Does tourism drive energy retrofits in the building stock? Evidence from Tuscany

Abstract
In recent years, the tourism sector and the residential construction sector have shown increasingly significant interconnections, particularly with respect to the energy efficiency of housing. The study investigates the role that a territory's tourism attractiveness may play as an incentive to improve the energy efficiency of the building stock. In particular, it aims to assess whether the tourism supply influences decisions to carry out energy retrofits, with specific attention to the residential sector and to dwellings used for short-term rentals or second homes.
The estimates suggests that areas with a strong tourism vocation tend, on average, to have a more energy-efficient building stock.

1. Introduction

In recent years, the tourism sector and the residential construction sector have shown increasingly significant interconnections, particularly with respect to the energy efficiency of housing. The increase in tourist arrivals observed in the post-pandemic years—especially in some highly attractive areas—may in fact represent an important stimulus for improving the energy performance of the housing stock.
On the one hand, growing tourist flows generate greater demand for accommodation, both in traditional hospitality facilities and in private dwellings used for short-term rentals. This phenomenon encourages owners to upgrade properties in order to make them more competitive on the market. An energy-efficient dwelling ensures greater thermal and acoustic comfort, lower operating costs, and an overall better guest experience—features increasingly valued by tourists, especially those attentive to environmental sustainability.
On the other hand, energy efficiency improvements help contain the environmental impact of tourism, a sector characterized by high energy consumption. Interventions such as insulation of the building envelope, replacement of obsolete systems, installation of renewable energy generation systems, and the adoption of consumption-monitoring and control technologies make it possible to limit greenhouse gas emissions and reduce resource use. In tourist contexts with high seasonal density, these interventions can have particularly significant effects on the territory's overall energy balance.
The relationship between tourism and energy efficiency upgrading also has an economic and social dimension. Investments in building retrofits can generate positive spillovers for the local economy, creating employment in construction and building-services industries and enhancing the value of the existing housing stock. At the same time, more efficient homes benefit not only tourists, but also improve residents' quality of life, contributing to more balanced and sustainable development of destinations.
The study investigates the role that a territory's tourism attractiveness may play as an incentive to improve the energy efficiency of the building stock. In particular, it aims to assess whether the tourism supply influences decisions to carry out energy retrofits, with specific attention to the residential sector and to dwellings used for short-term rentals or second homes. The underlying hypothesis is that, where tourism generates greater income opportunities, owners and investors may be more inclined to intervene in the housing stock to increase quality, reduce operating costs, and improve comfort—thereby turning tourism attractiveness into an indirect driver of energy efficiency improvements. At the same time, it is not self-evident that this relationship is always positive: areas

under high tourism pressure may also exhibit a high prevalence of historic or heritage-protected buildings, higher renovation costs, and intermittent (seasonal) use of properties, which can reduce the economic incentive for structural interventions.

The study relies primarily on administrative and technical data contained in Energy Performance Certificates (EPCs), which provide a comprehensive and standardized basis for describing the energy quality of buildings and their construction and system characteristics. EPCs allow observation of the energy class, performance indicators, energy carriers used, the presence and type of systems (heating, cooling, domestic hot water production), envelope characteristics (windows, insulation, materials), as well as the date of issuance and information on any renovation. These elements make it possible to construct comparable indicators of energy efficiency and to identify systematic differences between buildings located in areas that are more or less attractive from a tourism perspective.

Tourism attractiveness is measured through territorial indicators that capture tourism intensity and specialization and are more directly linked to the residential building stock, such as the supply of beds in non-hotel accommodation and, in particular, in the short-term rental segment. By integrating these indicators with georeferenced EPC information, the research examines the spatial distribution of energy efficiency and evaluates whether properties located in tourist destinations show, all else equal, a statistically significant causal relationship. The analysis explicitly considers potentially confounding factors: local socio-economic characteristics (income, demographic dynamics), real estate market conditions (prices), building typology (apartment blocks, single-family houses), and the age of the built environment.

First, the study presents maps and summary statistics to highlight the status of Tuscan housing units in terms of deposited certificates, associated energy classes, and performance indices. Next, it estimates models in which the outcome of interest is the number of buildings undergoing major renovation or an energy-efficiency intervention, as a function of local tourism intensity and a set of control variables.

The expected contribution of the research is twofold. From a scientific standpoint, it clarifies a channel that is often overlooked in the debate on the energy transition and urban regeneration: the role of tourism demand and local rents as a potential lever for upgrading the quality of the building stock. From a public policy perspective, the results may help design more targeted instruments. If tourism attractiveness emerges as a factor that fosters efficiency improvements, incentives and regulations could be calibrated to mobilize private resources—for example, by promoting minimum standards for tourist rentals or retrofit programs in the most touristic destinations. If, instead, the relationship proves weak or negative, this would suggest the presence of specific barriers (architectural constraints, short investment horizons, seasonality) and the need for dedicated policies, such as technical and financial support for historic buildings or demand-aggregation tools for condominium-level interventions. In both cases, the use of EPC data enables a high-granularity analysis that is replicable and potentially updatable over time, providing a solid empirical basis to guide building decarbonization strategies in territories where tourism and urban quality interact particularly intensely.

