What will you pay for an "A"? – a review of the impact of building energy efficiency labelling on building value

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Abstract

Energy labelling of buildings to rent or buy has been widespread in OECD countries for over a decade. The main objective is to help occupiers to make an informed choice in their building selection; a desired secondary impact of this is to increase the market value of more efficient buildings and hence provide an incentive to supply them.

The EPBD has provided the main mechanism in the EU; it required Member States (MSs) to introduce building labels, Energy Performance Certificates (EPCs), to be available to renters and buyers at the point of legal agreement. A DG Energy commissioned report on the impact of EPCs was published in 2013 (Mudgal et al 2013).

Since then a new requirement was added in the 2010 recast of the EPBD; the EPC has to be included in advertisements of buildings to let or buy. Also, a plethora of new reports and papers have been published on the impact of building labelling in the EU, possibly due to large volumes of data on property transactions and building efficiency becoming more available.

This paper has reviewed recent research on residential property in Europe, examining 15 papers covering 15 countries. The main finding is that the initial deduction that higher energy efficiency results in higher property prices is confirmed: all but one study found that to be the case, over a wide range of climates, and at different scales e.g. cities, regions and countries.

The review has also illustrated how difficult it is to do these investigations – detailed data are needed to eliminate the effect of factors which could co-correlate with energy efficiency and muddy the results. Further, the use of multiple factors requires large samples in order to get significant results. More studies and analysis need to be done to draw more far-reaching conclusions.

Introduction

Energy efficiency is often cost effective – the higher up front cost is offset by reduced running costs – but consumers don't always recognise that. The initial rationale for energy labels for appliances and cars was to provide information on energy performance to the consumers – in economic terms to address 'information failure' (discussed for example in Boardman et al, 2000). Manufacturers and retailers present consumers with information on some aspects of the goods they are selling (for example time to accelerate from 0–60 mph for cars (in the UK) or the picture quality of TVs) but before mandatory labelling this rarely included energy. Energy labels are designed to address this gap by providing energy information in a consistent way to the consumer at the point of sale.

Energy efficiency in buildings may offer advantages beyond those in appliances and transport – providing benefits in addition to energy savings (with associated cost reductions and climate benefits) in terms of increased comfort (fewer draughts, a more comfortable temperature) and reduced maintenance (e.g. fewer lamp replacements). Also, buildings are often perceived as a long-term investment for the owner which should encourage a tolerance for longer payback periods. Against this

are several factors which reduce the attractiveness of energy efficiency, such as the possible disruptive effect of retrofitting energy efficiency measures and unfamiliarity of the technology and processes (see for example Brown et al 2014). Finally, there is the familiar split incentive issue – simplistically the landlord pays for the measures and the tenant benefits by having reduced energy bills (discussed in the context of price premium in Kholodilin et al 2016).

Energy labelling clearly has a potentially valuable role to play in this situation: providing information to all parties and an incentive to improve efficiency to increase value, both at the point of sale and when a property is rented. On the other hand, unlike appliances or cars, it is possible for prospective purchasers to see some of the features that make a property more energy efficient: types of glazing, types of heating, level of loft insulation and so on can all be observed on a property viewing. So, is there less added value in an efficiency label for a building?

Also, in energy terms buildings are complex systems: a combination of fabric, heating, cooling, ventilation and lighting, each of which can have many components. So perhaps it is not surprising that building energy labelling has generally lagged behind that of appliances – for example in the EU mandatory labelling refrigerators, started in 1995 whereas for buildings it was only introduced (under the 2002 Energy Performance of Buildings Directive, EPBD) in 2006. Similarly, in the US the compulsory, EnergyGuide label was originally introduced for appliances in 1980 (Energy Efficient Strategies and Maia Consulting 2014), but voluntary ratings for homes, the Home Energy Score[1], only in 2012. (Although, conversely the US endorsement label, ENERGY STAR was first introduced for appliances in 1992 (computers and monitors) followed by new homes in 1995[2]).

For researchers interested in the evaluating the impact of labels buildings labels have one substantial advantage over cars or appliances – they are repeatedly re-sold or re-let during their lifetime, so the value of the label (and the underlying efficiency) is repeatedly revealed. Countries rarely require second-hand appliances or vehicles to be labelled (an exception is in Ghana where 'pre-owned' refrigerators represent the majority of the market) so for each product the relationship between energy efficiency, the energy label and the price is only available at one point in time. Not only does this provide the single data point, it is in a transaction which is heavily influenced by the manufacturer and the retailer.

