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ON THE ECONOMICS OF EU ENERGY LABELS IN THE HOUSING MARKET

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Summary

THE HOUSING MARKET can play an important role in the reduction of global carbon emissions, and this has been the motivation behind the introduction of certification schemes for the energy performance of private dwellings. The rationale of energy performance certification Schemes, such as the EU energy label, is that they will alter homebuyer behaviour towards favouring properties that display enhanced levels of energy efficiency. However, in the absence of objective data that measures to what extent such schemes actually do have an impact on homebuyer behaviour, it is difficult to make statements as to whether they are a meaningful intervention in seeking to address climate change.

Based on data from the Netherlands, which was one of the early adopters of a certification scheme under the EU Energy Performance of Buildings Directive, this report by Dirk Brounen of Erasmus University, Rotterdam, and Nils Kok of Maastricht University provides some of the first evidence as to the market adoption and financial impact of energy performance certificates. A unique aspect of the certification system in the Netherlands is that it is, in effect, semi-mandatory, allowing the authors to more accurately analyse the motivations behind certification.
Key findings from the research:

- The initial results show that adoption rate was approximately 25 percent after the scheme was introduced, but fell soon after that
- The propensity to certify a property increases in high-density neighborhoods, where average monthly income is low, and where voting for ‘green’ political parties is more common
- There also seems to be a higher uptake of certification in areas of weak market demand, suggesting that energy performance certificates are regarded as an aid to marketing and selling a property
- There is a premium associated with properties that demonstrate high levels of energy efficiency, with a 2.8 percent higher transaction price for properties with an A, B, or C certificate.
- The label price increment varies with the outcome of the label and mostly reflects the financial benefits from lower energy expenses in more energy-efficient buildings.

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01 Introduction

THE CURRENT FOCUS on carbon abatement has lead to increased attention on energy efficiency in the built environment, which offers substantial opportunities for reduction of greenhouse gasses [10,24]. Globally, policy makers target the real estate sector with stricter energy-efficiency standards and mandates. For instance, the European Union implemented the Energy Performance of Buildings Directive (EPBD) in January 2003, with the explicit goal of promoting energy performance improvements in buildings in the European Union. The Directive, which was recently recasted, includes an explicit element on the disclosure of energy performance in buildings: "...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 led to the 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.

Although building codes have generally been effective in reducing energy consumption [2,15], the introduction of energy labels can be viewed as an additional step to enhance the transparency of energy consumption in the built environment. Greater transparency may enable private and corporate occupiers to take energy efficiency into account when making housing decisions. Recent evidence shows that providing feedback to private consumers with respect to their energy consumption is an effective 'nudge' to improve energy efficiency [3,7]. From an economic perspective, the energy performance certificate could have financial utility for both real estate investors and tenants, as the resulting energy savings flowing from more energy efficient building may be capitalized in lower operating costs and higher property values.

However, empirical evidence regarding the implementation and valuation of energy labels is limited, the diffusion and uptake of energy performance certificates across Europe has been slow, and private consumers are uncertain about the value represented by labels that indicate some level of modeled energy efficiency.

Providing feedback to private consumers with respect to their energy consumption is an effective 'nudge' to improve energy efficiency

[1] *Article 7, Energy Performance of Buildings Directive, EU, 2009.*

This report is the first to empirically address the diffusion of energy performance certificates under a large-scale labeling program in the European Union. In it, the researchers study the drivers of the adoption of energy performance certificates and the consequent economic implications in the residential housing market, using the Netherlands as a laboratory, as energy performance certification for homes was introduced in the Netherlands in January 2008, one year before the introduction date prescribed by the European Union. This makes the Netherlands an early adopter of the EPC initiative. Energy conservation is a significant issue for Dutch residents, as the average energy bill of a Dutch household was €152 per month in 2009 (€53 for electricity and €99 for gas), ranging from €105 for the most energy efficient homes to €231 for the least energy efficient homes. In some cases, energy costs represent almost half of the total monthly housing expenses.

Energy performance certification is not fully mandatory in the Netherlands: homebuyers are allowed to sign a waiver that alleviates the seller's obligation to provide a certificate for the dwelling. This semi-mandatory choice for energy performance certification creates a natural experiment to study the adoption and market effects of the energy label in the residential housing market. During the first three months of 2008, more than 25 percent of all housing transactions had an energy label. However, soon after this the adoption rate of Dutch energy labels started to decline, eventually reaching an adoption rate of less than seven percent of the 150 000 homes that were for sale in September 2009. The empirical results show that the choice of certification is driven partially by the quality of a dwelling, with duplex homes, constructed during the 1970s and 1980s, and located in high-density, low-income areas being significantly more likely to obtain an energy performance certificate. The thermal characteristics of a dwelling, like insulation and heating system, do not influence the certification decision. The results also provide some indication of ideology driving the adoption of energy labels: adoption rates are higher in areas where there was high level of support for 'green' political parties during the 2006 national elections.

Turning to the market implications of the energy label, it seems that the label fulfils its informational role and has a moderately powerful market signal. By looking at the transactions of some 33 000 certified homes, it emerges that there is a positive relation between the energy efficiency of a dwelling and its transaction price: homes with a 'green' label sell at a premium of 2.7 percent, relative to otherwise comparable dwellings with non-green labels. The price premium for energy efficiency varies according to the level of energy efficiency described by the label, and it does seem to be the case that this variation is partially related to the underlying energy consumption of the dwelling.

The next section is a brief review of the literature on energy efficiency in the built environment. Section 3 discusses the various programs of energy performance certification in the real estate sector and provides more details on the European energy performance certification program. Section 4 describes the data and provides descriptive statistics. Section 5 discusses the empirical results and Section 6 is a brief conclusion.

02 Energy efficiency in buildings

What do we know about the economics of energy efficiency in buildings?

MODELS ATTEMPTING to predict future residential energy consumption not only take the housing stock and its projected growth into account, but also take account of the demographic, social and behavioral characteristics of the occupants [4,17]. To reduce the carbon footprint of the real estate sector, it is necessary to increase demand from occupiers and investors for more energy-efficient real estate. Evidence on the willingness to pay for energy efficiency in the real estate sector is mostly focused on commercial real estate. In a series of papers that study the investor and tenant demand for 'green' office space in the US office market, Eichholtz et al. [8,9] 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 two to three percent higher compared to equivalent non-labelled office buildings. Transaction prices for energy-efficient office buildings are higher by 13-16 percent. Further analyses show that the cross-sectional variation in these premiums is strongly related to real energy consumption, indicating that tenants and investors in the commercial property sector are capitalizing energy savings into their investment decisions.