2. The European and National Context

Faced with environmental challenges and rising energy costs, the European Union has decided to act through concrete measures to upgrade the building stock, promote the use of renewable energy sources, and foster greater sustainability. The 2024 Energy Performance of Buildings Directive

(EPBD) is one of the most important and ambitious European initiatives in the field of sustainability and the fight against climate change. It is part of a broader package of regulatory initiatives aimed at making Europe carbon neutral by 2050 and drastically reducing energy consumption. This directive focuses on energy efficiency in the building sector, which accounts for a significant share of greenhouse gas emissions in the EU as well as energy use. In this context, the EU has set deadlines and concrete targets to improve the energy efficiency of buildings, with the goal of achieving, by 2050, a low-energy building stock and a broader production of energy from renewable sources.

Italy, too, has long pursued policies supporting the renovation of the building stock—policies that peaked in 2020 with broad and generous incentives for building refurbishment and energy retrofits, although they had already begun, in more limited form, as early as 1998. According to the Chamber of Deputies' Research Service (Ufficio Studi della Camera dei Deputati), tax deductions for building refurbishment and energy efficiency measures have been effective on the market since 1998 (the former) and since 2007 (the latter). Their applicability has been repeatedly extended over time and subject to multiple changes affecting deduction rates, maximum eligible expenditure, and the categories of interventions that qualify for support. The budget laws for the years 2017 to 2020 not only extended these deductions for the respective years, but also introduced significant innovations regarding measures aimed at seismic risk mitigation. The 2020 budget law also introduced the deductibility from personal income tax of 90% of expenses incurred in 2020 for construction works—including ordinary maintenance—aimed at the recovery or restoration of building façades (the so-called "Façade Bonus").

However, it was Article 119 of Decree-Law no. 34/2020 (the so-called "Relaunch Decree"), which introduced—as a measure to support the construction sector after the pandemic crisis—a 110% tax deduction (the so-called "Superbonus") for expenses related to specific energy efficiency interventions and seismic measures, that gave a major boost to renovation activity. ENEA estimated that the Superbonus, between 2020 and 2024, cost a total of €124.2 billion (ENEA, 2024), while other studies—whose results are not always consistent—have examined the distributional effects of both the Ecobonus and the Superbonus (Forni et al., 2025; Giarda et al., 2025; Parliamentary Budget Office, 2023). What can certainly be highlighted is the contribution of these measures in increasing the production of energy certificates, providing an important knowledge base in a thematic area that suffers from significant information gaps.

3. Brief Literature Review

This literature review summarizes the available evidence on how—and under what conditions—tourism, through demand, investment, and public policies, may incentivize the energy retrofit of the building stock. Existing research focuses in particular on buildings used for hotel accommodation (hotels and comparable facilities) and, in part, on cases of tourism-driven reuse of existing buildings, including those with historical and cultural value.

The review identifies three main strands of literature, which are nonetheless weakly integrated with one another. The first examines energy efficiency in the hospitality sector, focusing primarily on the energy performance of hotel buildings and retrofit interventions (Arenhart et al., 2024; Damigos, 2023; Singh et al., 2024; ENEA & Federalberghi, 2024). The second strand concerns the adaptive reuse of existing buildings—including historic ones—for tourism purposes, with primary attention to conservation, enhancement, and functional compatibility, and only marginally to energy performance (Vafaie et al., 2023; Zhang et al., 2025; Arfa et al., 2022; Vardopoulos et al., 2023). The third strand addresses public policies and programmes promoting sustainable tourism, which

more or less explicitly include measures aimed at encouraging energy retrofits of the building stock (UNWTO and UNDP, 2018; European Directive 2010/31/EU).
The most robust evidence points to the existence of a segment of demand in the hotel sector that is willing to reward "green" supply (with a specific role played by certifications), and to the centrality of energy consumption in hotels, which can make efficiency interventions economically viable.
However, the literature rarely identifies a clear correlation between tourism and an increase in the rate/depth of energy retrofitting of the building stock. Many studies discuss sustainability, reuse, and competitiveness, but do not explicitly measure energy outcomes at the stock level, especially in relation to non-hotel accommodation. The present contribution is positioned precisely in an attempt to fill this gap.