The one-off nature of the purchase has also meant that evaluators have largely had to work from limited data and instead rely on customer surveys and laboratory experiments to assess what influence energy labels have on what consumers buy and what they are prepared to pay for more efficient products. This is useful information; but what consumers say that they are going to do, or do in a laboratory situation, is not always the same as what they do when actually buy something. Whereas purchase and rental price data for buildings is 'real world' information. The counterpart to this is that 'real world' information is messy; it requires large volumes of data, carefully analysed, to be able to draw robust deductions. However, a growing number of researchers are taking up this challenge and trying to filter out the knowledge from the noise. This paper sought to see what could be learnt from this growing evidence base.

Building labels/ratings/certificates/benchmarking

A wide variety of schemes exist worldwide to classify buildings' energy performance and different terms are used to describe them: certificates, ratings and benchmarking being used more widely than labels. The different terms and meanings are discussed in a 2008 study (Perez-Lombard et al, 2008). Both mandatory and voluntary schemes are in widespread use – often alongside each other. The systems also have different coverage – in terms of the type of residency of the building (residential (single family or multi-family), public or commercial), whether they apply to new or existing buildings only and how they are assessed – asset (based on calculations or models) or operational (based on measured consumption). This diversity is illustrated in Table 1 which shows information on schemes in IPEEC countries in 2014 (Building Energy Efficiency Taskgroup, 2014).

In addition to these energy focused schemes there are broader 'green' or sustainability ratings which include energy in use but also take into account other environmental impacts such as water use, and materials used in construction. An example of these, which while developed in the USA is used in many countries, is LEED, or Leadership in Energy and Environmental Design[3].

Picking the wheat from the chaff – how do you determine what difference energy efficiency has made?

Buildings are very diverse and their market value at any given point in time is affected by numerous factors including: size; age; character; location and condition (for example the factors considered by German house buyers are described in Amecke 2012). What is more, the value changes depending on market conditions – both supply and demand and broader economic conditions. There is a considerable challenge therefore in identifying the effect of just one factor, a challenge that was recognised by Sherwin Rosen who developed a way to address it – the hedonic correlation method (Rosen 1974). The method is applied slightly differently by each set of study authors, see the referenced papers for details.

A significant difficulty in undertaking this analysis for energy efficiency specifically is that it can be correlated with several other aspects – if these are not accounted for separately then the apparent price differential due to energy efficiency is actually that for energy efficiency compounded with other factors. For example, in EU countries energy use is heavily correlated with date of construction – both because of changes in technology, material or style of construction but also because, (starting, generally in the 1970s) of building energy codes requiring efficient building, with increasing efficiency demanded over time. Thus, the date of construction or age of building needs to be

1. Information from https://betterbuildingssolutioncenter.energy.gov/home-energy-score/home-energy-score-about-score.

2. Information from https://www.energystar.gov/about/history/major-milestones.

3. Information from http://www.usgbc.org/leed.

Table 1. Building rating schemes in IPEEC countries (Building Energy Efficiency Taskgroup, 2014).

			Assessment type		Building type					
Country	**Scheme**	**Mandatory?**	**Asset**	**Operational**	**New**	**Existing**	**Public**	**Non-Res**	**Res SF**	**Res MF**
Australia	NABERS	Y		●	●	●		●	●	
	Commercial Building Disclosure	Y		●		●		●		
	NatHERS		●		●	●			●	
Brazil	PBE Edifica		●		●		●	●	●	●
Canada	EnerGuide Rating System		●		●	●			●	●
	ENERGY STAR Portfolio Manager			●	●	●	●	●		
	REALpac Energy Benchmarking Program			●		●	●	●		
China	China 3 Star Building Energy Efficiency Evaluation		●	●	●	●	●	●		●
European Union	Energy Performance Certificates (EPCs)	Y	●	●	●	●		●	●	●
	Display Energy Certificates (DECs)	Y		●			●			
France	Diagnostic de Performance Energetique	Y	●	●	●	●	●	●	●	●
Germany	Energieausweis	Y	●	●	●	●	●	●	●	●
India	Star Rating for Buildings			●		●	●	●		
Italy	Certificazione Energetica	Y	●		●	●	●	●	●	●
Japan	CASBEE		●	●	●	●	●	●	●	●
Russia	Energy Passports		●		●	●	●	●	●	●
South Korea	Certificate of Building Energy Efficiency		●	●	●	●	●	●		●
United Kingdom	EPCs	Y	●		●	●		●	●	●
	DECs	Y		●		●	●			
USA	ENERGY STAR			●		●	●	●		●
	Home Energy Score		●		●	●			●	
	Commercial Building Energy Asset Score		●		●	●	●	●		●
	HERS		●		●	●			●	