However, evidence on the willingness to pay for energy efficiency in residential dwellings is scant. Glaeser and Kahn [13] argue that if the externalities associated with carbon emissions were appropriately priced, energy costs per household would increase by $830–$1410 per household per year, depending on the climatic conditions and, more importantly, on a city's population and density. However, the early literature as well as more recent studies both show that households do not directly take carbon emissions or energy efficiency into account in relocation decisions, but rather focus on broader and more easily-observed environmental externalities, such as pollution, traffic and access to green spaces [1,5,14,21].

To improve the energy performance of the built environment, building codes have become more stringent over the past decades and construction standards have improved. These mostly supply-side measures have led to substantial energy savings over the past decades [2,23]. However, other studies have shown that improvements in the energy efficiency of buildings have slowed down. Nassen, Sprei and Holmberg [20] 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 – of investments in energy efficiency. This is in line with Kempton and Layne [18], who show that inefficient allocation of data on energy consumption restricts energy savings behavior of consumers. Other studies have shown that inadequate 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 [22].

Increased information transparency in energy consumption can be instrumental as a 'nudge' to encourage energy conservation among private consumers. Some recent experiments show that providing feedback to consumers on energy consumption can substantially reduce energy bills [3], although political ideology seems to be an important moderating factor [7]. Standardized energy performance certification programs can provide a cheap alternative to these small-scale experiments.

To reduce the carbon footprint of the real estate sector, it is necessary to increase demand from occupiers and investors for more energy-efficient real estate

[1] *Article 7, Energy Performance of Buildings Directive, EU, 2009.*

03 Energy performance and European certification

Energy performance certification and the European Performance of Buildings Directive

VARIOUS NATIONAL governments have initiated rating systems that measure the extent to which both residential dwellings and commercial buildings meet energy efficiency standards. The Energy Star program, a joint initiative by the U.S. Department of Energy and the U.S. Environmental Protection Agency (EPA), is a long-running and notable example. Residential buildings can receive an Energy Star certificate if they are at least 15 percent more energy efficient than homes that are built to the 2004 International Residential Code (IRC) and which include additional energy-saving features that typically make them 20–30 percent more efficient than standard homes. For consumers, there should be a clear relation between investments in energy efficiency and the consequent savings, as stated by the 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 consumption 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 buildings sector and will introduce transparency for prospective owners or users with regard to the energy performance in the Community property market."*[3] This Directive mandates the introduction of comparable energy performance certificates (EPCs) across the European Union. The Directive should have been formally introduced in all member states in January 2006, but 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. The recast of the Directive in 2009 expanded the existing legislation: the certificate now has 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 documentation accompanying a rental or sales transaction.

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

The energy performance certificate offers a variety of benefits to private consumers. The certificate increases the transparency as to the energy consumption of a specific dwelling, and results in EU-wide recognition of investments in energy conservation. This not only assures homeowners that energy-efficiency investments are recognized at the time of sale, but it may also lead to a lower cost of funding, through more favorable mortgage terms for energy-efficient homes. An energy label may also shorten the time taken to buy and sell houses by revealing information to prospective homeowners [12]. This may be important in the opaque market for housing transactions.[4]

The energy performance certificate assists homebuyers in making an estimate of their future energy costs. The certificate thus represents a certain economic value, with a higher rating leading to a revenue stream arising from future energy savings. However, poorly defined label requirements and insufficient training of official certification agencies have characterized the recent introduction of energy performance certificates across the European Union. Also, 'escape clauses' have allowed homebuyers to circumvent the mandatory disclosure of energy performance certificates in housing transactions. In the Netherlands, for instance, buyers can sign a waiver, exempting the seller from acquiring and providing the certificate. As the Netherlands was, until recently, a seller's market, with demand outpacing supply in most places, there was a clear motivation for homebuyers to offer sellers this option, given that the seller paid for the certificate. In addition, homebuyers and industry bodies have openly questioned the reliability of the information provided by energy certificates in housing transactions. The combination of these factors has led to a slow uptake in the use of energy labels in European housing markets, as most buyers do no longer bother to demand an energy performance certificate from the seller. This may also affect the economic value of energy performance certificates in the market place.

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

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

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

[4] *There is a large body of literature that addresses information transparency in the residential housing market. See Levitt and Syverson [19] for but one example.*

04 Data

SINCE JANUARY 2008, all transactions in the Dutch housing market need to be accompanied by an energy performance certificate. Based on an energy index, 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. Professionally trained and certified assessors 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 (e.g., building size, quality of insulation, type of windows, etc.) with information on recent energy bills. This information is transformed into an energy index, which corresponds to a certain label class, and reported to an official database. Once the information is verified, the certificate is registered and issued to the seller. Obtaining the certificate requires an investment of approximately €200, which is incurred by the seller of the dwelling. Dwellings that have been constructed after 1999, or that are classified as monuments[5], are exempted from mandatory disclosure of the energy performance certificate. Importantly, if the buyer of the dwelling signs a waiver, the seller is also exempt from providing the certificate. The sell-side real estate agent typically offers such a waiver.

Agentschap NL, an agency of the Dutch Ministry of Economic Affairs, exerts quality control and registration of the certificates. This has enabled them to build up a database, which provides information on the exact rating, the address, and a number of physical building characteristics of all buildings with an energy performance certificate. As of September 2009, more than 100 000 residential homes (rental and owner-occupied) had been certified.

The researchers also used the database of the National Association of Realtors (NVM) to obtain information on housing transactions, which includes information on the address, the characteristics of the transaction, and a wide array of quality characteristics for each transacted dwelling.[6] As of September 2009, the NVM database contained 194 379 housing transactions since the introduction of energy performance certificates in the Dutch housing market (in January 2008).[7]

For a slightly smaller subset of the sample, they collected economic data on the neighborhood characteristics of the home. The Central Bureau of Statistics (CBS) provided information on housing density and average monthly household income, both for 2007. This information is available at the ZIP code level. The average time on the market for homes transacted in 2006 and 2007, also at the ZIP code level[8], was used as. a proxy for local housing market conditions

To account for ideological heterogeneity of homeowners, they obtained voting data on the 2006 national elections and calculated the percentage of votes for ‘green’ parties.[9] The Netherlands has two political parties that specifically focus on animal rights and conservation policies: the Green Party and the Party for the Animals. The 2006 national elections had a turnout of more than 80 percent, and are thus a representative proxy for the political balance at the community-level.