4. Energy Performance of Tuscan Buildings: EPC Certifications (APE)

As a reminder, APE is the Italian acronym for *Attestato di Prestazione Energetica*, i.e., the Energy Performance Certificate (EPC): a document that summarizes a property's characteristics in terms of energy consumption and energy efficiency.
The EPC uses a rating scale ranging from G to A4. A building in class G is characterized by high energy consumption and a significant environmental impact—so much so that there is no upper limit set for maximum consumption. Conversely, a building aiming for class A4 must achieve the lowest possible environmental impact, up to full energy self-sufficiency.
The rating takes into account multiple aspects, including:

- the orientation of façades and the building as a whole, the climatic zone, and the building's architectural features;
- the condition of walls and windows, as well as their structural characteristics;
- the condition and characteristics of existing systems for heating/cooling and domestic hot water production;
- the presence of any energy production systems based on renewable sources.

The issuance of an EPC has been mandatory since 2009 for property sales, and since 2010 also for rentals. It is also required in several other cases:

- for new buildings, including newly constructed buildings, buildings subject to demolition and reconstruction, and new conditioned volumes added through extensions of existing buildings;
- in the case of sale/purchase transactions and new rental contracts;
- in the case of major renovations, i.e., interventions on elements of the external envelope (external walls, roof, windows, etc.) whose total surface area exceeds 25% of the envelope;
- additional cases are set out in the relevant legislation (Legislative Decree no. 192 of 19 August 2005, as amended).

It is useful to clarify that an EPC can be issued either for the entire building or for an individual housing unit.
As noted above, the EPC is valid for 10 years in most cases. However, if works are carried out that affect aspects and parameters that can change the rating, the EPC must be updated.
The energy class is the key piece of information shaping end users' perception of a building's energy quality and—again—follows the G-to-A4 classification. The qualitative alphanumeric label is also associated with a quantitative value, the non-renewable global energy performance index (EPgl,nren), which expresses the amount of non-renewable energy consumed per year per unit of surface area, measured in kWh/m²/year.

The number of EPCs issued over time has been increasing, as has renovation activity. This reflects a combination of factors, including the ageing of the building stock (which over time requires interventions to maintain functional standards), changing quality standards in housing, turnover in ownership, and technological and regulatory innovation that encourages the replacement and upgrading of systems. An equally important role must be acknowledged for the financial incentive schemes that have supported building refurbishment and energy retrofits since 1998 and have become widely adopted in the years that followed.

In the next section we report the main results obtained from the analysis of energy data declared up to the end of 2024 in the SIERT cadastre of the Tuscany Region, and we then estimate the role of tourism in the energy-efficiency upgrading process of the building stock.

5. The State of the Tuscan Building Stock

The analysis consists of descriptive statistics on buildings' energy performance, derived from the information reported in their certificates.

The data come from the regional information system SIERT, which archives the certifications produced for properties in Tuscany. As already noted, the available data cover the period 2019–2024.

Before examining the information contained in EPCs, we provide a brief description of the Tuscan building stock with specific reference to residential buildings, drawing on both cadastral data from the Revenue Agency's Real Estate Market Observatory (*Agenzia delle Entrate – Osservatorio del Mercato Immobiliare*) and census data from ISTAT.

According to cadastral data, the total number of real estate units in Tuscany is just over 3.1 million, of which nearly 70%—about 2.1 million units—are intended for residential use.

An analysis of the period of construction (Table 1) is a relevant aspect that affects buildings' energy performance. The historic building stock—which also represents an important identity value, especially in Tuscany—creates critical issues related both to structural vulnerability and to energy performance, and therefore highlights the need for retrofit interventions.

Table 1. – Construction period of residential buildings (2021). Percentage distribution of buildings by construction period.

	Before 1919	1919-1945	1946-1960 e	1961-1970	1971-1980	1981-1990	1991-2000	2001-2005	After 2005
Centre-North	18.2	10.6	13.7	16.9	16.3	9.9	6.9	4.1	3.4
of which Tuscany	25.7	13.3	15.0	15.1	12.8	7.4	4.9	3.2	2.7
ITALY	15.0	10.9	14.0	16.8	17.4	12.0	7.1	3.8	3.0

Source: IRPET elaborations on ISTAT data.

Another aspect highlighted is the number of storeys of residential buildings, used as a proxy for the prevailing building typology, which may also play a role in buildings' energy performance (Table 2). In particular, the strong prevalence of buildings with up to two storeys emerges, consistent with

Italy's settlement pattern, which is predominantly characterized by a low-density urbanization model.

Table 2. – Residential buildings by number of storeys (2021).
Number and percentage of total.

	Total	Share of one-storey buildings only	Share of one- and two-storey buildings
Centre-North	7.178.674	10.1	63.1
of which Tuscany	733.499	10.9	65.5
ITALY	12.187.698	17.1	66.2

Source: IRPET elaborations on ISTAT data.

Another relevant parameter concerns the analysis of construction materials in residential buildings, which shows a clear predominance of load-bearing masonry—especially in Tuscany—confirming the historic and traditional nature of the building fabric that largely characterizes the region. The limited presence of innovative materials (steel, timber) is another distinctive feature of Tuscany, pointing to a building renewal process that remains very limited.

Table 3. – Construction materials of residential buildings.
Percentage distribution.

