]***	[0.013]***
Housing Type				
Corner	0.167	0.175		
	[0.008]***	[0.008]***		
Detached	0.662	0.666		
	[0.009]***	[0.009]***		
Semi Detached	0.337	0.342		
	[0.008]***	[0.008]***		
Row	0.086	0.094		
	[0.006]***	[0.006]***		
Period of Construction				
1906 – 1930	-0.046	-0.046	-0.157	-0.143
	[0.013]***	[0.013]***	[0.025]***	[0.024]***
1931 – 1944	-0.060	-0.065	-0.375	-0.352
	[0.014]***	[0.014]***	[0.025]***	[0.025]***
1945 – 1959	-0.148	-0.146	-0.335	-0.313
	[0.014]***	[0.013]***	[0.025]***	[0.024]***
1960 – 1970	-0.178	-0.180	-0.397	-0.377
	[0.013]***	[0.012]***	[0.023]***	[0.023]***
1971 – 1980	-0.122	-0.129	-0.315	-0.297
	[0.012]***	[0.012]***	[0.024]***	[0.023]***
1981 – 1990	-0.124	-0.139	-0.281	-0.265
	[0.013]***	[0.013]***	[0.024]***	[0.024]***
1991 – 2000	-0.027	-0.055	-0.123	-0.126
	[0.014]*	[0.014]***	[0.025]***	[0.025]***
> 2000	0.025	-0.025	-0.117	-0.136
	[0.033]	[0.032]	[0.042]**	[0.041]***
Isolation		0.007		0.007
		[0.002]***		[0.003]**
Maintenance Interior		0.038		0.040
		[0.003]***		[0.004]***
Maintenance Exterior		0.027		0.029
		[0.004]***		[0.007]***
Regional Dummies	Yes	Yes	Yes	Yes
Constant	10.023	9.643	9.081	8.609
	[0.030]***	[0.035]***	[0.069]***	[0.079]***
R^2-adj	0.495	0.510	0.424	0.451
Observations	18176	18176	3991	3991

Notes: In this table, we present the results from OLS regressions in which the dependent variable is the logarithm of price per square foot. The transaction price is related to a binary variable, which is one if a building has a green energy performance certificate (i.e. A, B or C) and zero otherwise, the size of the dwelling, the type of house (reference group is apartment), the age of the house (reference group is home build before 1906), the region (reference group is the province of Limburg), and to the level of maintenance and isolation. Standard errors are corrected for heteroskedasticity and stated in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

Table 4
Regression Results Transaction Prices and Energy Performance Certification

	All Segments		Apartments	
	(1)	(2)	(3)	(4)
Energy Performance Certificate				
Label A	0.198	0.121	0.147	0.079
	[0.026]***	[0.026]***	[0.047]**	[0.046]
Label B	0.135	0.069	0.130	0.080
	[0.012]***	[0.013]***	[0.021]***	[0.021]***
Label C	0.100	0.043	0.108	0.071
	[0.010]***	[0.011]***	[0.017]***	[0.017]***
Label D	0.066	0.019	0.063	0.035
	[0.010]***	[0.010]	[0.015]***	[0.015]*
Label E	0.052	0.014	0.041	0.022
	[0.010]***	[0.010]	[0.015]**	[0.015]
Label F	0.025	-0.000	0.019	0.005
	[0.010]*	[0.010]	[0.016]	[0.015]
Size (log sq. m.)	-0.581	-0.593	-0.311	-0.320
	[0.006]***	[0.006]***	[0.013]***	[0.013]***
Housing Type				
Corner	0.169	0.176		
	[0.008]***	[0.008]***		
Detached	0.663	0.665		
	[0.009]***	[0.009]***		
Semi Detached	0.340	0.343		
	[0.008]***	[0.008]***		
Row	0.086	0.094		
	[0.006]***	[0.006]***		
Period of Construction				
1906 – 1930	-0.045	-0.046	-0.155	-0.142
	[0.013]***	[0.013]***	[0.025]***	[0.024]***
1931 – 1944	-0.058	-0.063	-0.369	-0.348
	[0.014]***	[0.014]***	[0.025]***	[0.025]***
1945 – 1959	-0.146	-0.145	-0.331	-0.312
	[0.014]***	[0.013]***	[0.024]***	[0.024]***
1960 – 1970	-0.182	-0.181	-0.398	-0.378
	[0.013]***	[0.012]***	[0.023]***	[0.023]***
1971 – 1980	-0.134	-0.132	-0.320	-0.301
	[0.012]***	[0.012]***	[0.024]***	[0.023]***
1981 – 1990	-0.138	-0.142	-0.292	-0.272
	[0.013]***	[0.013]***	[0.024]***	[0.024]***
1991 – 2000	-0.050	-0.065	-0.137	-0.133
	[0.014]***	[0.014]***	[0.025]***	[0.025]***
> 2000	-0.023	-0.053	-0.138	-0.145
	[0.033]	[0.033]	[0.042]**	[0.041]***
Isolation		0.006		0.007
		[0.002]***		[0.003]*
Maintenance Interior		0.036		0.039
		[0.004]***		[0.004]***
Maintenance Exterior		0.026		0.028
		[0.004]***		[0.007]***
Regional Dummies	Yes	Yes	Yes	Yes
Constant	9.991	9.646	9.018	8.590
	[0.031]***	[0.035]***	[0.071]***	[0.079]***
R^2-adj	0.497	0.510	0.427	0.451
Observations	18176	18176	3991	3991