[5]A building is officially classified as a monument if it is “of general societal importance due to: beauty, relevance for science, or cultural-historic value.” (Monument Law, 1988). The minimum building age is 50 years.
[6]The members of the NVM collectively cover approximately 70 percent of all housing transactions in the Netherlands.
[7]Only transactions for which all data is available are included, and for which the transaction price ranges between €10,000 and €10,000,000.
[8]The 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
[9]Data is obtained from www.verkiezingsuitslagen.nl.

Data

They then matched the datasets based on address information. Approximately 17 percent of the transaction sample – 33 483 homes – has an energy performance certificate. The first point to emerge is that transactions of houses with certificates 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 number of housing transactions itself is interesting, showing the reduction of liquidity in the housing market, with monthly transactions decreasing year-on-year by some 25 percent, on average, in 2009. The graph also shows that the proportion of homes sold that had an energy performance certificate decreased dramatically over the sample period, starting at about 25 percent in January 2008 and decreasing to about 9 percent in August 2009. This is mainly due to initial problems surrounding the implementation of the label: consumer organizations and the real estate industry raised concerns about the lack of consistency and reliability of the label. Thus, the initial enthusiasm of homebuyers to gain an insight in the energy efficiency of their prospective home, and the transparency that the energy performance certificates created, soon dwindled.

There is also substantial regional variation in the market penetration of energy performance certificates. Figure 2 shows labeled housing transactions as a fraction of the total transaction volume for the 12 provinces in the Netherlands. The two main provinces that form the economic core of the Netherlands (the so-called 'Randstad'), North-Holland, which includes Amsterdam, and Utrecht, both have relatively low adoption rates of energy performance certificates. This contrasts with the high adoption rates in more distant provinces like Zeeland and Limburg. The regional variation in adoption rates seems to coincide with the state of the local housing market: in provinces where there is less competition for space, the adoption rate of energy performance certificates is lower.[10]

Table 1 provides some descriptive statistics on the physical characteristics of the certified dwellings and non-certified dwellings. Simple comparisons show that certified dwellings sell for slightly lower prices and are three days longer on the market, on average. The dwelling type composition of the certified sample is comparable to the composition of the sample of non-certified dwellings. There are some quality differences between certified homes and non-certified homes: the former are smaller by about six percent and are predominantly constructed between 1960 and 1990. Maintenance of the interior and exterior, and insulation are of slightly lower quality when compared to the non-labeled transaction sample. The neighborhood characteristics show that certified dwellings are located in less dense areas, with lower average household incomes.

Within the sample of certified homes, about one third of the transactions have been awarded a 'green' label – corresponding with rating A, B, or C. About a quarter of the certified homes have a D rating, where D indicates that there is room for improvement in energy efficiency and 39 percent of the certified sample has a red label (E or lower), which indicates that there are considerable opportunities to increase the energy performance of these particular dwellings. Last, the economic downturn is clearly reflected in the distribution of the transactions over the sample period: more than half of the transactions took place in the first two quarters of 2008, with transactions in the housing market virtually grinding to a halt in the third quarter of 2009.

[10] *A simple correlation (0.75) between the adoption rate of energy performance certificates and the average time on the market of transacted dwellings confirms this observation.*

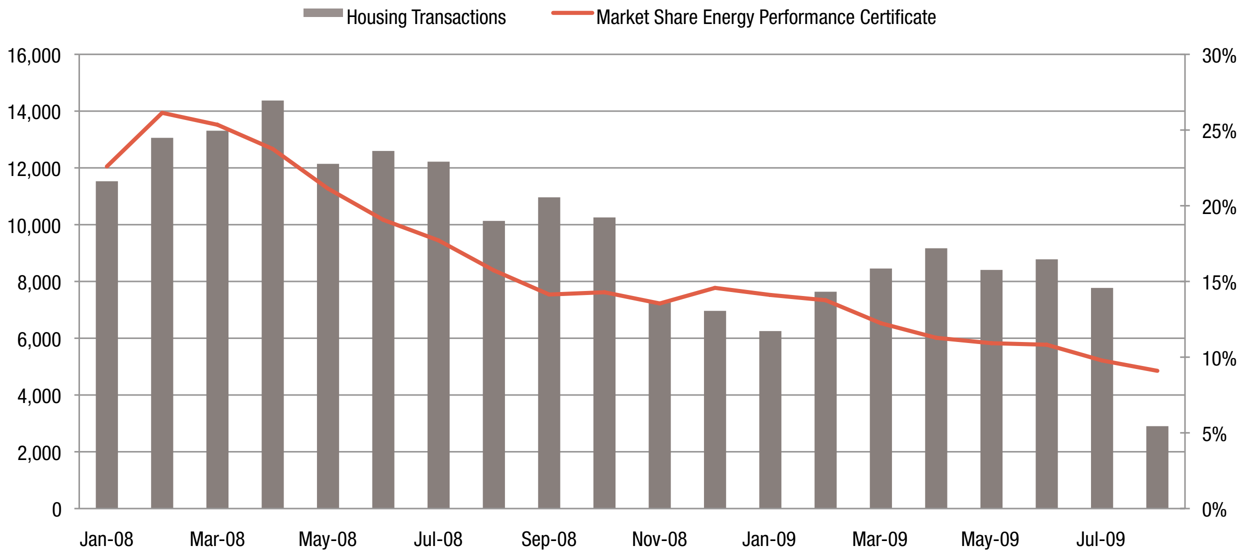

Figure 1: Market transaction volumes and energy label adoption rates (Jan 2008–Aug 2009)

