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Energy Performance Certificates (EPCs) of residential dwellings: Evidence from Lombardy, Piedmont and autonomous province of Trento

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- Objectives
- Legislative background
- Literature
- Data
- Descriptive statistics
- Preliminary estimates

Objectives

→ The objective of our research is threefold

1. To provide motivation for the use of Energy Performance Certificates (EPCs) in economic analysis
2. To provide descriptive statistics of the characteristics of the energy efficiency levels of the dwelling stock in three Italian regions: Lombardy, Piedmont and the Autonomous Province of Trento
3. To investigate the relationship between EPCs and house prices

Background: European legislation

European Performance of Buildings Directive (EPBD)

2002/91/EU

Defined the framework for European countries to develop standards for energy efficiency in buildings. EPCs are made mandatory

EPBD (Recast)

2010/31/EU

EPBD (Recast)

2018/844/EU

Each Member State must have a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings

«green buildings» directive (evolving)

14 March 2023

1. **All new buildings will have to be zero-emission by 2028**
2. **Residential buildings must be renovated to at least class E by 2030 and class D by 2033**
3. **Class G should correspond to no more than 15% of the buildings with the worst energy performance**

Background: Italian legislation

Legislative decree 192/2005

It transposes the EPBD for Italy

Decree 59/2009

From 2009 EPCs are mandatory for all sold dwellings. From 2010 EPCs are mandatory for rented out dwellings and for those that undergo major renovations

Legislative decree 63/2013

Introduction of a new methodology to compute EPCs (in Italian, from ACE to APE)

Literature: the EPC-price nexus (1)

- Scholars have extensively studied the **relationship between EPCs and house prices**
- With increasing awareness and concern about energy performance, EPCs are expected to positively influence consumers' choices and shift their preferences towards environmentally sustainable buildings
- Most studies employ hedonic regressions, while others extend the analysis by applying spatial models
- Perhaps the first study in this direction is that of Berry et al. (2008) for **Australia** who apply a hedonic regression to investigate whether house energy ratings affect prices: ratings are found to be positively associated with price and to have a significant relationship
- Brounen and Kok (2011) implement a Heckman model to **Dutch data**; Cerin et al. (2014) find that EPCs contribute to property price premiums in **Sweden**. Similar results are found for other countries such as Fuerst et al. (2013) and McCord et al. (2020a and 2020b) for **Wales**, and Droutsa et al. (2016) for **Greece**
- Mudgal et al. (2013) perform a comparative analysis on **Austria**, **Belgium** (Flanders, Wallonia, Brussels-Capital), **France** (Lille, Marseille), **Ireland**, **UK** (Oxford, South East)

Literature: the EPC-price nexus (2)

- There is **very limited evidence for Italy**, since publicly available data on EPCs is scarce – even more so on data linking EPCs and prices

- Fregonara et al. (2017) assess the impact of the EPCs on the real estate market of **Turin**, a city in the Northwest of Italy. They employ a hedonic price model and find that low EPCs were priced in the market although EPC labels explained only between 6% and 8% of price variation

- The study of Bisello et al. (2020) focuses on the real estate market of **Bolzano**, a city in the Northeast of Italy, and finds a price premium of around 6% on moving from the worst to the best energy efficiency class. Moreover, they also uncover spillover effects to nearby properties. Both hedonic price regressions and spatial models are employed

The data

- Data sources:
  - Lombardy: CENED (https://www.cened.it/opendata-cened-2.0), 2015-2022
  - Piedmont: Regione Piemonte (https://www.dati.piemonte.it/#/catalogo), 2015-2023
  - Trento: Open data Trentino (https://dati.trentino.it/dataset/attestati-di-prestazione-energetica-trentino), 2013-2023
- Access to Immobiliare.it data would be ideal
- We porform our analysis on **residential dwellings**

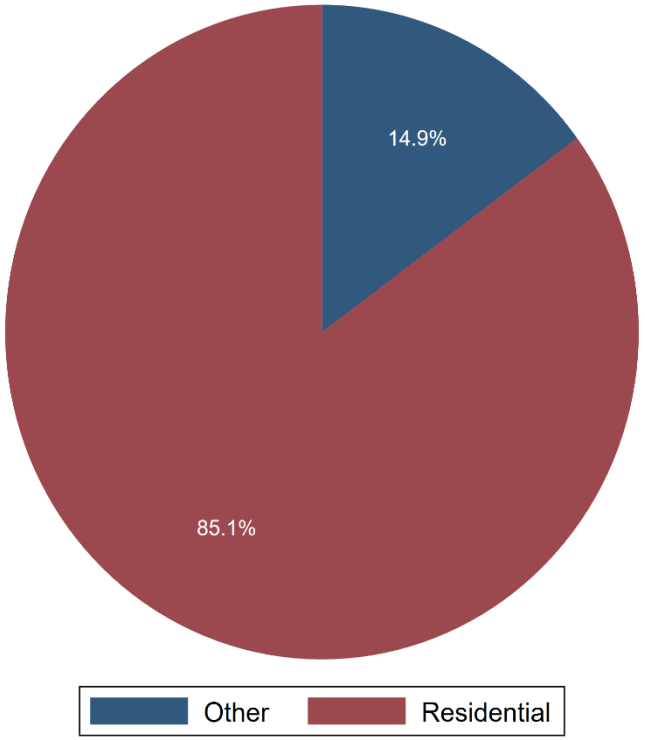
Region	No. of dwellings with EPC	Residential dwellings with EPC	Non-residential dwellings with EPC	% of total no. of residential dwellings (2021 Census data)
Lombardy	1 389 643	1 182 616	207 027	21.1%
Piedmont	533 398	474 935	58 463	17.0%
Trento	151 464	133 639	17 825	34.3%

