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## Does Energy Performance Certification evenly increase residential values?

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**Abstract:** In the EU the buildings accounts for 40% of energy consumption, offering room for improvement. In this context the EC has passed the Energy Performance Building Directive (EPBD), which main aim is to give energy transparency to real estate transactions by means of EPC. This policy indirectly tries to incentive the production of efficient buildings and rehabilitations: it departs from the idea that tenants and buyers are willing to pay a market premium for efficient buildings. Although across Europe a number of studies have proven the positive impact of EPC on residential prices, in Spain such studies are scarce due the late transposition of EPBD. In this paper, using a hedonic approach, we analyse the impact of EPC on multifamily dwellings' prices in Metropolitan Barcelona due its mild weather makes an excellent case study where to observe energy efficiency impacts on real estate prices. The results suggest that the asking price premium for "A" labelled apartment is 9.6% and 3.9% for a "D" in relation to the worse grade "G". Nevertheless, such impact seems to differ across market segments. In the segment of recently built apartments the energetic label does not play any role in the prices, since apartments do have other architectonic attributes. On the contrary, in the segment of poor quality, with few facilities, the energetic label has a paramount importance on prices. This latter finding has important implications for policy making, since EPC has a deep impact on poor owned dwellings, precisely in the socioeconomic strata where energetic rehabilitation is not a priority. Thus, a good environmental policy may imply unexpected negative social consequences.

**Keywords:** Energy performance certificates, hedonic pricing, green labels, Barcelona

### Introduction

In the fight against climate change, the European Union (EU) has since its first Energy Performance of Buildings Directive (2002/91/EC, EPBD) decided to give energy market transparency, as a way to promote better informed renting and purchasing decisions.

This article aligns with the pioneering works that study the impact of energy ratings on the formation of real estate prices in Spain, and especially, if this incidence is the same between the different segments that make up the residential market. In the latter sense, Das & Wiley (2014) have shown for the US office market that the Energy Star and LEED tags are contingent on the characteristics of buildings in determining their rental prices, therefore, there are no reasons to think that in the residential market this impact is stationary. With this objective, a sample of homes on sale is used, which is representative of both the multi-family market prices in metropolitan Barcelona and the energy rating of the multi-family stock certified with an EPC. Thus, using a hedonic price model, it is explored the marginal price of each of the possible energy class. Due its mild climate weather Barcelona emerges as an excellent case study where observe energy efficiency impact on residential prices.

The results suggest that an *asking price premium* for the best rated dwellings exists. In fact, the relationship between this premium and the energy class is not linear, but tends to be exponential, so that there is a psychological effect that rewards especially the select club that make up the apartments qualified with energy class "A" (the most efficient). However, this overvalue is not homogeneous along the different residential segments. In fact, in the newer dwellings, characterized by a large proportion of active air conditioning systems, advantages in their architectural program (e.g. more bathrooms or community pool) and high quality, energy differentiation plays a zero role in the formation of real estate prices. On the contrary, in the case of housing built in the period of "developmental" urban growth, usually located in low-income areas characterized by low prices and few architectural features, energy differentiation emerges with singular strength in the determination of sales prices. Finally, for the segment of the oldest houses, generally located in the widening and classic districts, there is also a *premium market*, although smaller than in the case of the worst housing.

The rest of the article is organized as follows: first a review of the studies that, following the same methodology of hedonic prices, is offered; The scope of study, the source of information and the methodology used is then outlined; The next section contains the results and; Finally, in the conclusions the work is put into perspective.