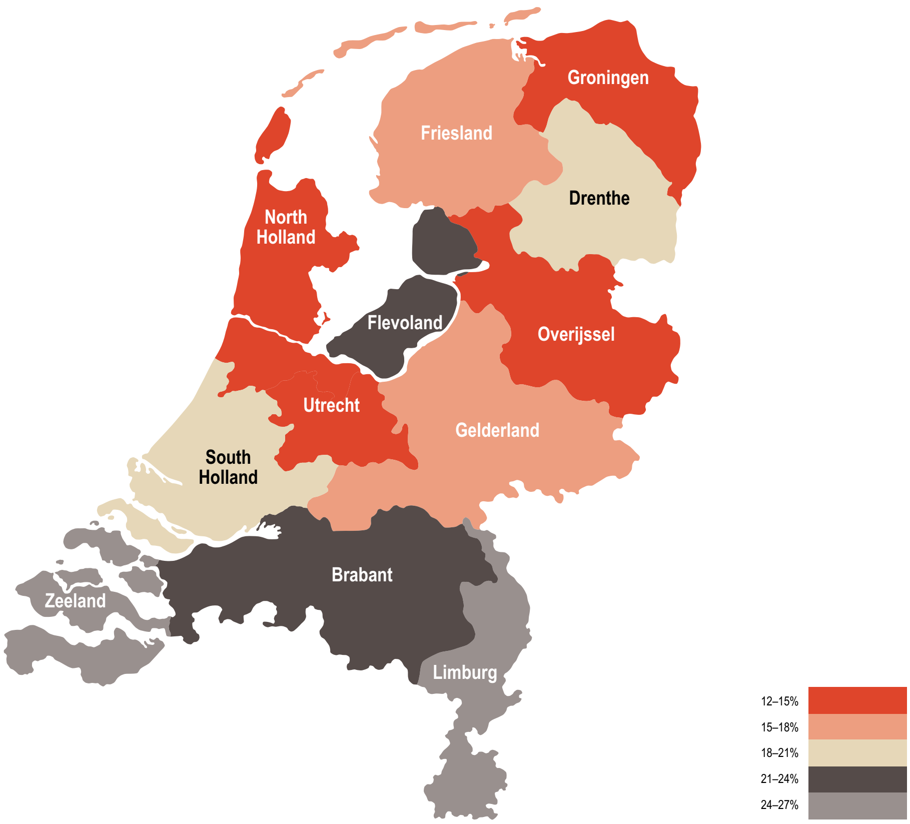

Figure 2: The Geography of Energy Label Adoption Rates (The Netherlands, Jan 2008–Aug 2009)

Notes: This graph reflects the fraction of housing transactions with an energy performance certificate.
Source: Dutch Association of Realtors (NVM) and Agentschap NL

Data

Table 1: Comparison of labeled and non-labeled dwellings (Jan 2008–Aug 2009)

	Labeled Dwellings 33,483		Non-Labeled Dwellings 160,996	
Sample Size	**Mean**	**St.Dev.**	**Mean**	**St.Dev.**
Transaction Price (€/square meter)	2011.53	702.14	2222.15	863.29
Time on Market (days)	139.86	161.59	137.00	166.62
Dwelling Type (percent)				
Apartment	30.34	45.98	31.99	46.64
Duplex	45.57	49.80	41.55	49.28
Semi-Detached	13.37	34.03	13.56	34.24
Detached	10.71	30.92	12.89	33.51
Period of Construction (percent)				
1500 – 1905	3.32	17.90	5.73	23.24
1905 – 1930	9.61	29.47	11.95	32.44
1930 – 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
1970 – 1980	22.04	41.45	14.66	35.37
1980 – 1990	17.62	38.10	11.94	32.42
1990 – 2000	11.83	32.29	13.52	34.20
> 2000	0.99	9.91	12.53	33.10
Quality Characteristics				
Size (square meters)	114.81	48.17	121.62	57.30
Central Heating (1 = yes)	91.04	28.56	90.92	28.74
Insulation Quality (1 – 5)	2.13	1.76	2.27	1.84
Interior Maintenance (1 = "Good")	86.98	33.65	88.67	31.70
Exterior Maintenance (1 = "Good")	91.48	27.92	91.85	27.35
Neighbourhood Characteristics[‡]				
Housing Density	1941.02	1727.01	2069.65	1979.31
Average Monthly Household Income (€)	2088.97	616.41	2202.85	660.94
Average Time on Market (days)[‡‡]	130.09	48.46	128.77	51.86
Political Ideology (percent)				
Green Vote[‡‡‡]	6.96	3.18	7.33	3.47
Energy Label Score (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

Notes: [‡]Neighborhood characteristics are all at the ZIP code level. [‡‡]Calculated for dwellings transacted in 2006 and 2007.
[‡‡‡]Green Vote is calculated as the total votes for the Green Party and the Party for the Animals during the 2006 national election, as a fraction of the total votes.

05 Method and results

The adoption process of energy performance certificates

ALTHOUGH THE ADOPTION of the energy performance certificates in Dutch housing transactions is mandatory, sellers can avoid this requirement if the buyer signs a waiver. So, sellers can make a trade-off between the costs and benefits of acquiring a certificate. The costs are straightforward, given that certification costs on average €200, a price that the seller of the home has to incur. The benefits are more opaque. The most important benefit is that energy labels resolve part of the information asymmetry between seller and buyer, as more information is disclosed if an energy label is issued during the transaction process. Thus, the energy label could be an instrument for prospective buyers in narrowing down the available choice, and it may shorten the economic search process [12]. Potential buyers will be able to consider the consequences of energy efficiency, which could be capitalized into the price that they are willing to offer.

To formally explore the drivers of label adoption, the researchers estimated the following logit model:

$$P(EPC)_{inc} = \alpha + \beta_i X_i + \delta_n L_n + \sum_{c}^{c=1} \lambda_c C_c + \varepsilon_{inc} \quad (1)$$

where EPC_{inc} is a binary variable with a value of 1 if transacted dwelling i has an energy performance certificate, and zero otherwise. X_i represents a vector of quality characteristics of a dwelling, such as size, age and building quality. L_n is a vector of variables that reflect the neighborhood characteristics of each individual dwelling in cluster n, such as density, average monthly household income, and the average time on the market. These variables are all at the ZIP-code level and vary per area 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 four different specifications. All specifications include monthly time-fixed effects to control for time-variation in the adoption of energy performance certificates, and community-fixed effects to control for regional variation in the adoption rate. The first column includes housing type and dwelling size. Relative to detached dwellings (the default category), semi-detached dwellings, and especially duplex dwellings, are significantly more likely to have an energy performance certificate. In contrast, apartments are significantly less likely to be labeled. This may be due to the fact that the relative homogeneity of apartments as compared to other housing types may reduce the need to reveal information about the energy performance of the dwelling to the seller. Monuments are less likely to be certified: current legislation does not require an energy performance certificate for dwellings that have been awarded monument status. The square footage of a dwelling has a significantly influence on the likelihood of energy performance certification, with larger dwellings being less likely to be labeled.