Data cleaning and merging

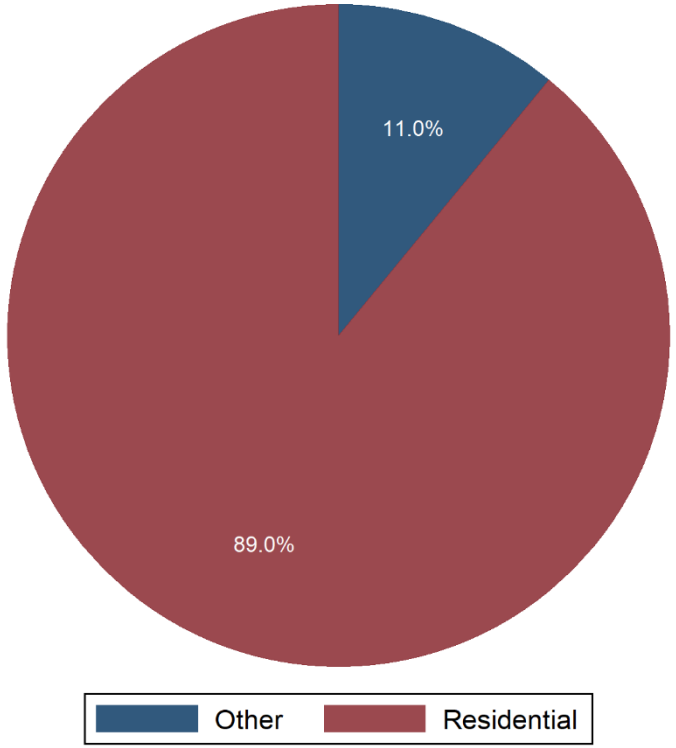
- The data cleaning steps are the following:
  - Textual cleaning of addresses, municipality names and corrections due to deletion/merging of municipalities
    - For instance, addresses now all have the following form: “Via/Viale/Piazza”, “name” and “streeet number” (i.e., Via GiosuÃƒÂ¨ Carducci 24 → Via Giosuè Carducci 24)
  - Winsorisation at 0.1% and 99.9% of variables such as: “consumption of natural gas”, “consumption of electricity”, “CO2 emissions”, “useful heated surface” to remove outliers
  - Geolocalisation of each dwelling to attribute them latitude, longitude and postcode
- Merging with house price data by OMI zone:
  - OMI (Osservatorio Mercato Immobiliare - Real Estate Market Observatory) zones are defined by Italy’s Revenue Agency as portions of the municipal territory reflecting a homogeneous segment of the local real estate market, in which there is uniformity in the economic and socio-environmental conditions

EPC by type of dwelling

LOMBARDY



PIEDMONT



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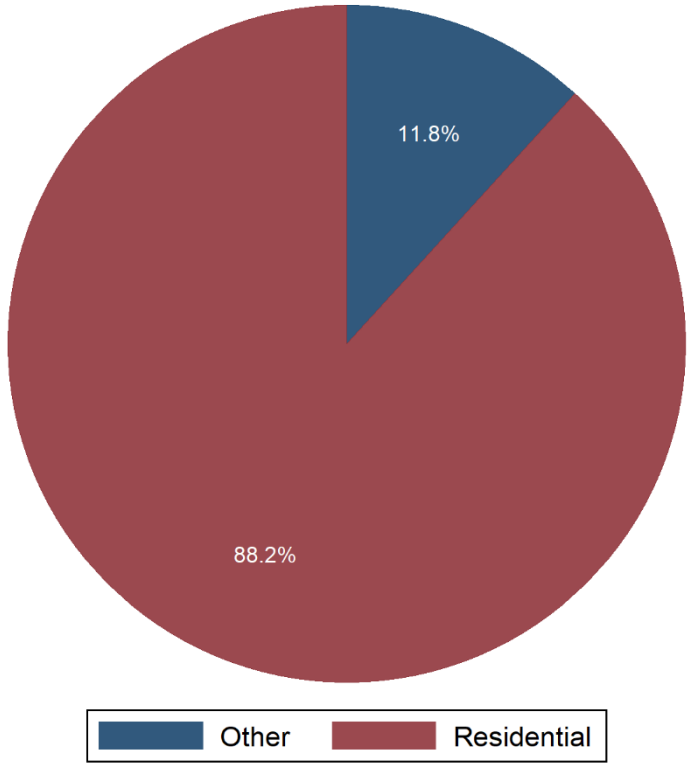
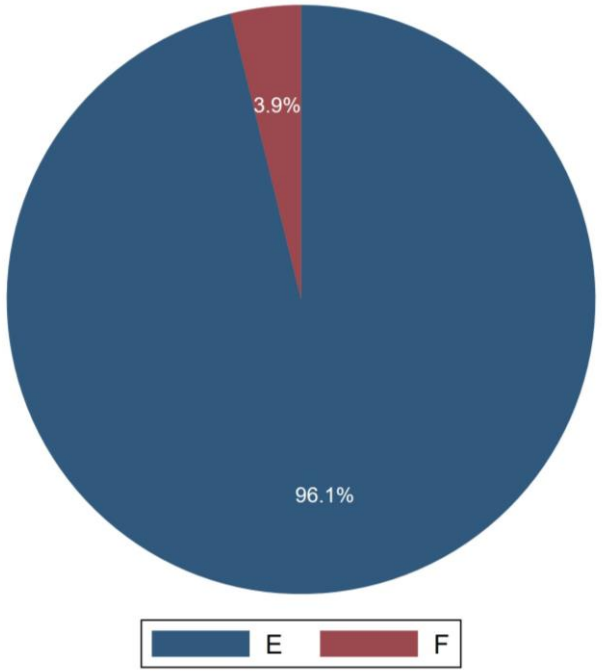