	Load-bearing masonry	Concrete	Altro
Centre-North	58.5	27.2	14.3
of which Tuscany	69.5	22.2	8.3
ITALY	57.2	29.5	13.3

Source: IRPET elaborations on ISTAT data.

Finally, we look at the state of maintenance. From this perspective, buildings show a higher share in good or excellent condition, thanks to renovation works that have affected the building stock over the years.

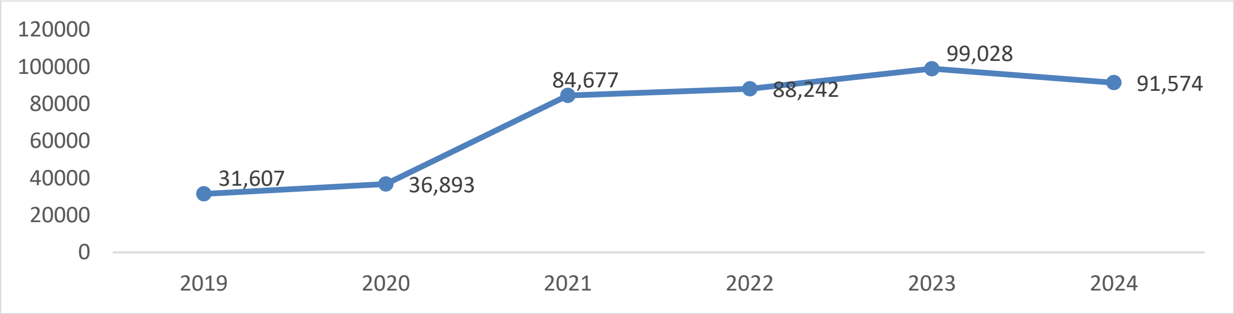
Table 4. – State of maintenance of residential buildings (2021).
Percentage distribution.

	Excellent	Good	Poor	Very poor
Centre-North	37.6	49.1	12.1	1.3
of which Tuscany	37.0	51.5	10.4	1.1
ITALY	31.8	51.4	15.2	1.7

Source: IRPET elaborations on ISTAT data.

We now turn to the analysis of the number of EPCs issued in Tuscany over the period we have already mentioned, covering the years 2019 to 2024. The archive contains 432,021 certificates, and—as shown in Figure 5—the total has increased markedly over time, rising from 31 thousand certificates in 2019 to over 90 thousand in the most recent years, also as a result of the national incentive schemes described in the previous sections.

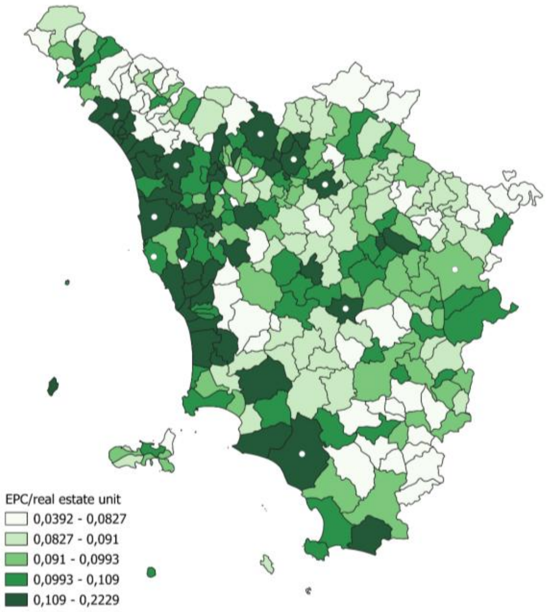
Figure 5. EPC certifications by year. Number of EPCs, Tuscany, 2019–2024.



Source: IRPET elaborations on Tuscany Region data.

The territorial distribution of EPC certifications in Tuscany (Figure 6) highlights an interesting pattern: their number, relative to the existing real estate units, is higher both in urban areas—affected by tourism linked to art cities—and in coastal areas with a strong seaside tourism vocation.

Figure 6. EPC certifications in Tuscan municipalities: values per real estate unit, 2024.