Column 2 adds building characteristics and dwelling amenities to the model. The period of construction has a distinct influence on the likelihood of energy performance certification. Relative to the reference period, which consists of all dwellings constructed before 1930, it is only dwellings constructed after 2000 that are significantly less likely to be labeled. This is in line with the legislation regarding the certification process: dwellings that were constructed after 1999 are exempted from energy performance certification in the transaction process.
The coefficients further indicate that buildings constructed between 1970 and 1990 are particularly likely to be certified.

The results on building quality characteristics are mixed. It seems that the likelihood of label adoption is not simply a reflection of the thermal quality characteristics of the dwelling. The presence of central heating and the quality of insulation – two factors that are directly reflected in the energy performance certificate – do not significantly increase the likelihood of a label. Thus, the label does not seem to be systematically used by sellers to reveal information on superior dwelling quality to the market. The quality attributes of certified dwellings have an inconsistent effect on label adoption: certification decreases when the quality of interior maintenance increases, but adoption rates are positively related to the quality of external maintenance.

Column 3 of Table 2 also includes neighborhood characteristics. The results show that adoption rates are highest among homes that are located in neighborhoods with higher densities (i.e., areas which are more urbanized) and populated by households with lower average incomes. The characteristics of these areas coincide with more difficult housing market conditions – the average time on the market of dwellings transacted in 2006 and 2007 is positively related to the likelihood of energy performance certification.

Method and results

Table 2: The drivers of label adoption logit regression

	(1)	(2)	(3)	(4)
Dwelling Type‡				
Apartment	-0.161***	-0.113***	-0.189***	-0.197***
	[0.030]	[0.032]	[0.035]	[0.034]
Duplex	0.191***	0.097***	-0.018	-0.018
	[0.024]	[0.025]	[0.027]	[0.026]
Semi-Detached	0.078***	0.063**	0.024	0.035
	[0.026]	[0.027]	[0.028]	[0.028]
Monument	-0.207***	-0.146*	-0.099	-0.071
	[0.077]	[0.078]	[0.080]	[0.079]
Dwelling Size	-0.653***	-0.407***	-0.264***	-0.270***
(log)	[0.022]	[0.024]	[0.025]	[0.025]
Period of Construction‡‡				
1931 – 1944		0.033	0.039	0.083***
		[0.030]	[0.030]	[0.030]
1945 – 1960		0.524***	0.509***	0.569***
		[0.027]	[0.028]	[0.027]
1960 – 1970		0.496***	0.495***	0.518***
		[0.024]	[0.024]	[0.024]
1971 – 1980		0.667***	0.708***	0.758***
		[0.023]	[0.024]	[0.023]
1981 – 1990		0.629***	0.659***	0.706***
		[0.024]	[0.025]	[0.024]
1991 – 2000		0.120***	0.236***	0.284***
		[0.026]	[0.027]	[0.026]
> 2000		-2.299***	-1.985***	-1.903***
		[0.059]	[0.070]	[0.070]
Quality Characteristics				
Central Heating		0.027	0.009	-0.003
		[0.023]	[0.024]	[0.023]
Insulation		0.002	0.004	0.004
		[0.004]	[0.004]	[0.004]
Maintenance Interior		-0.200***	-0.180***	-0.170***
		[0.026]	[0.026]	[0.026]
Maintenance Exterior		0.160***	0.146***	0.129***
		[0.030]	[0.031]	[0.030]
Neighbourhood Characteristics				
Housing Density			0.020*	0.034***
(log)			[0.011]	[0.009]
Average House Value			-0.709***	-0.747***
(log)			[0.032]	[0.030]
Average Time on Market			0.001***	0.000
			[0.000]	[0.000]
Voting Green				1.067***
				[0.301]
Constant	2.436***	0.985*	5.540***	5.331***
	[0.676]	[0.570]	[0.709]	[0.248]
Time-Fixed Effects	Y	Y	Y	Y
Community-Fixed Effects	Y	Y	Y	Y
Sample Size	194,375	194,375	179,314	177,566
Pseudo R2	0.065	0.104	0.094	0.065

*Notes: ‡Default dwelling type is "detached". ‡‡Default for building period is "< 1930". Standard errors are in brackets. Significance at the 0.10, 0.05, and 0.01 levels indicated by *, **, and ***, respectively*

The last column addresses the environmental ideology of homeowners as a driver of label adoption. The literature on ideology and consumer choice provides evidence that 'green' consumers are more likely to adopt environmental innovations [16] and are more responsive to energy conservation 'nudges' [7]. As a proxy for environmental ideology, the researchers used the fraction of votes for 'green' parties in the 2006 national elections. This variable is available for 479 unique voting districts. The results on voting preferences and label adoption show a significantly positive coefficient on the measure of voting 'green', which provides some indication that the choice for adopting the energy label may also be driven by ideological beliefs.[11]

Summarizing, the adoption rates for energy performance certificates have been steadily decreasing. However, there is evidence that some factors significantly increase the likelihood of label adoption. Households living in single-family dwellings (as opposed to apartments) of moderate size are more likely to have their home certified. The propensity to take out a label also increases in high-density neighborhoods, where average monthly income is low, and where voting for a "green" political party is more common. Some of these dwelling and neighborhood characteristics coincide with more difficult housing market conditions, which could be an indication that sellers use label adoption – regardless of the outcome – to resolve part of the asymmetric information problem, as a 'strategic' tool to facilitate the transaction process. However, sellers do not seem to adopt an energy performance certificate to signal superior building quality to prospective buyers.

[11]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.