### **The impact of Energy Performance Certifications on real estate prices**

The reform of the EPBD (2010/31/EU) and Directive 2012/27/31 is the current framework on which "universal" energy certification has been transposed in the Member States. In this context, the pioneering study by Brounen & Kok (2011) analyzed for the first time the incidence of these new green labels on residential prices, although the data used correspond to the period in which the purchasing part could exempt the selling part, of deliver the EPC. The results of this study found a positive correlation between the best-rated dwellings and verified sales prices in real estate transactions. These authors assume that energy ratings are a categorical measure of the efficiency of housing. So, considering the intermediate score "D", as a basis for comparison, they found that the marginal price ranged from 10% for the "A" class, to -5% for the "G" class. That is, above the reference *market premiums* are formed, while below *market penalties* appear. In the same country, Kok & Jennen (2012) also pioneered the incidence of EPC in the office market in Europe, finding that only offices rated with "C" class (in relation to class "D") formed an overvalue of 4.7% in their rental transaction prices. The study by Hyland *et al.* (2013) conducted in different Irish cities was the first to simultaneously compare the incidence of EPC on the rental and sale market. To do so, these authors started from listing prices of both markets, generally finding that the incidence of the energy ranking is greater in the market of sale than in the rental market. For example, a home for sale qualified as "A" (in relation to "D") has a *market premium* of 9.3%, and only 1.8% if it is transacted in the rental market, *ceteris paribus*. Likewise, the *market penalty* for a home classified as "F" or "G" (in relation to "D") is much higher (-10.60%) than the received by the rental market (-3.20%). The higher incidence of green labels on sales prices, in relation to rental prices, is a regularity that had already been reported by previous work based on other certification schemes. Examples of such research are the work of Fuerst & McAllister (2011) for LEED offices in the USA (+ 31.4% for sale and only 9.2% for rental), or Eicholtz, Kok & Quigley (2010) for LEED offices (+ 11.1% for sale and only 5.8% for rental) and Energy Star (+ 13% for sale and only + 2.1% for rent).

In this sense the work of Fuerst & McAllister (2011) for the English office market has empirically demonstrated the relationship of inverse proportionality between yield and energy rating of the BREEAM scheme. It seems, therefore, that investors value the energy rating more, because they understand that real estate has better outlets in the market produced by higher occupation rates (Wiley & Benefield, 2010), higher rental prices and lower depreciation (Caijas And Piazzolo, 2013) in relation to users, for whom savings in energy bills could be lower relative to other operating expenses (including the own real estate rent).

In the work of Mudgal *et al.* (2013) again, the incidence of EPC is more pronounced in selling prices than in rental prices. From this study, it should be noted that EPCs appear to have more impact on hinterlands (e.g. Belgium and Ireland, with Austria as an exception) than in capital cities. According to these authors, this differential impact can be explained by the fact that savings in energy bills are more important in relation to the base price of housing in lower urban areas (where housing is cheaper) than in capitals. Also, not always a higher energy rating implies a *market premium*, since in the rental market of Oxford there is apparently a penalty for the best rated dwellings (-4% per EPC step). Although the authors of this work recognise the enormous deficiencies of their analysis, since in that city, the older and better located, high-priced stately homes have, in turn, a low energy rating. In general, the very poor control of urban characteristics (i.e. accessibility, quality of urbanization and social hierarchy) affecting residential values, as studied by Roca (1988) is a deficiency of such work and can bias the coefficients of their models. In Sweden, Pontus *et al.* (2014) have carried out a peculiar study in which the sale price of the dwellings has been correlated directly with the energy consumption contained in the EPC label. The coefficient of energy consumption in their hedonic model appears with a contradictory sign ( $Bx = 0.06$ ,  $p = 0.000$ ), where  $x$  is the log of consumption in kWh/year/m<sup>2</sup> and  $Y$  the log of the price per m<sup>2</sup>): the higher the consumption in kWh/year/m<sup>2</sup>, the higher the price of housing, everything else equal. In this sense, it is highly probable that for the demand energy classes in the label constitute a clearer message of ordinal comparison of the energy efficiency, in comparison to the technical units of its measurement. However, when the sample is segmented, the results are different, as is discussed in the next section.