Non-res, non-residential; Res SF – residential single family; Res MF, residential multi-family.

included as a separate variable to account for this. (This strong correlation of energy performance with time is demonstrated in many of the results sections of the papers discussed below). Experience would also suggest that building location is another key factor – as well as having a strong effect on price in its own right, different types of housing, with different levels of energy efficiency, tend to be clustered in different areas and so may be correlated with energy efficiency. (The correlation of price and location is also shown in many of the results references).

In fact, the effect of correlated factors on the apparent price effect of energy efficiency was shown by researchers (Fuerst et al, 2016b) in a study of apartment sales in Helsinki. The team were fortunate enough to have extensive information on a large sample of properties (>6,000), which included detailed neighbourhood data. The initial results from the hedonic model gave a statistically significant 3.3 % price premium for apartments in the top three energy efficiency categories; when a set of detailed neighbourhood characteristics was accounted for separately in the regression this was reduced to 1.3 %.

Another issue for this type of analysis is that the market for property can change radically over quite short periods of time, so if data from an extended period is used then the author would assert that it is important to account for the date of transaction (both monthly and quarterly periods have been used in the analyses reviewed in this paper), so that market changes don't mask or generate price changes for a particular factor.

Generally speaking, it seems that the more data on more different aspects of the property can be gathered and accounted

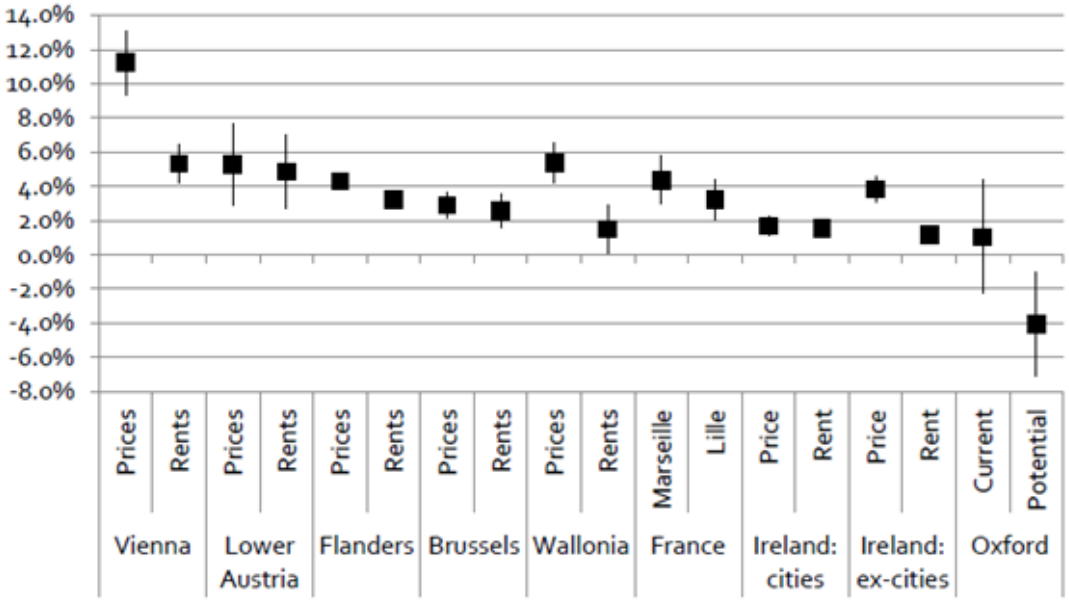

Figure 1. Effect of one-letter or equivalent improvement in EPC rating on property price across European property markets (95 % confidence interval shown). Mudgal et al (2013).

separately in the hedonic analysis the more robust the results are likely to be. However, generally the more aspects are covered the greater the size of the sample needs to be to get statistically valid results. Furthermore, the more detailed the dataset is required to be the fewer are likely to be available – although the rise of 'big data' may be helping to make this more practicable.