Method and results

The Market Pricing of Energy Performance Certificates

One justification for residential energy performance disclosure is that increased transparency through reliable information on energy efficiency leads to the capitalization of energy performance in housing transactions. This should translate into a price discount for less energy efficient homes and a premium for more energy efficient homes, where the price effect partially depends on the discount rates used by private consumers.[12]

The researchers study the effects of energy performance certificates on the transaction process of dwellings in the Netherlands, using a standard valuation framework, focusing on the sample of certified dwellings, estimating 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:

$$(2)\quad \log P_{inc} = \alpha + \beta_i X_i + \delta_n L_n + \sum_{c}^{c=1} \lambda_c C_c + pG_i + \varepsilon_{inc}$$

In the formulation represented by equation (2), 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 capturing the attributes of the neighborhood n in which a dwelling is located. Gi 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 a vector of scores of the energy label, ranging from A to G (where the G-label serves as the 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 3 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 [26] and all specifications include community-fixed effects and monthly time-fixed effects. The most basic model in column 1 explains some 54 percent of the natural logarithm of the transaction price, based on 33,482 observations. Selling prices are higher for smaller dwellings, although the number of bedrooms has a significantly positive effect. Duplex dwellings and apartments transact at discounts of 42-45 percent relative to detached dwellings.

A key finding is that, within the sample of certified dwellings, homes with label class A, B or C – which is generally referred to as a "green" label – transact at an average price premium of 6.1 percent, ceteris paribus. It could, of course, be that part of the "green" increment may be explained by the better building quality of homes with an A, B, or C label. Therefore, columns 2 and 3 more explicitly control for differences in dwelling quality, and differences in neighborhood characteristics.

Column 2 shows that there is an increasing price discount for older dwellings, relative to homes that are either new (constructed post 2000) or very old (constructed pre-1930). Interestingly, this discount is largest for dwellings that were constructed between 1960 and 1970. Age becomes valuable once it is officially recognized: dwellings that are registered as monuments sell at a premium of some 6 percent.

The quality of thermal characteristics has a positive effect on home prices: the presence of central heating – now prevalent in most homes in the Netherlands – and better insulation are both significantly and positively related to the transaction price. Central heating leads to an average increase in transaction prices of 1.2 percent. In line with expectations, high-quality interior maintenance positively affects property prices. This effect is substantial: well-maintained homes transact at a premium of 3.8 percent. Overall, when controlling for the quality of the dwelling, the "green" increment decreases to 2.8 percent, but it remains statistically and economically significant.

In column 3, the variables that reflect local economic characteristics all show the expected signs: house prices are higher in high-density areas, and the average monthly household income is positively related to the transaction price. The average time on the market in the neighborhood is negatively related to transaction prices. The coefficient on the "green" energy performance certificate shows that the price premium is not just a reflection of potential differences between "green" and "non-green" dwellings: when explicitly accounting for dwelling-specific characteristics and neighborhood effects, the price premium for green dwellings remains both economically and statistically significant. Considering that the average transaction price of dwellings in the certified sample is equal to €231,000, the euro value of the "green" price premium amounts to some €6,200, at the point of sale.

[12]There is a large body of literature on the capitalization of energy savings in prices of appliances and homes, and the discount rate used therein. See Train [25] for an early discussion.

Table 3: Regression results. Transaction prices and energy performance certification (Dependent variable: natural logarithm of price per square meter)

	(1)	(2)	(3)	(4)
"Green" Energy Label	0.061***	0.028***	0.027***	
(A, B, or C)	[0.003]	[0.003]	[0.003]	
Energy Label Score				
A				0.121***
				[0.018]
B				0.075***
				[0.007]
C				0.053***
				[0.006]
D				0.037***
				[0.005]
E				0.031***
				[0.005]
F				0.018***
				[0.006]
Dwelling Type				
Apartment	-0.451***	-0.411***	-0.408***	-0.408***
	[0.006]	[0.009]	[0.009]	[0.009]
Duplex	-0.416***	-0.389***	-0.352***	-0.353***
	[0.005]	[0.007]	[0.006]	[0.006]
Semi-Detached	-0.221***	-0.214***	-0.214***	-0.213***
	[0.005]	[0.006]	[0.006]	[0.006]
New Construction	-0.003	-0.009	-0.011	-0.010
	[0.009]	[0.009]	[0.009]	[0.009]
Dwelling Size	-0.180***	-0.188***	-0.289***	-0.290***
(log)	[0.005]	[0.009]	[0.009]	[0.009]
Number of Rooms	0.003***	0.003***	0.003***	0.003***
	[0.001]	[0.001]	[0.001]	[0.001]
Monument		0.055***	0.049***	0.048***
		[0.017]	[0.015]	[0.015]
Period of Construction				
1931 – 1944		-0.044***	-0.050***	-0.048***
		[0.007]	[0.006]	[0.006]
1945 – 1960		-0.106***	-0.088***	-0.089***
		[0.006]	[0.005]	[0.005]
1960 – 1970		-0.149***	-0.138***	-0.140***
		[0.005]	[0.005]	[0.005]
1971 – 1980		-0.123***	-0.140***	-0.145***
		[0.005]	[0.005]	[0.005]
1981 – 1990		-0.086***	-0.100***	-0.107***
		[0.005]	[0.005]	[0.005]
1991 – 2000		-0.015**	-0.059***	-0.070***
		[0.006]	[0.006]	[0.006]
> 2000		0.003	0.007	-0.014
		[0.017]	[0.019]	[0.019]

Table 3: Regression results. Transaction prices and energy performance certification (Dependent variable: natural logarithm of price per square meter) – continued

	(1)	(2)	(3)	(4)
Quality Characteristics				
Central Heating		0.012***	0.010**	0.009**
		[0.005]	[0.004]	[0.004]
Insulation		0.001*	0.002**	0.001**
		[0.001]	[0.001]	[0.001]
Maintenance Interior		0.038***	0.029***	0.028***
		[0.005]	[0.004]	[0.004]
Maintenance Exterior		0.004	0.005	0.004
		[0.006]	[0.005]	[0.005]
Neighbourhood Characteristics				
Housing Density			0.008***	0.008***
(log)			[0.003]	[0.003]
Average Monthly Household Income			0.383***	0.383***
(log)			[0.007]	[0.007]
Average Time on Market			-0.000***	-0.000***
			[0.000]	[0.000]
Constant	7.934***	9.069***	6.700***	6.096***
	[0.221]	[0.045]	[0.058]	[0.056]
Time-Fixed Effects	Y	Y	Y	Y
Community-Fixed Effects	Y	Y	Y	Y
Sample Size	33,482	33,482	32,600	32,600
R^2	0.543	0.566	0.633	0.634
R^2-adj	0.536	0.560	0.627	0.628