As can be seen, there is a great divergence in the impact of EPCs on residential values throughout Europe, explained by the important differences in terms of income, energy costs, construction, climatic, and techniques requirements, and, perhaps, the importance of environment preservation. Moreover, as Garcia-Hooghuis and Neila (2013) have studied, the way in which the Directive has been transposed has resulted in divergent calculation methods, often supported by previous state regulations, which make cross-border comparisons difficult. In this context in Spain there are two pioneering works in the study of the hedonic agenda of the EPC. The work of Ayala *et al.* (2016) is based on sales values declared by a sample of respondents from 5 cities (Madrid, Bilbao, Seville, Vitoria and Málaga) and from an own calculation of the energy rating. It has found that dwellings with "A", "B" or "C" energy class have a value, in the opinion of its owners, higher by 9.8% than those rated as "D", "E", "F" or "G". Marmolejo (2016) uses listing prices for a sample of dwellings in Barcelona and finds an over price of 5.11% in the pass from the "G" to the "A" rating, or 9.62% if we accept that people perceive the rating scale to be nominal. Both works require a deeper study, the first because it departs from non-qualified opinion values and

fails to control of microterritorial locative factors and the architectural quality of the dwelling, which, as Roca (1988) points out, have a huge influence on values, and their non-consideration can lead to a bias. The second, because precisely the microterritorial factors make the variable "energy rating" appear as statistically significant in the models, and therefore suggests a heterogeneous impact of this factor along the real estate market. The present work aims, therefore, to explore in more detail this latter aspect.

### Scope of study, methodology and data

The scope of study is made up of the municipalities registered in the management area of the Metropolitan Transport Authority of Barcelona and which at the same time have multi-family offer with energy ranking. In total there is information for 178 municipalities.

The methodology has consisted in three steps:

1. Construction of a Geographic Information System with data related to real estate offers and urban/territorial characterization data at scale of census section and transport area. Through a geospatial consultation, the urban and territorial characteristics of the location of the dwellings have been transferred to the data matrix by housing using an area of influence of 300 m radius from the geo-location of each real state.
2. Calibration of a hedonic price model at the dwelling scale.
3. Segmentation of real estate offers according to the architectural and urban characteristics that effectively affect the formation of prices. In doing so, a factorial analysis followed by 2 steps cluster process has been used, obtaining as explained in the next section 3 clusters: 1) high-income consolidated areas, 2) medium income new-homes, 3) low income poor-quality-houses. The variables used in the segmentation are all that have been found to be significant in the model next explained except the energy class to avoid endogeneity issues.

The assessment of the impact of the energy rating is done using the hedonic price method. In the specialized literature, it is usual for this marginal value to be calculated through a regression model, and in the absence of a clear theoretical posture on the log-linear functional specification (Addae-Dapaah & Chieh, 2011). This procedure has several virtues, on the one hand, facilitates that the distribution of the dependent variable (the price) approximates to the normality thus enabling the calibration by OLS, and on the other, it allows interpreting the coefficients as semi-elasticities, that is as percentage variations in the dwellings price for each unit that increase the independent variables. Specifically, in this paper the functional expression used is:

$$\ln P = \sum_{A=1}^n BA + \sum_{E=1}^n BE + \sum_{L=1}^n BL \quad (1)$$

In (1)  $P$  is the natural logarithm of the supply price of a statistically significant sample of dwellings on sale in the study area;  $A$  is a vector that includes the architectural characteristics of each dwelling studied (including energy qualification );  $E$  is the same but referred to the building, while the houses in question are multi-family type, so that there are common services that can affect the price of these;  $L$  is a vector that internalizes the spatial factors of urban and territorial type that impact on the formation of residential prices through land rent and, finally  $B$  are the coefficients that, as mentioned above,

measure the percentage impact of previous taxes on real estate prices. It is important to indicate that the energy rating has been introduced as a set of dichotomous variables for each of the seven steps that can have according to RD 235/2013.

The offer data come from Habitacalia (one of the main portals in Catalonia in residential listing), and have been depurated using the *Mahalanobis* distance. After depuration none "B" class apartment is present in the sample.