We concentrate on **residential dwellings**

EPC by climate zone

LOMBARDY



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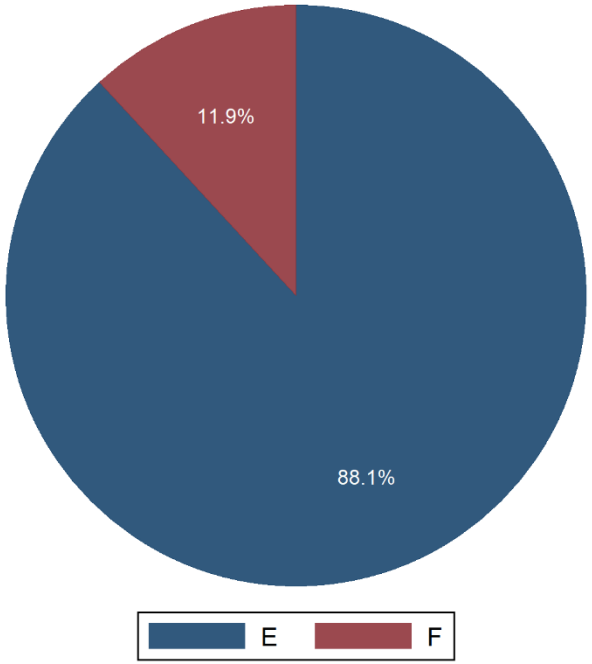

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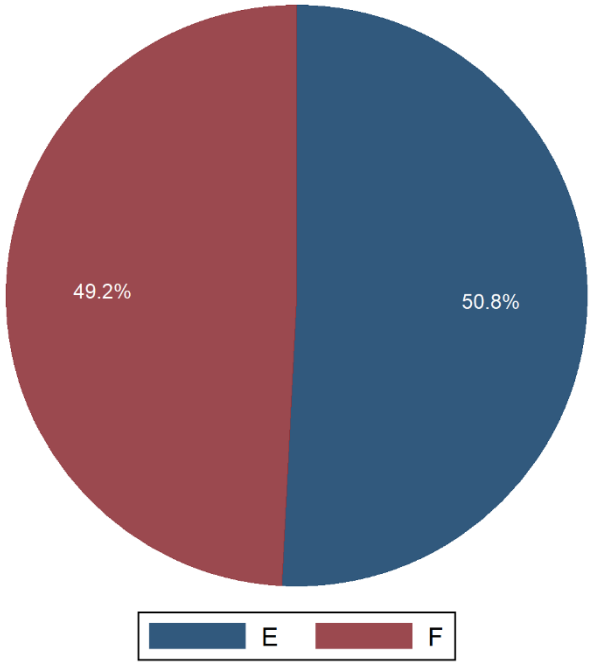
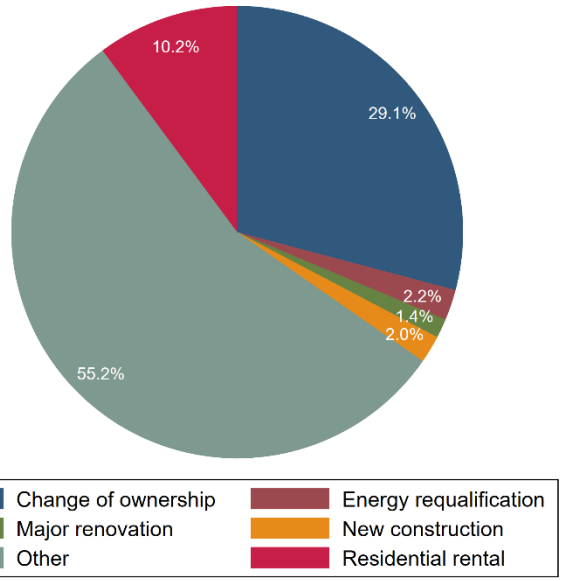