*Notes: ‡Default dwelling type is "detached". ‡‡Default for building period is "< 1930". 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.*

The fourth column of Table 3 presents the results when the specific score of the energy performance certificate is included in the model. This shows that the premium for energy efficiency constitutes a series of positive price effects that correspond to the outcomes of the different label categories. A-labeled homes transact at a price premium of 12.1 percent as compared to similar homes with a G-label, whereas dwellings with an F-label transact for some 1.8 percent more. Interestingly, the variation in the premium for energy efficiency seems to correspond quite precisely with the present value of future energy savings that result from higher energy efficiency. In 2009, a standardized Dutch dwelling had an average monthly energy bill of €152, ranging between €105 for energy label A, to €231 for energy label G. Capitalizing the difference in the energy bill of an F-labeled dwelling, compared to a G-labeled dwelling, results in a present value of some €4000.[13] This is about 1.7 percent of the average transaction price and comparable to the average price premium documented for F-labeled dwellings in Table 3. Comparing the capitalized energy savings of A-labeled dwellings with G-labeled dwellings yields a present value of about €16 000, or 7.2 percent of the average transaction price. Hence, the 12 percent price premium for A-labeled homes, reported in Table 3, seems to reflect more than just future energy savings.

Finally, they test for the robustness of the 'green' transaction premium over the sample period, by including interaction terms of "green" and quarterly time dummies in Model 2. They hypothesize that, with decreasing consumer confidence in the energy performance certificate, the signaling value of the label may be negatively affected. Figure 3 shows the transaction volume of dwellings with an A, B, or C certificate and the index for the 'green' premium. Controlling for differences in location and quality, the average price premium for homes with an A, B or C certificate remains relatively constant for most of the sample period, but drops to close to zero in the third quarter of 2009. However, the sample size is also very small during that period.

The results provide an indication that homebuyers use the information revealed by the energy label and take the relative energy efficiency of their prospective home into account when making investment decisions. This evidence adds to the small number of studies that have addressed the empirical relation between characteristics of thermal efficiency and transaction prices [12] and to studies on energy efficiency and labels in commercial buildings [8,9].

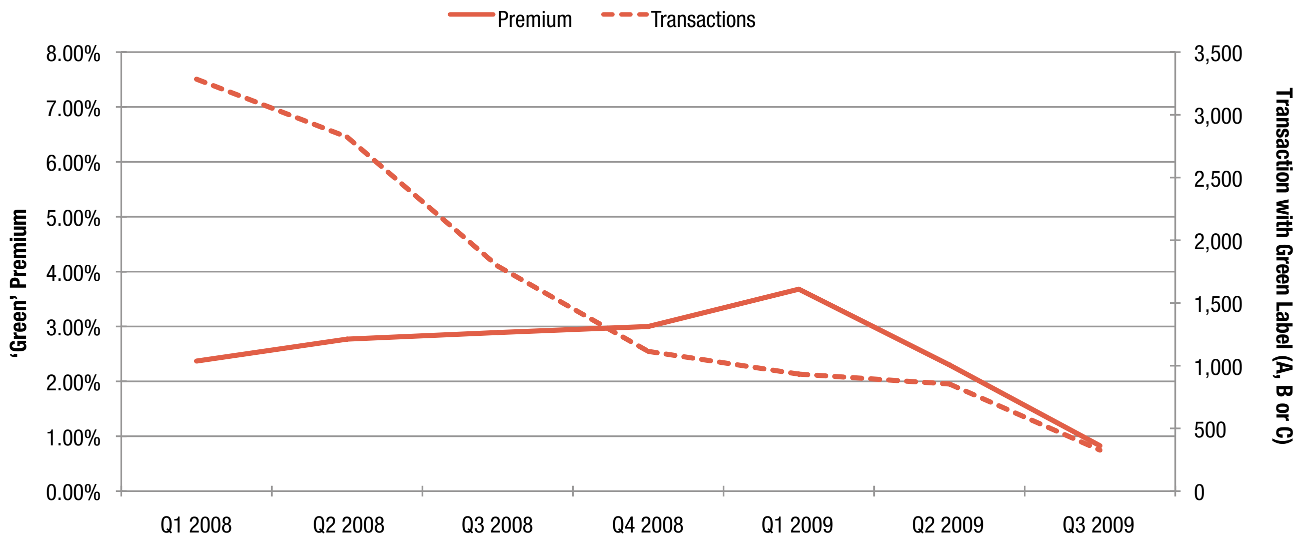

Figure 3: Transaction prices and energy performance certification. Dynamics of 'Green' transactions

Notes: The solid line reflects the time trend in the transaction premium for dwellings with a "green" label (A, B, or C) relative to dwellings with label D or lower, based on quarterly label interaction terms in Model (2). The dotted line represents the transaction volume of "green"-labeled dwellings

[13] *To calculate the present value of future energy savings, we capitalize the monthly difference between the average energy bills of dwellings with different energy labels (A through G), assuming a 12-year duration (the average holding period of Dutch homeowners), and a 4 percent discount rate (assuming homeowners treat proceeds from future energy savings as risk-free). The Dutch Ministry of Housing provided the data on the average energy bills of dwellings in different labels classes, based on a sample of 4,750 homes.*

06 Conclusions

THE RESIDENTIAL HOUSING market can play an important role in energy efficiency improvements and the reduction of global carbon emissions. As well as more traditional policies, such as stricter buildings codes, energy labels can be instrumental in resolving information asymmetries regarding the energy performance of both private dwellings and commercial buildings. The information provided by energy labels may thus encourage energy conservation in the built environment. This paper provides some of the first evidence on the market adoption and economic implications of energy performance certificates using a large-scale mandatory labeling program in the European Union. Using a dataset of some 194,000 transactions, it has been possible to empirically address the diffusion of energy labels in the market for residential dwellings. What this has shown is that the rate of adoption of energy labels is declining. Single-family dwellings of moderate size and constructed between 1970 and 1990 are most likely to be labeled, but the thermal or quality characteristics of the home are not related to label adoption. The label is not systematically used to signal superior dwelling quality. Neighborhood characteristics have a distinct influence on the propensity to adopt a label: labeled dwelling are mostly located in high-density neighborhoods, where monthly household incomes are lower, and where voting for 'green' parties is more common. Some of the neighborhood characteristics and the regional variation in label adoption are related to lower levels of competition in local housing markets (i.e. where the average time on the market is longer). These results imply that the initial lack of transparency in labeling practices, in combination with the current legislation regarding energy performance certification which provides a simple escape clause, hinder a complete uptake op energy labels by the market.