## Results

Table 1 details the results of the calibrated models for each of the real estate segments. It is important to note that according to the Chow test ( $F=8.55 > F \text{ crit } 1.16$  to 99% confidence) there are structural differences in the explanation of the prices of the different segments and therefore divergent hedonic agendas. In this table, only statistically significant variables are reported at 95% confidence, except for those related to the different energy classes, where again the letter "G" is the comparison situation. In all of them control variables, including social ones have been used. In all cases the sign of the coefficients is as expected, except for cluster 1 where, paradoxically, the sign of the high socioeconomic indicator is reversed, even after having verified the absence of multicollinearity problems. This is likely to occur since the sample (the smallest of the three) is very homogeneous in location patterns due to the segmentation procedure used. If the focus is on the object of study, three interesting conclusions emerge:

1) On the one hand, the energy rating seems to affect the older dwellings, both those located in the centers/widening ones (Cluster 1), and those located in the neighborhoods that were born of the developmental expansion of the metropolis (cluster 3). On the other hand, in the most recent dwellings (Cluster 2), and precisely in those that are better qualified and with more presence of active systems of air conditioning, the energy rating does not seem to play any role in the real estate differentiation from the perspective of the formation of the offer prices.

2) However, the impact of the rating is not equal in the two segments in which it appears as significant. Thus, in the most expensive, central and well-established housing segment, the "A" rating; has an impact of 13.8% (but with a level of significance on the edge of the limit demanded in our analysis). On the other hand, in dwellings located in working-class neighborhoods and with worse active air conditioning services and generally poorer architectural quality, the impact of the "A" rating is almost three times higher, situated in 32.7% (with a higher statistical significance). In this last cluster also appears the "D" rating with an impact of +8.7% and in a reversed sense the "C" rating but with a slight impact located at -0.9%.

3) All together seems to suggest that real estate differentiation in the segment of the newest dwellings and with more architectural and technological equipment does not seem to respond to the ranking that has led to the emergence of the EPC in our country. Quite the contrary, in the case of the (very abundant) houses located in the lower range, in the absence of attributes of architectural quality/equipment, the qualification becomes a true distinctive capable of strongly influencing the differentiation of selling prices.

In short, the impact of energy ratings, in the light of the aforementioned results, does not appear to have a stationary impact on the multi-family market segments. *Real estate differentiation, from the perspective of the supply price formation mechanism, and in relation to the energy ranking seems to occur in the lower segment.* Thus, in the dwellings with less architectural attributes related to residential quality, this ranking has a significant impact on prices. This can have enormous social repercussions on the conformation of energy submarkets as is discussed in the conclusions.

Table 1. Explanatory models of housing prices by real estate segments

		Mod High income-consolidated zones			Mod Medium income-new houses			Mod Low Income		
		r <sup>2</sup>	r <sup>2</sup> aj	sig.	r <sup>2</sup>	r <sup>2</sup> aj	sig.	r <sup>2</sup>	r <sup>2</sup> aj	sig.
		84,68%	84,16%	0,000	55,89%	55,36%	0,000	44,12%	43,78%	0,000
		B	Beta	Sig.	B	Beta	Sig.	B	Beta	Sig.
Significative control structural variables	Constant	10,749			10,312			10,243		
		3			6			2		
Significative control building variables		1			2					
Energy class	A	,138	,046	,049	,064	,035	,102	,327	,038	,031
	C	,038	,014	,545	,066	,036	,091	-,090	-,045	,019
	D	,054	,043	,123	,023	,021	,412	,087	,044	,019
	E	,017	,020	,528	,022	,026	,350	,017	,022	,307
	F	,030	,022	,412	-,017	-,013	,568	,023	,021	,298
	Significative accesibility variables					1			2	
Significative social control variables		2			2			2		

Note: Dependent variable Ln of the price, variables introduced by successive steps, except those related to energetic qualification. In gray appear the non-significant energy rating variables at 95% of confidence

Source: Own elaboration using stepwise method

## Discussion and conclusions

It has been 15 years since the Energy Performance Building Directive (EPBD) joined the mainstream of green certifications through its Energy Performance Certifications (EPC). In this way, the European Union has decided to fade the information asymmetries in energy matters regarding real estate transactions. Thus, it has been committed to giving universal energy transparency as a mechanism to favour better informed purchasing and renting decisions, and in this way promote more sustainable buildings.