Reasons for filling in an EPC

LOMBARDY



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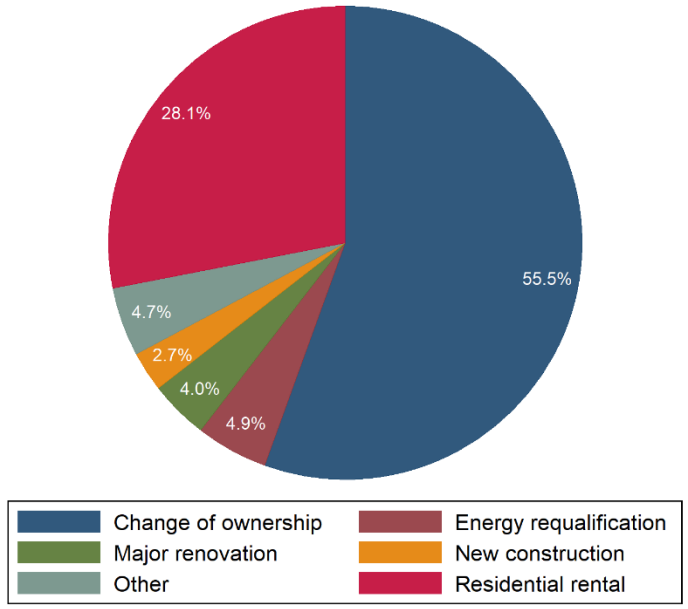

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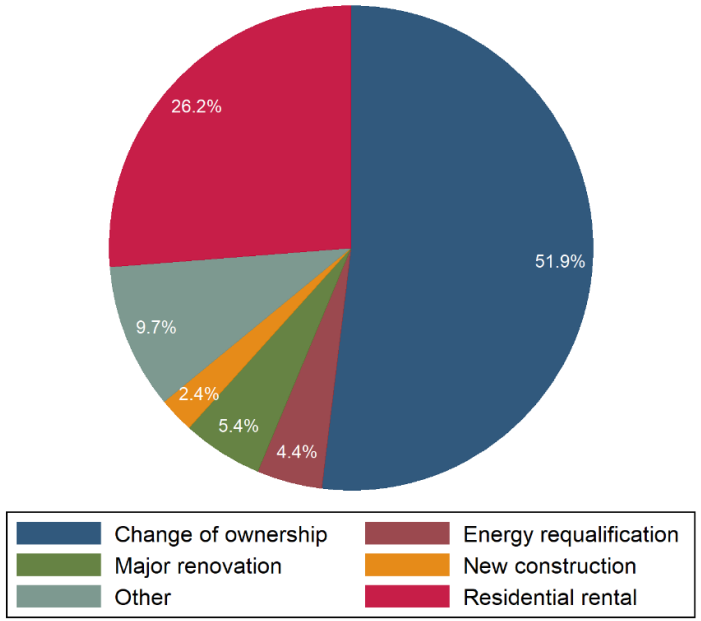
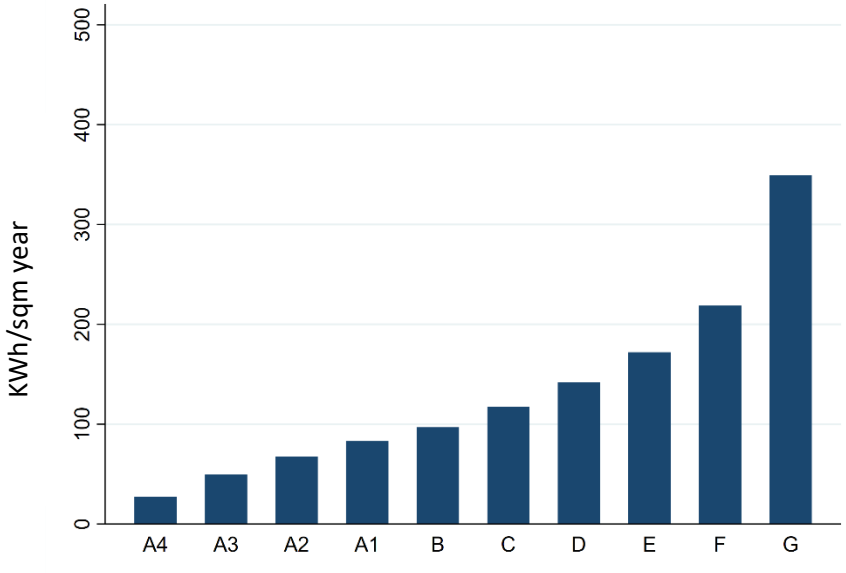


Energy performance index (non-renewable) by energy class

LOMBARDY



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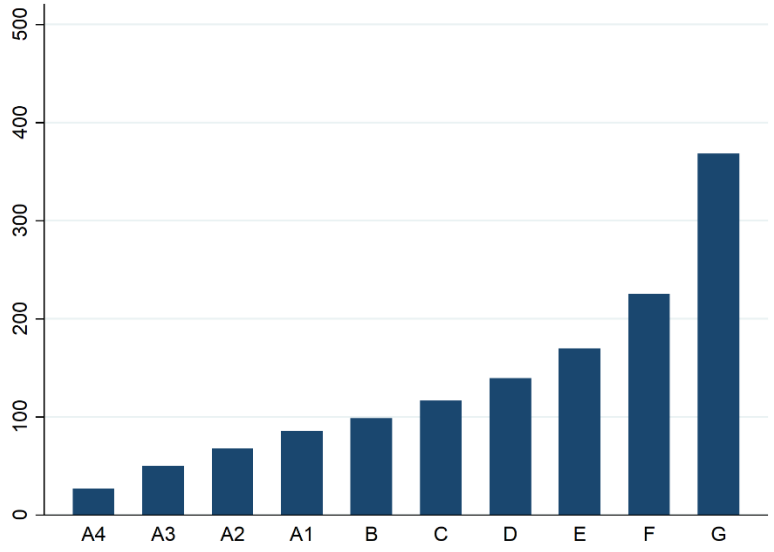