Notes: In this table, we present the results from OLS regressions in which the dependent variable is the logarithm of price per square foot. Here, the transaction price is related to specific score of the energy certificate, the size of the dwelling, the type of house (reference group is apartment), the age of the house (reference group is home build before 1906), the region (reference group is the province of Limburg), and to the level of maintenance and isolation. Standard errors are corrected for heteroskedasticity and stated in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.

Table 5
Time on the Market and Energy Performance Certification

	All Segments		Apartments	
	(1)	(2)	(3)	(4)
Green Label	-2.935	-2.549	-2.412	-2.359
	[3.013]	[3.065]	[5.915]	[6.003]
Size (log sq. m.)	8.806	8.644	29.309	29.729
	[2.868]**	[2.885]**	[7.617]***	[7.621]***
Housing Type				
Corner	12.843	14.679		
	[3.825]***	[3.843]***		
Detached	87.502	89.551		
	[4.313]***	[4.338]***		
Semi Detached	29.262	31.115		
	[3.882]***	[3.905]***		
Row	-2.005	-0.427		
	[3.107]	[3.127]		
Period of Construction				
1906 – 1930	-5.810	-6.095	23.174	22.962
	[6.678]	[6.674]	[14.223]	[14.231]
1931 – 1944	-17.618	-18.564	23.815	23.128
	[7.014]*	[7.013]**	[14.619]	[14.667]
1945 – 1959	2.756	2.495	48.845	48.515
	[6.869]	[6.866]	[14.117]***	[14.142]***
1960 – 1970	6.122	5.745	41.244	41.406
	[6.316]	[6.314]	[13.304]**	[13.335]**
1971 – 1980	10.954	11.122	45.724	45.328
	[6.225]	[6.224]	[13.695]***	[13.713]***
1981 – 1990	7.883	10.747	50.949	47.524
	[6.465]	[6.542]	[13.973]***	[14.055]***
1991 – 2000	13.183	17.546	72.887	67.336
	[6.798]	[6.996]*	[14.457]***	[14.817]***
> 2000	26.036	29.917	60.222	57.221
	[16.343]	[16.450]	[23.980]*	[24.207]*
Isolation		-2.715		2.559
		[0.849]**		[1.655]
Maintenance Interior		6.151		1.274
		[1.779]***		[2.593]
Maintenance Exterior		-1.376		-8.373
		[2.133]		[3.978]*
Regional Dummies	Yes	Yes	Yes	Yes
Constant	101.331	71.667	-5.197	40.619
	[15.022]***	[17.667]***	[39.894]	[46.385]
R^2-adj	0.062	0.063	0.040	0.041
Observations	18176	18176	3991	3991

Notes: In this table, we present the results from OLS regressions in which the dependent variable is the time on the market, measured in days. The time on the market is related as to whether the house was provided with a green label, the size of the dwelling, the type of house (reference group is apartment), the age of the house (reference group is home build before 1906), the region (reference group is the province of Limburg), and to the level of maintenance and isolation. Green label is a binary variable, which is one for the buildings with an Energy Performance Certificate corresponding to C or higher, and zero otherwise. Standard errors are corrected for heteroskedasticity and stated in brackets. Significance at the 0.10, 0.05, and 0.01 levels are indicated by *, **, and ***, respectively.