This study also sheds light on the effects of energy performance certification on the outcome of the transaction process. Controlling for thermal and other characteristics of the building, it has shown that homebuyers are willing to pay a premium for homes that have been labeled as more energy efficient, or 'green', with this price premium varying according to the exact outcome of the energy performance certificate, although it is not significantly influenced by variations in housing quality. The energy performance certificate is instrumental in creating transparency in the energy performance of a dwelling and seems to be an effective signaling device, which is capitalized into home prices.

These findings contain some important lessons for homeowners – private as well as institutional. When improving the energy efficiency of a dwelling, there is not only an immediate financial benefit from lower energy expenses, but the increased energy efficiency is also recognized at the time of sale, leading to a higher transaction price. Although it is possible to cast some light on the size of the energy-efficiency increment and real energy savings, ultimately it is not possible to distinguish between the intangible effects of labeling itself and the economic effects of energy savings *per se*. Detailed information on energy consumption of the individual households would be needed in order to further disentangle these effects.

For policy makers, the results of this paper may help in refining energy performance certification programs and in stimulating more extensive dissemination of the certificates. This paper shows that current legislation regarding the adoption of the label is not strong enough. The numerous opt-outs allow homeowners to avoid certification of dwellings. For the energy performance of the complete residential stock to improve, all homes should have an energy performance certificate.

The case of the Netherlands demonstrates that start-up problems surrounding the energy performance certificate were neither adequately tackled, nor clearly communicated. The negative publicity that surrounded energy performance certificates hindered the market uptake. The resulting lack of confidence in the certificate is costly to repair. Other governments should learn from these mistakes, because the information conveyed by a well-regarded energy labeling system seems to represent an effective market signal. This may trigger investments in more energy-efficient buildings, thereby reducing energy consumption and carbon emissions.

Homebuyers are willing to pay a premium for homes that have been labeled as more energy efficient

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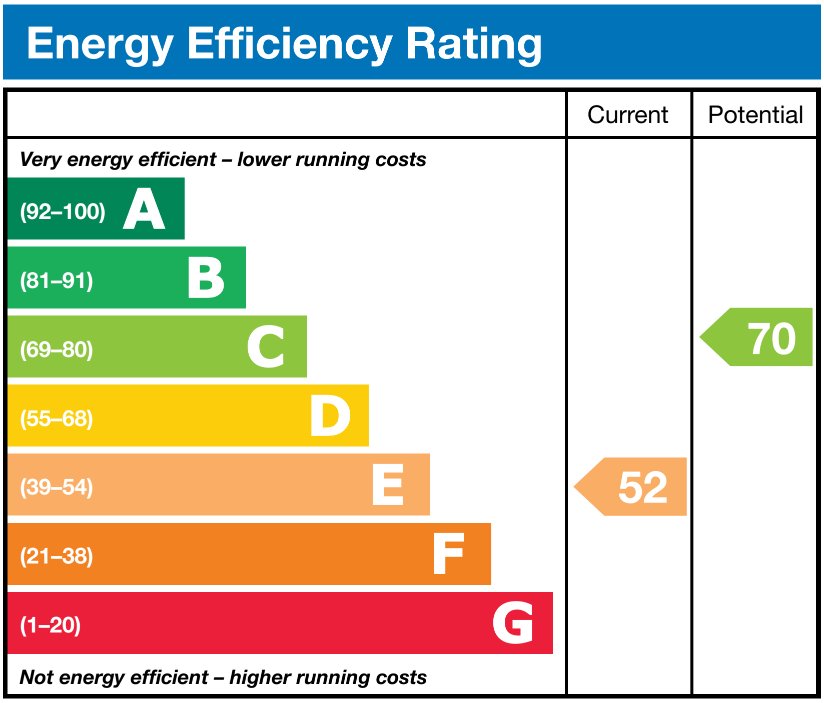
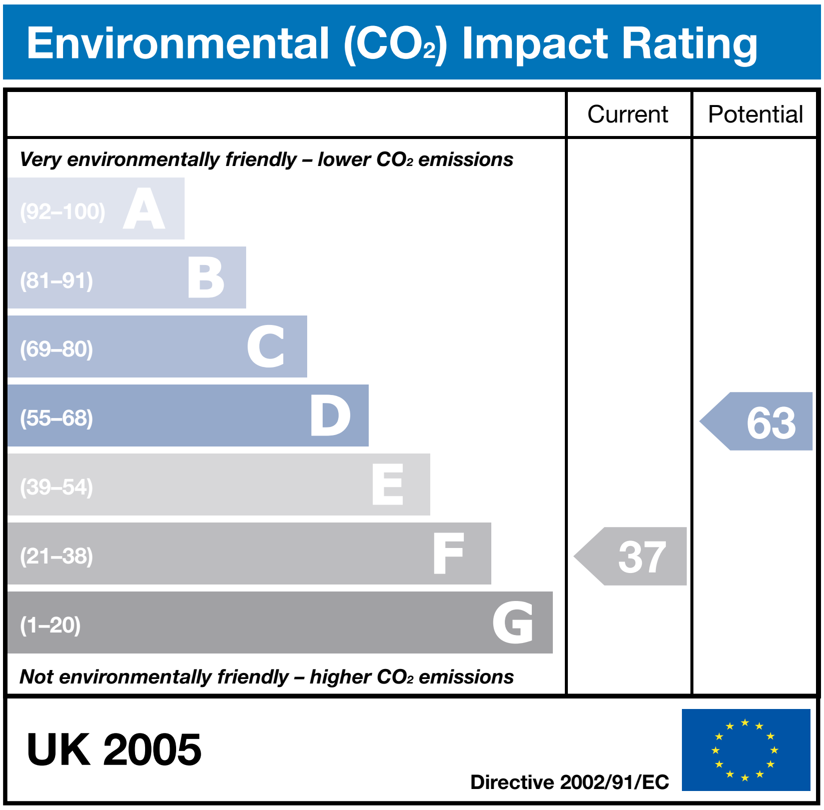
Appendix A

Energy Performance Certificates in the European Union (Example from the United Kingdom)





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