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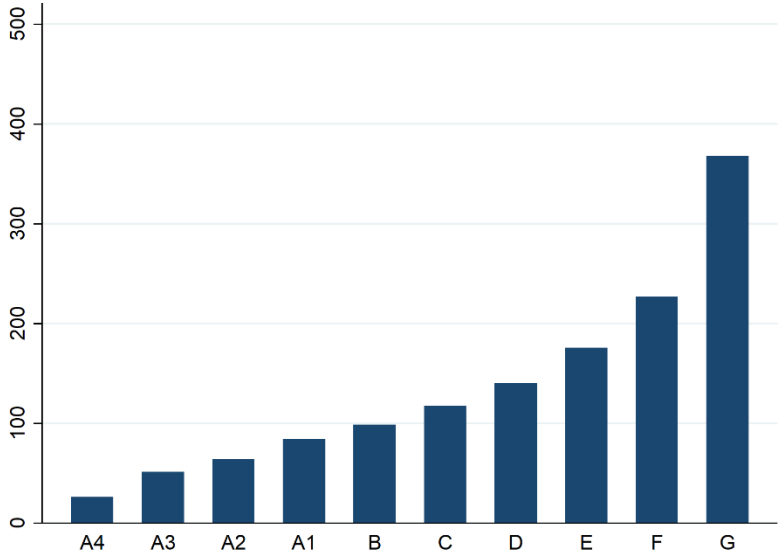
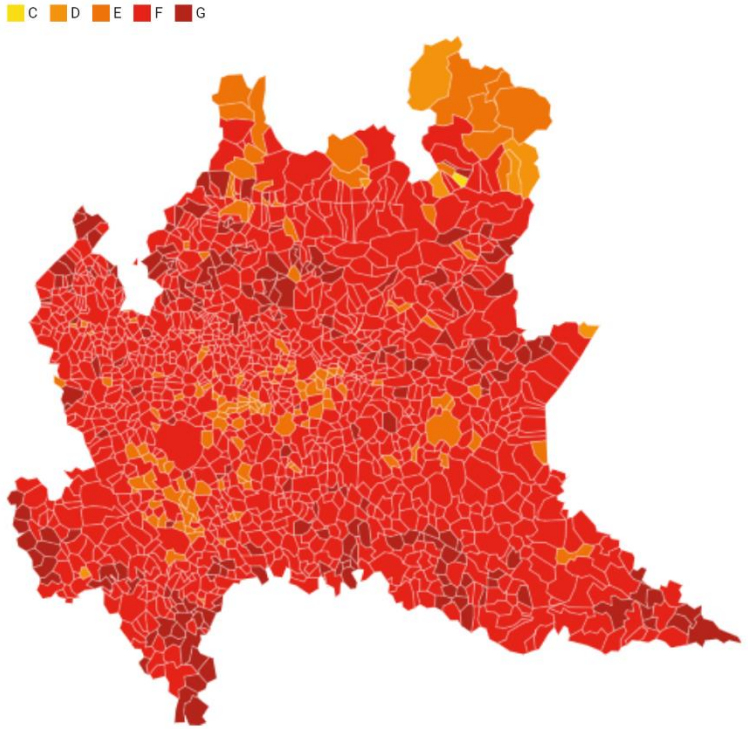


Energy performance class: average by municipality

LOMBARDY



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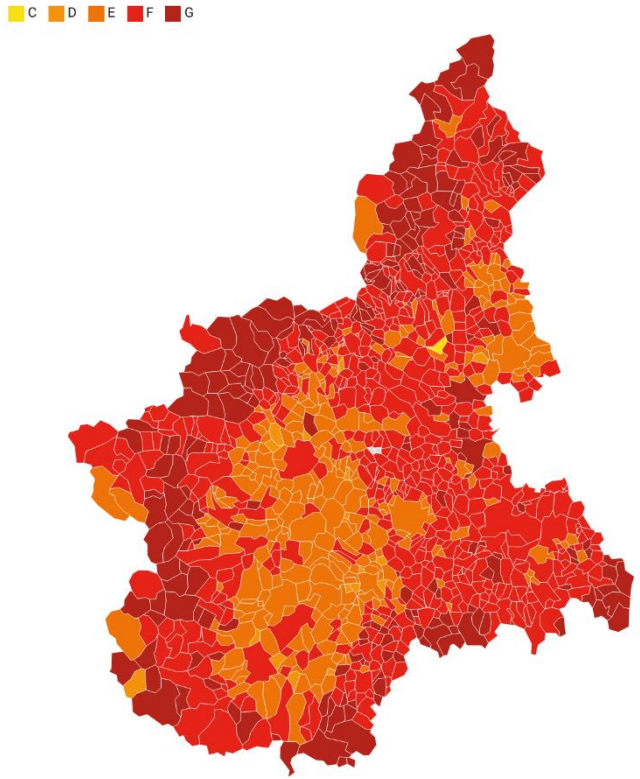