Previous EU findings

The review of for the European Commission on the effect of EPC's for building rents and costs (Mudgal et al 2013) included a literature review which found seven extant analyses of the effect of the presence of energy/environmental labelling[4] on the price of residential property. Most found a positive correspondence between price and the label; one found a negative result. [It is interesting to note the increase in the number of publications on this topic – from a total of seven worldwide found for 2007[5] to 2012 quoted in the EC review report, to 15, just on the EPC, from 2013 to 2016 – see below.]

One of the main tasks of the study was to undertake hedonic price analysis for EPCs in multiple countries. A semi log-analysis was undertaken in each case with the following factors accounted for (text taken directly from the report):

- location fixed effects, as granular as possible, to account for location-specific and population-specific attributes affecting the price;
- date/period the property was listed/transacted, typically done quarterly, to account for changing market conditions over time – an important consideration given the history of some EU property markets over the past decade;
- house size and type attributes, and other quality-related attributes other than energy performance, including surface area (where recorded, or bedroom/bathroom numbers elsewhere), whether it is an apartment, detached home or other type of property, and the age of the property (where available);
- energy efficiency attributes of the property, including whether it had a rating at all, what that rating was (categorical scale), the date of the rating relative to the market transaction or listing (if available), and whether the rating was known to the purchaser (if relevant).

The sources of data, the period of the data and the degree to which it was possible to match EPC information to listings, and therefore the number of data points varied by country. The state of the market for residential property, to buy or to let, also varied and it was acknowledged that this would probably have an effect on the results. The summary results are shown in Figure 1.

The report authors note that some for some countries the period of construction of the property was not available and, as noted in the previous section, this may be correlated with energy efficiency and therefore can have an effect on the result. The means and degree of correction for location also varied between datasets and this may have had an impact also.

Which recent studies to include?

The original intention of the author was to look at the whole range of the literature since the Review for the EC (Mudgal et al 2013) in order to present the broadest possible picture. However, the realisation of the large number of new studies led the need to restrict the scope. Thus, the author chose to focus

4. Five of these were for endorsement type schemes, all but one of which were green labels i.e. not just energy related, and compared labelled with non-labelled property so were not directly comparable to the examples reviewed in this paper; two looked at the effect of different levels of ratings within a given scheme.

5. When the first paper of this type was published (Mudgal et al, 2013).

on residential buildings only. The intention was still to cover as wide a geographic area as possible– after all there were analyses from China (Zhang et al 2016), Japan (Fuerst and Shimizu 2015), Switzerland (Feige et al 2013), and the USA (Kahn and Kok 2014 and Bond and Devine 2016). However, all of these were for green labels – covering a number of factors besides energy efficiency, such as water use and construction materials. As the Swiss study (Feige et al, 2013) found, energy efficiency may not be the most highly valued green attribute and it would not be possible in most cases to separate out energy efficiency from these other factors. That left one study outside the EU – on ENERGY STAR in the USA, (Walls et al, 2016). But this was on the effect of a voluntary (endorsement) label, so the methodology was quite different from the EU studies (using non-certified samples matched as far as possible as a control) and was rejected on these grounds.

On reflection, this lack of equivalents to the EPC outside the EU should not be a surprise – as shown in Table 1 – there are few countries with mandatory energy ratings for residential buildings outside the EU.

This left the still respectable total of 15 studies, covering 14 Member States (MSs) plus Norway published from 2013 to 2016. Also, the Energy Performance of Buildings Directive (EPBD) allows Member States considerable flexibility in how EPCs are used[6] and a certain amount of leeway in when different aspects were introduced. These may be expected to have an effect on when and how the EPCs have an effect on the housing market, so there this was still the prospect of different variations on labels producing different results.

The different ways and dates that EPC's have been introduced for the relevant Member States that are relevant to this paper are shown in Table 2 (Data accessed via Concerted Action on Energy Performance of Buildings[7] as a primary source, supplemented in some cases by MSs study). For example, one of the changes introduced by the revision of the EPBD adopted in 2010 was that MSs were to introduce a new requirement that the energy performance should be included in all advertisements of buildings to be sold or let. In principle, this change could increase the importance of energy efficiency ratings – it should make purchasers more aware of energy efficiency and make it easier for them to take account of energy efficiency in the purchasing process. This took effect in MSs at different times, and at different points in the period of data studied in different countries. One of the questions for this review was then – is this effect noticeable? Does the presence of the EPC in advertising have any effect on the price premium? See Table 2[8, 9, 10, 11, 12, 13].

What is the recent evidence from the EU?

DESCRIPTION

Fifteen recent (published 2013 or later) studies on EU were identified in the literature search. The literature source for each study is shown in Table 3.