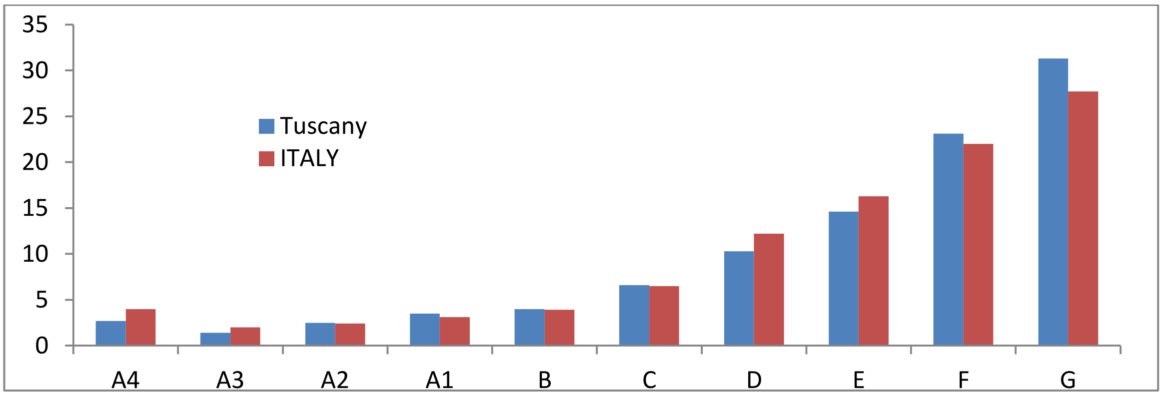


Source: authors' elaborations based on data from the Italian Revenue Agency – Real Estate Market Observatory, and the Tuscany Region

This suggests that a territory's tourism vocation may be connected to the production of certifications related to buildings' energy performance. In particular, an aspect that requires further investigation concerns the role of a territory's tourism attractiveness in fostering the energy-efficiency upgrading process of buildings.

The composition of issued certificates by energy class shows that the building stock is overall poorly performing from an energy perspective. In Tuscany, the highest energy classes (A) account for only 10% of buildings, the intermediate classes B, C and D for 21%, and the lowest three classes E, F and G for 69% of buildings. The class with the largest share—30% of the total—is G, i.e., the one associated with the lowest performance levels (Figure 7).

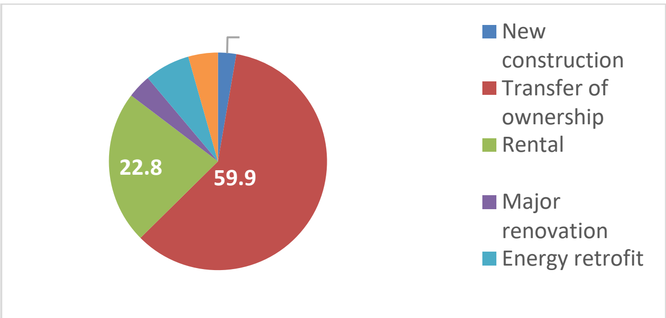
Figure 7. Buildings' energy class. Percentage distribution of EPCs, 2019–2024.



Source: IRPET elaborations on Tuscany Region data.

As already noted, Tuscany's building stock is old, to the extent that the large majority predates 1919, while progressively smaller shares were built as we move closer to more recent years.
Another factor explaining the large number of buildings falling into the lowest energy-performance class emerges from the analysis of the reason (as reported in the certificate) for which the EPC is issued (Figure 8). The certificate lists six possible cases: new construction, change of ownership, rental, major renovation, energy retrofit, and other. In most cases, the EPC is issued because of a change of ownership of the property: this accounts for 60% of certificates, to which a further 23% relates to the signing of rental contracts. In these cases, there is therefore no associated improvement in buildings' energy performance; rather, the EPC simply fulfils a legal requirement. Only 7% of certificates are linked to energy retrofit interventions, while 3% are associated with major renovations; a smaller share falls into the "other" category, which accounts for only 4%.

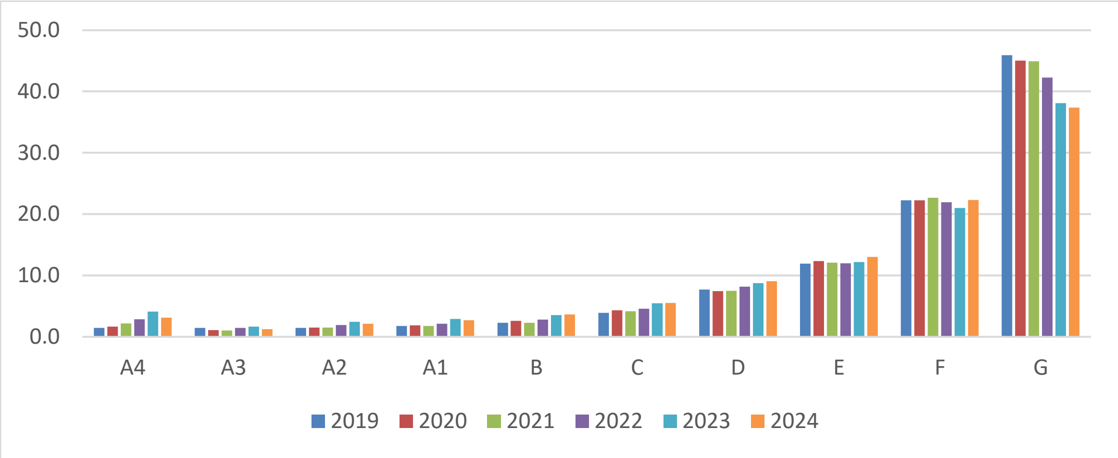
Figure 8. Composition of EPCs by reason for issuance, 2019–2024.