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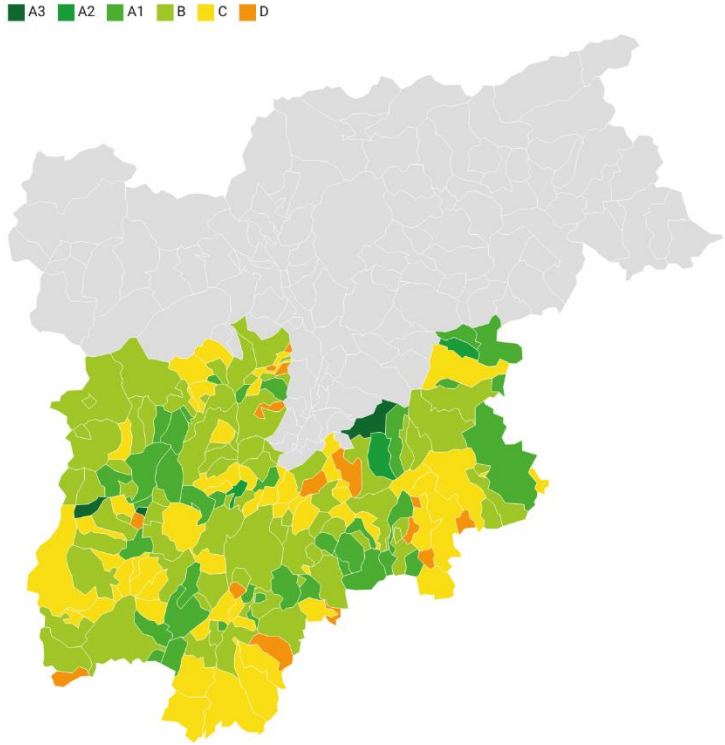
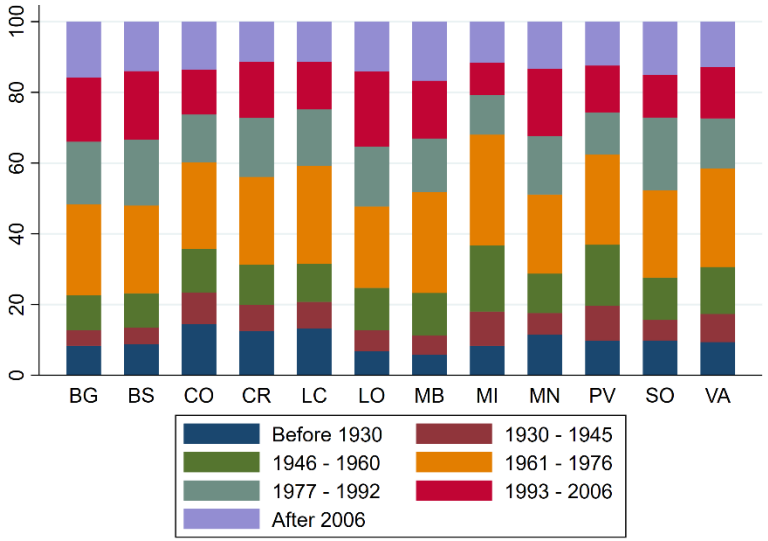


Age of the dwelling stock by province

LOMBARDY



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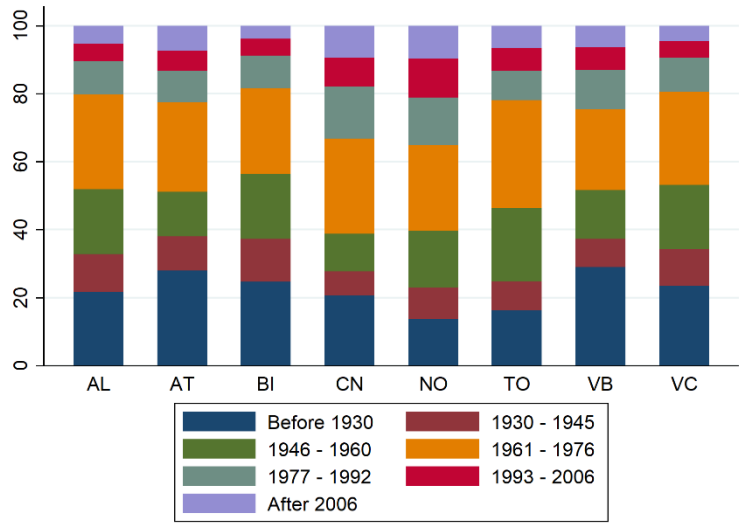