The characteristics of these studies, in terms of the data used and factors accounted for in the hedonic calculations are listed in Table 4[14, 15, 16, 17]. It should be noted that some of the studies did not account (or only partially accounted) for all three of the factors that the author considers necessary to separate out energy efficiency from correlated factors, that is: period of construction, location and date of sale.

RESULTS – THE EFFECT OF ENERGY EFFICIENCY ON RESIDENTIAL PRICES

Seven of the fifteen studies produced results expressed as the price differential for the change in categorical rating, generated using a log-linear regression and thus are reasonably comparable with the results from the EC review (Mudgal et al 2013) and each other. The results with 'acceptable' significance are shown in Table 5[18, 19, 20] (together with whether the respective study took account of the three factors identified above as likely to have the strongest effect on the robustness of the results: location, age (date of construction) and period of sale). Data for the multi-country study, (Rajkiewicz et al, 2016), are shown separately in Table 6[21] because the results for this study had lower levels of significance (NB the study did not appear to account for location or period of sale).

The results of the other studies are expressed in a variety of ways that are not directly comparable to those in Table 5 or Table 6, or generally, to each other. However all but one (11) show a positive correlation between price and energy efficiency. The findings are summarised in Table 7.

DISCUSSION– THE EFFECT OF ENERGY EFFICIENCY ON RESIDENTIAL PRICES

It is not possible to draw many firm conclusions from these data on effect of energy efficiency on residential property prices. One particular problem in analysis of the results is the wide variety of ways that they are expressed. It may be possible to convert these into mutual comparable measures but not within the resources of the author at present.[22] It is questionable whether this effort would be justified for some findings given that there is such a wide range of methodologies used. In particular, some studies take no account of the date of construction

6. For example, in exactly how energy performance is assessed and how the information is displayed.

7. Accessed via http://www.epbd-ca.eu/.

8. Date required in advert, Austria: Space heating and energy efficiency factor need to be provided but not the EPC.

9. Date required in advert, Denmark: Earlier date according to Jensen et al (2016).

10. Operational assessment type, Finland: Based on operational rating during the study period according to Fuerst et al (2016b).

11. Date required in advert, Netherlands: Not confirmed.

12. Date required in advert, Norway: Requirement not adopted by Norway.

13. Date required in advert, Sweden: Energy performance indicators since Jul 2012.

14. Sample size: Rounded when more than 1,000.

15. Sample size, Denmark: Paper also includes data and analyses from 2010 to 2012 but these are not considered here – see the results text.

16. Sweden: Study looked at correlations with energy consumption not energy efficiency.

17. Start of data period, Austria: Dates not stated in report.

18. Comments: In some studies a variety of models were used, generating different results. The author has selected what she think are the most appropriate model and results for comparison. The model is stated so that the reader can identify the results in each reference.

19. Reference rating, Ireland: The C rating on the Irish label is split into three categories: C1, C2 and C3, with C1 representing the highest rating.

20. Study accounts for date of sale, Portugal: All sales in a single month.

21. Sales surplus: This term is not defined in the report but is taken by the author as being the additional sale value attributable to the improvement in energy rating.

22. This work is self-funded.

Table 2. Aspects of ways EPCs applied in Member States relevant to price-rating studies.

Country	Assessment type		Label type		Date EPC introduced	Date required in advert	Additional aspects
	Asset	Operational	Categorical	Continuous			
Austria	♣		●		Jan 2006	NA	EPCs required in some regions pre-adoption of EPBD
Czech Republic	♣		●		2013	Jan 2013	EPC not required for houses < 1000m² until Jan 2019
Denmark	●		●		1997	Jan 2010 Jan 2013	
Finland	●	●	●		Jan 2009	Jun 2013	
France	♣		●		2006	Jan 2011	
Germany	●	●		●	2007	May 2014	
Ireland	●		●		2007	Jan 2013	
Italy	●		●		2009	Jan 2012	Owners can self-certificate properties as G
Luxembourg	♣		●		Jan 2008	Jul 2012	
Netherlands	●		●		2008	2013	
Norway	♣		●		Jan 2010	NA	
Portugal	●		●		Jul 2007 (new) Jan 2009 (existing)	Dec 2013	
Slovak Republic	♣		●		Jan 2008	Jan 2013	
Sweden		●		●	2006	Jan 2014	
UK	●		●		2007	Jan 2013	

♣ *Means assumed – not stated in documentation.*

Table 3. Literature source for each EU study.