Source: IRPET elaborations on Tuscany Region data.

The least significant reason among those for which certification is mandatory concerns new construction: it accounts for only 3% of the energy certificates filed in the Tuscan system, which helps explain the clearly minor share of buildings that fall into the highest energy classes.
An important point to emphasize, however, is the positive trend in certificates referring to buildings in the most efficient classes, which have increased over time, while—in parallel—certificates referring to buildings in classes with higher energy needs have declined (Figure 9).

Figure 9. Annual composition of EPC certifications by energy class, 2019–2024.



Source: IRPET elaborations on Tuscany Region data.

Looking at the intended use categories (Table 10), EPCs filed for residential properties amount to 17% of real estate units, whereas those referring to non-residential buildings reach almost 30%.

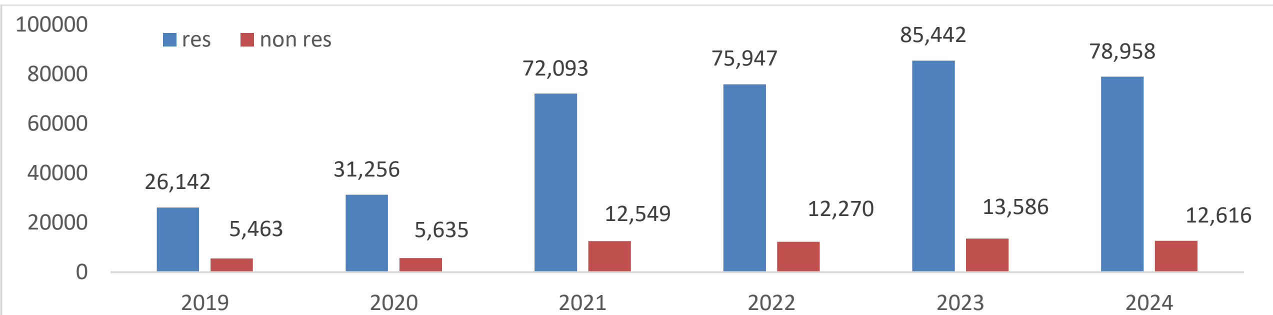
Table 10. Composition of EPCs by intended use: residential vs non-residential. Absolute values and percentages. Tuscany, 2024.

Use	No. of EPCs	No. of REU	% EPCs / REU
Residential	369.761	2.154.207	17.2
Non-residential	62.153	214.432	29.0
TOTAL	431.914	2.368.639	18.2

Source: authors' elaborations based on data from the Italian Revenue Agency – Real Estate Market Observatory, and the Tuscany Region

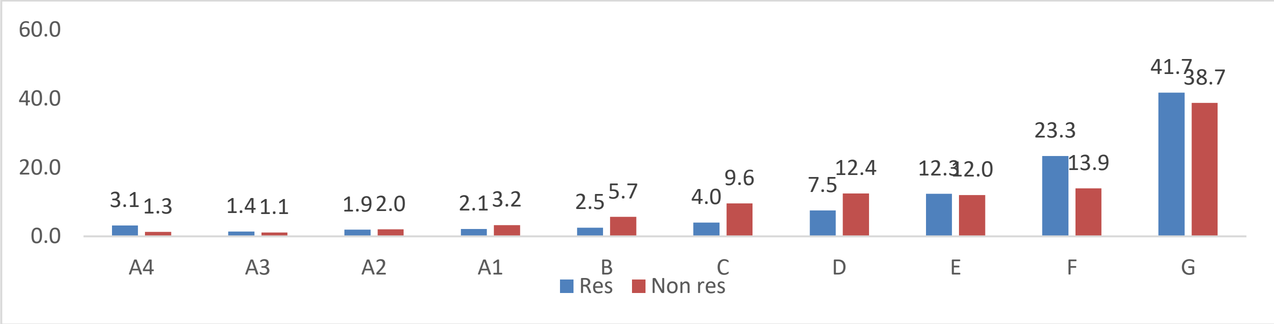
For both types—residential and non-residential buildings—the first two years (2019 and 2020) are the period in which the fewest certificates were issued. From 2021 onwards, however, the number increases markedly, reflecting the combined effect of the post-pandemic recovery—during which real estate transactions also resumed at a sustained pace—and the set of incentives introduced to support the retrofit of the existing building stock (Figure 11).

Figure 11. EPC certifications for residential and non-residential buildings, by year. Tuscany, 2019–2024.



Source: IRPET elaborations on Tuscany Region data.

Figure 12. Energy classes for residential and non-residential buildings by year. Percentage distribution, Tuscany, 2019–2024.