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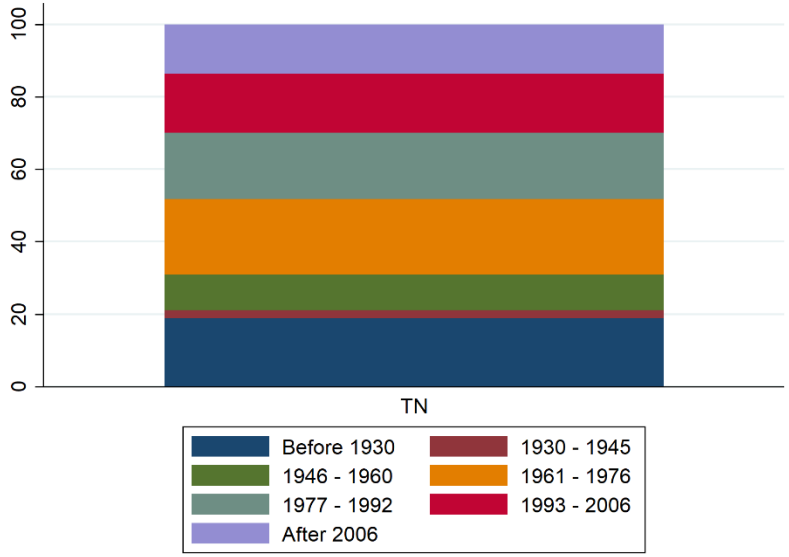
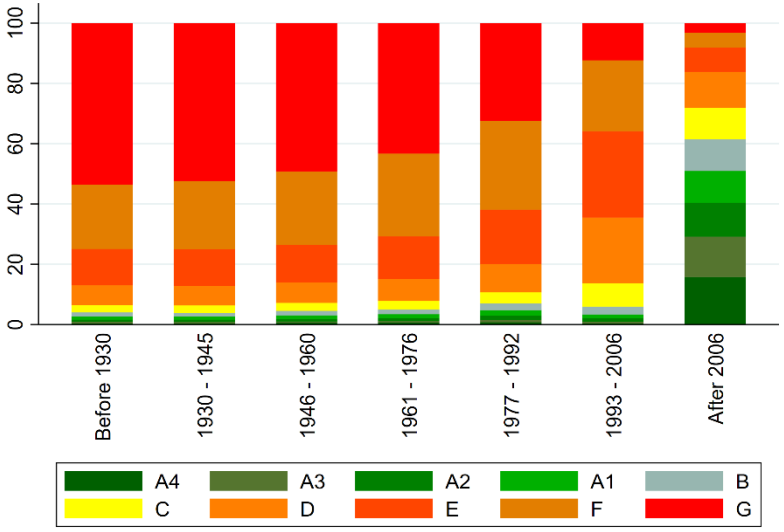


- Dwellings built before 1960 are 30.8% and 46.4% in Lombardy and Piedmont, respectively; this percentage is 30,9% in the province of Trento
- In Lombardy, Milan and Pavia are the provinces with the largest percentages of dwellings built before 1960 (36,7% and 36,9%, respectively)
- In Piedmont, the highest percentage of dwellings built before 1960 is in Biella (56,4%)

Energy class by year of construction

LOMBARDY



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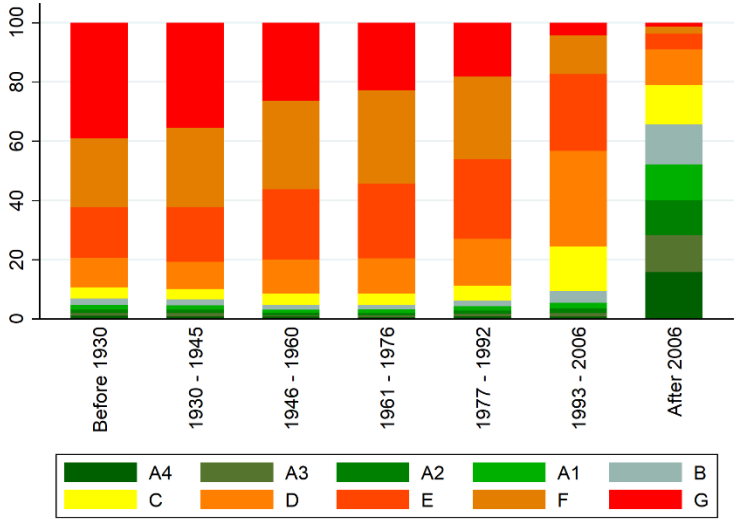

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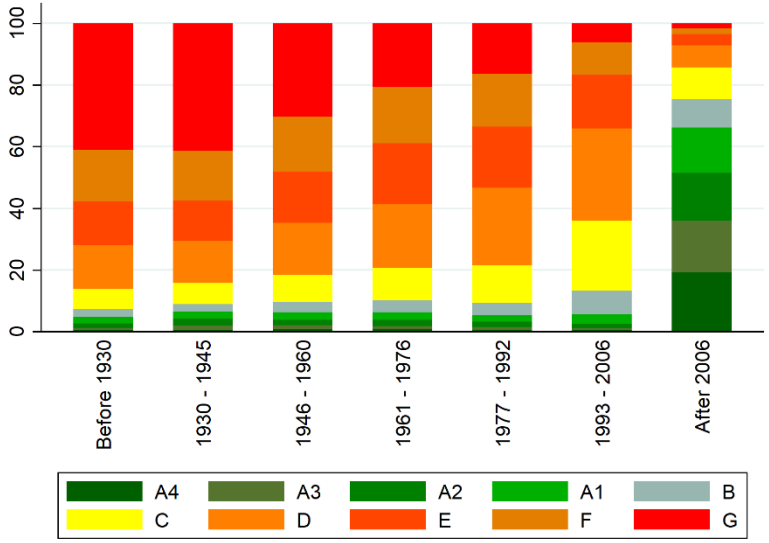