No	Country	Reference	Year	No	Country	Reference	Year
1	Denmark	Jensen et al	2016	9	Portugal	Ramos et al	2015
2	Finland	Fuerst et al	2016b	10	Sweden	Högberg	2013
3	Germany	Kholodilin et al	2016	11	Sweden	Hårsman et al	2016
4	Ireland	Stanley et al	2016	12	England (UK)	Fuerst et al	2013
5	Italy	Fregonara et al	2014	13	Scotland (UK	Pryce et al	2014
6	Italy	Bonifaci and Copiello	2015	14	Wales (UK)	Fuerst et al	2016a
7	Netherlands	Aydin	2016	15	Multiple	Rajkiewicz et al	2016
8	Norway	Olaussen et al	2015				

and only limited use of location data which means that their results are probably finding co-correlations with factors other than energy efficiency.

Of the single country studies, one, uniquely amongst these studies, appears to have examined the correlation with the energy consumption, in kWh, rather than the energy efficiency in kWh/m² (Hårsman et al, 2016, reference 11). This found that price increased with increasing energy use. They also found that energy consumption increased with size. As larger properties (with higher energy consumption,) would generally be expected to be more expensive, this would appear to explain this result. It is not possible to deduce what the results of the correlation of price with energy efficiency would be.

The multi-country study, (Rajkiewicz et al, 2016, reference 15), found a negative correlation in one of the 12 MSs studies, the Netherlands, but: this is an initial report of a longer study; the correlation was relatively low for all the results (as indicated by the R^2 values in Table 6) and no allowance appears to have been made for building location.

Another point to take into account is the problem in comparing price premia as % of overall property value between countries – as pointed out by the authors of the Welsh study (Fuerst et al, 2016a). The authors noted that the price premia in Wales were higher than a previous study (Fuerst et al 2013) had found in England and commented that this was almost certainly due to lower average house prices in Wales, rather than a greater absolute value being placed on energy efficiency in Wales.

Nonetheless, the findings are that there is overall a positive effect with energy efficiency in a large number of MSs, with some studies including very large sample sizes and able to

Table 4. Overview of data and factors accounted for in recent EU studies.

	Country	location	Data period		Sample size	Type included		Factors accounted for						
			Start	Finish		house	flat	Date of sale	Location (category)	Location (post code)	Period of construction	Type of heating	Condition	Extras
1	Denmark	Whole country	2007	2010	72,000	●		●		●	●	●		
2	Finland	Helsinki	2009	2012	6,200		●	●		●	●			
3	Germany	Berlin	2011	2014	30,000		●		●	●	●		●	
4	Ireland	Dublin	2009	2014	2,800	●	●	●		●	●			
5	Italy	Turin	2012	2012	577		●			●			●	
6	Italy	Padua	2013	2013	951	●	●			●				●
7	Netherlands	Whole country	2008	2011	30,000	●		●			●			
8	Norway	Oslo	2009	2014	99,000	●	●	●		●	●			
9	Portugal	Whole country	March 2015		21,000	●	●		●	●	●	●	●	●
10	Sweden	Stockholm	2009	2009	1,070	●					●			
11	Sweden	Whole country	2009-	2010	70,000	●			●		●	●		●
12	England (UK)	Whole country	1995	2012	320,000	●	●	●	●	●	●			
13	Scotland (UK)	Central Belt	2009	2012	11,000	●	●	●	●		●			
14	Wales (UK)	Whole country	2003	2014	147,000	●	●	●	●	●	●			
15	Austria	Whole country	6 months		3,000	●	●				●			
15	Czech Republic	Whole country	6 months		6.300	●	●				●			
15	Denmark	Whole country	6 months		7,400	●	●				●			
15	France	Whole country	6 months		265,100	●	●				●			
15	Germany	Whole country	6 months		22,500	●	●				●			
15	Luxembourg	Whole country	6 months		285	●	●				●			
15	Netherlands	Whole country	6 months		150,300	●	●				●			
15	Norway	Whole country	6 months		10,200	●	●				●			
15	Slovakia	Whole country	6 months		867	●	●				●			
15	Spain	Whole country	6 months		3,700	●	●				●			
15	Sweden	Whole country	6 months		1,400	●	●				●			
15	United Kingdom	Whole country	6 months		6,100	●	●				●			

Additional factors only accounted for in a single study included: Roof and wall materials (1), maintenance costs (2), style (3), size of estate agency (9), EPC improvement potential (10) and building quality (10).