In this research, we study whether greater energy transparency is reflected in the formation of prices. Specifically, the interest is particularly focused on analysing whether *energy ranking* has a homogeneous incidence across the segments of the multi-family market. With this objective, a sample of 3,474 multi-family dwellings located within the scope of management of the Metropolitan Transport Authority of Barcelona is analysed. Such analysis, as it is usual in international studies, is based on the hedonic pricing method, which assumes that households equalize the marginal utility of the urban and architectural attributes of the marginally priced housing they are willing to pay for benefit from them. Likewise, in order to segment the previous survey, a multivariate analysis was carried out, based on the characteristics of dwellings, community services and their location with proven incidence on price formation.

The results of the hedonic models suggest that, despite the very recent implementation of the obligation to include the energy label for real estate advertising (RD 235/2013), there is a *higher premium* in the best energy qualified dwellings. Thus, the owners of the best qualified dwellings are willing to be compensated for a higher amount, everything else equal, by their alienation. Of the set of energetic classes, the “A” and “D” have been statistically significant, increasing in 9.6% and 3.9% respectively the price, in relation to the lowest-rated (“G”) dwellings. This means that for the average apartment, these impacts can be translated into approximately 15.000 and 6.000 euros more, respectively. In addition, it is observed that such overprice tends to increase exponentially as the energy class increases. This has a special interest in the promotion of green dwellings, since the prize for the best real estate in terms of energy (“A”) rises in an exponential manner. In this sense, it is necessary to verify if a step break in the upper quartile compensates the overcost of construction, as has been studied in Spain by García-Navarro *et al.* (2014).

In any case, the incidence of the energy ranking in Spain on residential prices is lower than the 15% (“A/G”) reported by Brounen & Kok (2011) for the Dutch case, as well is lower than 19.9% (“A/G”) of the study from Hyland *et al.* (2013) for the Irish market and 12% for “A” dwellings in relation to the “G”, in the English case according to Fuerst *et al.* (2015). It is possible that behind these differences are the differences in real estate prices, energy cost, income level (in relation to the previous two), climatic differences and uneven concern for the environment conservation.

However, the *asking market premium* is not uniform across the residential segments:

- 1) In the segment of more recent houses, the energy ranking does not seem to play a role in the differentiation of real estate prices, which obscures the objectives pursued by this environmental policy. In this market, plagued by architectural features and active technologies for environmental comfort, energy rating does not represent a differential element.
- 2) In the case of the poorest stock, the enormous price discrimination that appears to play the energy ranking, in the absence of other attributes of differentiation, could penalize the poorest dwellings. Specifically, in this segment the worst rating, “G”, reduces the dwellings price in 32.7% regarding to the “A” rating.
- 3) In the case of older homes, located in upper middle-middle class areas, the results suggest that a *market premium* is also formed, although moderate and equivalent to 13.8% (“A/G”), which opens up huge hopes for energy rehabilitation, since it can be an element of real estate differentiation for the old stock. Not surprisingly wealthy population is ready to ask the most only for the top of the energy classes

In any case, from a social perspective, a higher market penalty for the worst-qualified housing of the poorest population is directly detrimental to the value of their assets, and hence their ability to improve housing through the substitution of the actual. This issue is serious if this population does not have access to aids devoted to energetic retrofits. So, a well-intentioned environmental policy could have unexpected pernicious effects from a social perspective, if the relevant corrective measures are not properly introduced. On the other hand, it does not prevent that such population may benefit for high efficiency houses, and thus the fact that in such segment there is also a demand for efficient homes.

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