→ Dwellings built after 2006 are more energy-efficient

Hedonic price model (1): average sqm price and average EPC by zone

	Coefficient	s.e.		Coefficient	s.e.
Average EPC: B	-62.54	(60.452)	Lecco	-882.82***	(46.772)
Average EPC: C	-418.63***	(60.902)	Lodi	-1038.28***	(51.48)
Average EPC: D	-367.19***	(68.823)	Monza-Brianza	-401.82***	(58.419)
Average EPC: E	-372.26***	(71.925)	Mantova	-1419.16***	(45.664)
Average EPC: F	-480.56***	(71.702)	Novara	-634.44***	(82.999)
Average EPC: G	-632.22***	(73.583)	Pavia	-1128.53***	(39.422)
Alessandria	-885.06***	(80.562)	Sondrio	-870.65***	(40.971)
Asti	-1034.46***	(82.826)	Torino	-584.43***	(78.548)
Bergamo	-974.60***	(38.451)	Trento	71.28	(51.399)
Biella	-1088.26***	(87.007)	Varese	-903.10***	(39.472)
Brescia	-712.26***	(38.276)	Verbano-Cusio-Ossola	-519.68***	(83.315)
Como	-670.05***	(43.378)	Vercelli	-726.99***	(91.595)
Cremona	-1449.32***	(45.005)	Intercept	2077.28***	(29.838)
Cuneo	-654.33***	(76.984)			
No. of obs.	5792				
Adjusted R-sq	0.417				

*: p<0.10, **: p<0.05; ***: p<0.01

Reference categories: EPC class A, Milano

- → Total no. of obs. = 5,792
- → Coefficients: euro per square metre

Results

1. Less energy efficient dwellings less expensive than those in class A (except class B, not significant)
2. Milan: most expensive province

Hedonic price model (2): «individual» price and average EPC by zone

	Coefficient	s.e.
Useful heated surface (in sqm)	2012.54***	(1.152)
Second homes	36767.85***	(987.298)
Climate zone: F	-12722.71***	(649.767)
Average EPC: B	1967.58	(1296.085)
Average EPC: C	-40605.13***	(1536.568)
Average EPC: D	-77126.28***	(2834.228)
Average EPC: E	-65833.83***	(3157.65)
Average EPC: F	-59970.11***	(3150.558)
Average EPC: G	-74287.89***	(3349.508)
Alessandria	-145966.01***	(3294.904)
Asti	-148646.31***	(3398.351)
Bergamo	-136429.50***	(619.26)
Biella	-157236.63***	(3483.087)
Brescia	-111858.61***	(580.819)
Como	-112739.58***	(780.913)
No. of obs.	1626066	
Adjusted R-sq	0.663	

*: p<0.10, **: p<0.05; ***: p<0.01

	Coefficient	s.e.
Cremona	-177975.70***	(1017.406)
Cuneo	-91641.08***	(3191.674)
Lecco	-135273.06***	(1013.238)
Lodi	-144906.78***	(1270.251)
Monza-Brianza	-91572.92***	(685.752)
Mantova	-196354.56***	(988.132)
Novara	-107646.30***	(3284.589)
Pavia	-146996.07***	(798.202)
Sondrio	-90601.89***	(1248.726)
Torino	-48947.93***	(3148.666)
Trento	-21232.71***	(1052.254)
Varese	-144005.59***	(659.218)
Verbano-Cusio-Ossola	-59520.26***	(3389.072)
Vercelli	-134044.58***	(3533.861)
Intercept	72946.51***	(304.059)

Reference categories: main home, EPC class A, Milano

- → **"Individual" price**: for each dwelling, we have multiplied the average area price by the square metres of the dwelling
- → Coefficients: total cost in euro
- → Total no. of obs. = 1,626,066

Results

1. Less energy efficient dwellings less expensive than those in class A (except class B, not significant)
2. Surface: average price per sqm
3. Second homes more expensive than main homes
4. Milan: most expensive province

Conclusions

- The Autonomous Province of Trento is the "greenest" region among those analysed
- Piedmont has the oldest dwelling stock and therefore a higher percentage of energy-inefficient dwellings
- Higher CO2 emissions in less efficient dwellings
- Estimates: there is preliminary evidence that the lower the energy class, the lower the price
- To do:
  - Work on the specification of the hedonic price model to incorporate more variables
  - Implement spatial models of the relationship between levels of energy efficiency and house prices
  - Hope to get individual data from Immobiliare.it

Thank you!

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Energy performance classes and energy performance indicator

ENERGY PERFORMANCE CLASSES

Class A4			relative EPI	≤	0.40
Class A3	0.40	<	relative EPI	≤	0.60
Class A2	0.60	<	relative EPI	≤	0.80
Class A1	0.80	<	relative EPI	≤	1.00
Class B	1.00	<	relative EPI	≤	1.20
Class C	1.20	<	relative EPI	≤	1.50
Class D	1.50	<	relative EPI	≤	2.00
Class E	2.00	<	relative EPI	≤	2.60
Class F	2.60	<	relative EPI	≤	3.50
Class G			relative EPI	>	3.50

relative EPI = (EPgl,nren)/(EPgl,ref,standard)

where:

(1) **EPgl,nren** is the global non-renewable energy performance index

(2) **EPgl,ref,standard** is the reference standard non-renewable energy performance index. It is the performance index of a dwelling with the same geometric characteristics, exposure and location as the building to be certified but with energy performance parameters equivalent to a class A1

Average energy performance indicator

$$\text{Average EPI} = \sum_{i=1}^{N} \frac{(relative\ EPI)_i * (useful\ heated\ surface)_i}{(useful\ heated\ surface)_i}$$