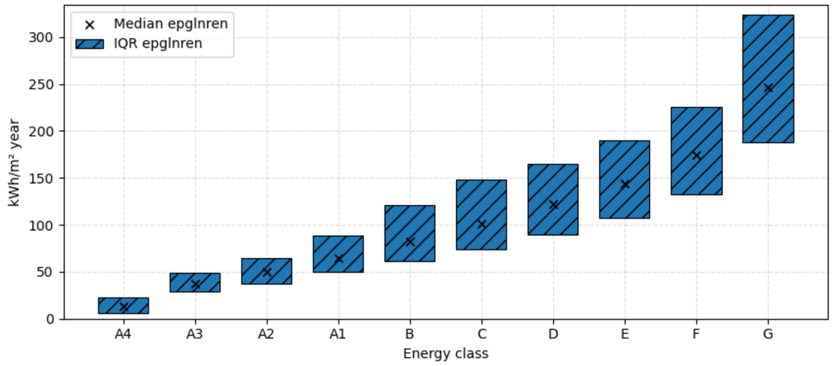


Source: IRPET elaborations on Tuscany Region data.

From the comparison by energy class, we highlight that residential buildings are more strongly represented in the highest-performing classes, likely as a result of a greater share of new construction. Conversely, in the lowest classes (F+G), dwellings dominate (65% versus 53%), reflecting the greater dynamism of the housing market. Non-residential buildings, by contrast, are more numerous in the intermediate categories (Figure 12).

At this point, we analyze the environmental performance of Tuscan buildings by drawing on the parameters reported in EPCs. In particular, we focus on the variable which—together with the climatic zone—determines the classification of the building stock into energy classes: EPgl,nren (non-renewable global primary energy), i.e., the energy consumed from non-renewable sources (natural gas, fuel oil, grid electricity) for heating, cooling, domestic hot water, ventilation, and lighting, measured in kWh/m² per year.

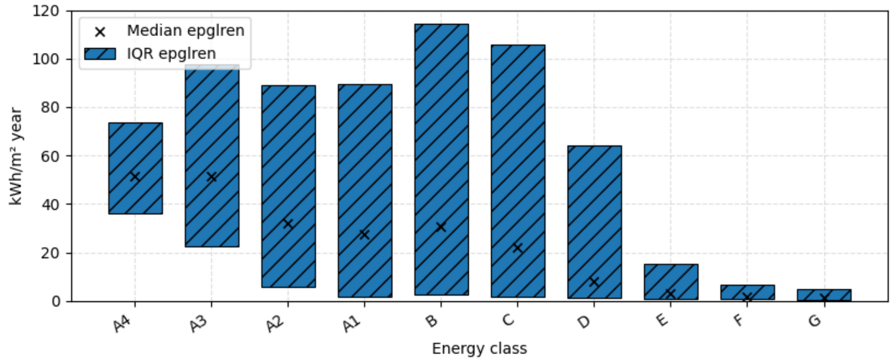
Figure 13. Non-renewable global primary energy by energy class.
Median values and interquartile range (IQR). Values in kWh/m² per year, 2024.



Source: IRPET elaborations on Tuscany Region data.

Looking at the results (Figure 13), we observe that as we move from class A4 to class G, the demand for non-renewable primary energy increases in an almost regular pattern. In the best classes (A4, A3, A2), median values are fairly low—on the order of a few tens of kWh/m² per year—and the interquartile range also remains relatively narrow: buildings are quite similar to one another and have low consumption. As we move down toward A1, B, C and then to E, F and G, the median rises to exceed 240 kWh/m² per year in class G, and variability also increases. In other words, the least efficient buildings not only consume much more, but within the same class there is also substantial dispersion—evidence of a highly heterogeneous building stock.

Figure 14. Renewable global primary energy by energy class. Median values and interquartile range (IQR). Values in kWh/m² per year, 2024.

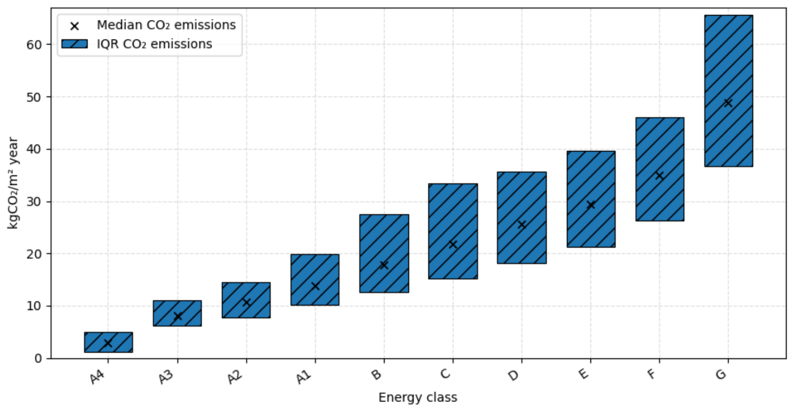


Source: IRPET elaborations on Tuscany Region data.