Table 5. Price impact by EPC rating for selected studies.

Ref	Country	Reference rating	Above rating	Price differential %	Below rating	Price differential %	Study accounts for			Comments
							Location	Age	Date of sale	
1	Denmark	D	A or B	6.6	G	-9.3	●	●	●	Model 3 results
2	Finland	D	ABC	1.5	E, F or G	NS	●	●	●	Model 3 results
4	Ireland	C1	A or B	NS	G	-12.8	●	●	●	Model 4 results
9	Portugal	D	ABC	5.9	EFG	-4.0	●	●	NA	
12	England	G	A/B	13.8	F	6.0	●	●	●	
14	Wales	D	A/B	11.3	G	-7.1	●	●	●	

NB only results significant above 99 % quoted (p<0,01). NS means the result did not meet this level of significance so is not included. All prices allow for area i.e. the table shows the price differential per square meter.

Table 6. Sales surplus for a one letter (category) improvement in energy efficiency, given as percentages of average dwelling price (Rajkiewicz et al, 2016).

Country	Sales surplus as a % of value	Adjusted R^2
Austria	18	0.280
Czech Republic	11	0.257
Denmark	13	0.191
France	9.0	0.327
Germany (pre-2014 EPC)	0.60	0.204
Germany (post-2014 EPC)	7.9	0.112
Luxembourg	2.6	0.351
The Netherlands	-0.81	0.566
Norway	6.4	0.270
Slovakia	16	0.383
Spain	27	0.487
Sweden	3.2	0.109
United Kingdom	4.8	0.430

Table 7. Summaries of results of other studies, by reference number.

Ref	Country	Results description
3	Germany	1 % to 11 % for one category (eg C to D) or equivalent improvement.
5	Italy	“the only significant contribution on prices is exhibited, by moving from high levels, (BC) to low levels (FG)”.
6	Italy	“Average variation in unit price is 3.6 % related to the increase of one step in energy rating, but it is possible to observe a greater influence among the lowest energy classes. Dwelling with a C label have a premium price of 17.4 % with respect of those with a G label, whereas between class A dwellings and those in class C, the premium prices is 4.5 %.”
7	Netherlands	If the energy requirement of a dwelling is reduced by half, the market price of the dwelling increases by around 11 percent for an average dwelling in the Dutch housing market.
8	Norway	There is higher price for higher category, from 15 % B to 1 % E.
10	Sweden	For each 1 % increase in EE the price increases 0.04 %.
11	Sweden	A 10 % increase in consumption will increase the price by about 0.7 %.
13	Scotland	An estimated 0.1 % increase in selling price has been identified for every 1 % fall in energy use per floor area.

consider repeated sales[23]. Also, the papers present some great insights on the statistics of the energy efficiency of residential properties and the uptake of EPCs in these countries.

RESULTS – THE EFFECT OF THE EPC ON RESIDENTIAL PRICES

One of the differences between appliances and dwellings is that at least some aspects of energy efficiency are obvious for the latter[24] – for example a purchaser can see if the windows are double glazed and what kind of heating system is used – district, gas boiler, electric etc. So a reasonable question to ask is – does the EPC itself make a difference in increasing the sale price of a more efficient building? What value is the label? Several of the studies reviewed have addressed this issue, in different ways, and come to different conclusions:

One study (Jensen et al, 2016, reference 1) looked at the effect of energy efficiency in Denmark, as expressed in EPCs, on residential prices before and after it was compulsory to include them in property advertisements in June 2010. It found that the effect of EPC rating on property price substantially increased afterwards (eg for a G rating relative to a D the price discount was 9 % before and 24 % after).

The study of data from the Netherlands (Aydin, 2016, reference 7), looked for discontinuities in regressions between the energy performance index and price near the categorical label boundary. It found that "for all cut-off points, the estimated change in transaction price that results from the assignment to a lower energy efficiency class is negative but not statistically significant. Thus, there is not enough evidence to argue that the labelling itself has a significant impact on the transaction price".

The Norwegian study (Olaussen et al, 2015 reference 8) looked at the effect of introduction of EPCs in Norway had on the price premium for energy efficiency using repeated sales. They find no increase in price premium after the introduction of EPCs.

Hårsman et al (2016, reference 11) looked at as the effect of 'readily observable' factors that would affect energy efficiency: the kind of heating system; having an efficient ventilation system; type of windows (single or double glazed); new roof; they found that they have a significant positive effect on price. They also considered the correlation of energy consumption with price and found that if the consumption went up so did the price. They concluded that the EPC is not adding value. However, energy efficiency, not energy consumption is the primary parameter used to set the EPC rating.

DISCUSSION – THE EFFECT OF THE EPC ON RESIDENTIAL PRICES

At face value this looks like bad news for EPCs – three out of four papers suggest that they do not add value.

One results appears to be easily explainable: the whole country Swedish study (Hårsman et al, 2016, reference 11) looked at the correlation of price with energy consumption, not energy efficiency, which is the parameter used for the EPC rating. So, their finding that the EPC rating has no effect does not look robust.

A number of factors could explain the findings of the other two papers – including different country climatic or cultural conditions, the ways that EPCs have been implemented in each country and so on. However one simple fact could explain the difference – cross-referencing Table 2 – which shows when compulsory EPC advertising was introduced in each country and Table 4, which shows the dates of data used in each study, shows that none of the sales considered by the two studies with no effect for the EPC took place at a point when EPCs were required to be included in property sale (or rental) advertisements.

Energy efficiency has not traditionally been an important criterion in property selection, for purchase or rent. Prior to advertising of the EPC being required it may be that the first the buyer saw the EPC and thought about energy use was at the point of sale or rental, by which time they would already be heavily committed. It seems reasonable that the earlier on in the sale process that the buyer becomes aware of the energy rating the more likely it is that it will affect their choice of property and the price they are willing to pay for it. So, it is possible that the finding in Denmark could be replicated. If the studies were to be repeated after EPCs are routinely included in adverts[25] they might find that there was a significant result.

Conclusions

The author started this research hoping that it would be able to answer a number of questions, namely:

1. Have more recent studies confirmed the findings of most of those reviewed in 2013 (Mudgal et al 2013) that certified energy efficiency increases domestic property prices?
2. If so, by how much? Is the difference symmetrical, that is, is the premium for being above the norm the same as the discount for being below it?
3. Does the building energy label (EPC) itself make a difference to the price, distinct from the features of the building which are visible and which contribute to the building being efficient?
4. Are the data robust enough to draw any conclusions about how the effect of energy efficiency/the EPC varies by country and why?
5. (bearing in mind that climates and markets vary enormously as well as the implementation of the EPC in different countries this was perhaps overly optimistic . A study of the penetration of high efficiency appliances by country (Attali et al, 2009), found many different factors were important).
6. There were also supplementary questions:
7. Do higher energy efficiency rated homes sell more quickly?
8. What effect do the recommendations for improving efficiency on the EPCs have on sales price?

Some of these questions have been answered by individual studies in particular circumstances. But the only one that that

23. Not specifically considered here due to lack of space and resource.

24. One of the reasons that labels have been so powerful for some appliances is that this is absolutely not true – a A+ energy efficiency rated TV can look in every way identical to a B rated TV.

25. Although from the information available from CA EBPD there is no intention to do this in Norway at present.

can be answered with confidence on the basis of the studies in this review is the first: of the 14 studies which looked at energy efficiency[26], 14[27] show that increasing energy efficiency increases the value of residential property. This is true over a wide range of climates, and at different scales (that is, cities, regions and countries). This is worth knowing; and may be worth publicising more widely to the general public?

The answer to question two, the degree of the effect and whether it is symmetric, is less clear – partly because the results are presented using a wide range of metrics that are difficult to compare but also due to differences in the methodologies and data used. Question three, does the label in itself have value beyond the energy efficient features it represents, is also not yet settled. The author's intuition is that further work will give the answer as 'yes' but at present this is still open to debate. The other questions remain unanswered as yet.

A significant finding of this review is that this type of research is really difficult to do. There are increasing amounts of data online: more MSs are collecting EPC data into registration systems which are accessible to researchers; internet advertisements mean that sales data is more available; national and local governments are making more geographically based data available to researchers. All of these are necessary to undertake this type of research. But, these are real data and they are messy. Data have to be cleaned; ingenious methods have to be applied to match up data from different sources designed for completely different purposes. And given that where and when properties are built is often correlated with how energy efficient they are it can be difficult to get enough data to be sure that it really is only the effect of the energy efficiency that is being measured.

The author's congratulations and thanks go to the researchers who do this work. Please keep on going! We need more efficient homes, for many reasons. If we can show that this pays, that home owners who increase efficiency are increasing the value of their most expensive asset, then that gives us one more weapon in our arsenal of reasons to act.

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