When we analyze renewable energy instead (Figure 15), using the values for EPgl,ren (renewable global primary energy), we obtain an almost mirror-image result. In the most efficient classes—especially A4 and A3—the median renewable energy is quite high, around 50 kWh/m² per year, with a wide interquartile range. This suggests that buildings in the highest energy classes make greater use of renewable sources, but with levels that vary substantially from one case to another—an indication that they may or may not have on-site renewable systems, while still remaining in a high class. Moving toward the intermediate classes and then to the least efficient ones, medians progressively decline: from class D downward, typical values become on the order of just a few kWh/m² per year, and in the lowest classes almost all buildings show negligible renewable contributions. In other words, in the lower classes, energy demand is covered almost exclusively by non-renewable sources.

Finally, the chart on CO_2 emissions (Figure 15) provides a synthetic representation of the previous indicators, showing that values increase as we move toward the worst classes, which correspond to emissions that are both higher and more variable. In essence, the lower the energy class of a building, the greater its climate impact—not only because it requires more overall energy, but also because the non-renewable share is higher and therefore the amount of CO_2 produced is greater.

Figure 15. Median values and interquartile range (IQR) of CO_2 by energy class. Values in $kgCO_2/m^2$ per year, 2024.



Source: IRPET elaborations on Tuscany Region data.

Indeed, as the energy class decreases, buildings become increasingly "energy-intensive", rely almost exclusively on non-renewable sources, and show rising emissions, with very high within-class variability. From this perspective, we can state that the energy class provides a good synthetic measure of both the efficiency and the degree of decarbonization of the building stock.
The analysis by building function—residential versus non-residential—highlights a positive trend in EPgl and EPgl,nren, indicating a decline in these values over the period analyzed, although this pattern shows some discontinuities in certain years (Table 16). EPgl,ren, which refers to energy consumption covered by renewable sources, is instead characterized by a more stable trend and indicates an increasing reliance on clean energy over time for both building types.

Table 16. Median values of EPgl, EPgl,nren, EPgl,ren and CO_2 emissions by EPC issuance year for residential and non-residential properties.
Values in kWh/m² per year for EPgl indices, and in $kgCO_2/m^2$ per year for emissions, 2024.

	Year of EPC issuance	N° APE	N° APE/ N°r UI	Total Epgl (Kwh/sm year)	Epglnren (Kwh/sm year)	Epglren (Kwh/sm year)	CO2 (Kq/sm year)
Residential	2019	20.050	0,93	185,2	1,6	196,7	36,4
	2020	23.945	1,11	186,4	1,7	198,9	37,0
	2021	55.416	2,58	183,3	1,8	198,6	36,6
	2022	58.374	2,71	174,9	1,9	191,5	35,0
	2023	65.072	3,03	163,6	2,1	182,6	32,9
	2024	59.851	2,78	169,4	2,2	187,3	34,0
Non residential	2019	11.566	5,31	220,6	12,7	255,4	45,3
	2020	12.954	5,95	216,1	14,5	253,7	45,3
	2021	29.265	13,44	210,7	13,1	250,2	43,9
	2022	29.870	13,72	210,3	14,2	253,0	44,5
	2023	33.956	15,59	207,8	14,7	252,1	43,8
	2024	31.723	14,57	206,2	17,6	254,9	44,1

Source: IRPET elaborations on Tuscany Region data.

Finally, we can highlight that the residential sector, as expected, shows lower average values than the non-residential sector for all the environmental variables analyzed (EPgl and CO_2). However, since residential real estate units are by far the most numerous, it is clear that they play a crucial role in achieving decarbonization and sustainability goals for our cities and, more broadly, for the region as a whole.

6. Tourism Pressure as a Determinant of Energy Efficiency Upgrading: An Empirical Analysis of Tuscany

6.1 Data and Methodology

To assess whether tourism pressure may play a role—at least partially—in driving energy efficiency upgrading in housing, we conduct an empirical analysis. This is implemented by estimating a multivariate linear regression model (OLS) aimed at identifying the main territorial factors associated with the energy performance of the housing stock. The dependent variable is defined, for each municipality, as the number of EPCs referring only to dwellings that have undergone major renovation works or energy retrofit interventions, normalized by the resident population.
The choice of an OLS model is motivated by the continuous nature of the dependent variable and by the objective of estimating the marginal effect of a broad set of socio-economic, demographic, and real-estate determinants, simultaneously controlling for different territorial dimensions.
The estimated model can be expressed in the general form:

$$\mathbf{y_i^{*}= \alpha + \sum X_i\beta+\epsilon_i}$$

where **X** represents the vector of explanatory variables and εi\varepsilon_iεi is the error term.

The independent variables included in the model were selected to capture three main dimensions: the economic and real-estate context, demographic and territorial characteristics, and the quality and structure of the building stock (Table 18).

Table 17. Explanatory variables included in the regression model.

Economic and real estate	IRPEF taxable income per taxpayer Average house prices Tourist overnight stays in Hotels per resident
Demography and territory	Population Share (%) of individuals aged 65 and over Dummy variable for provincial capitals Dummy variable for inner areas Territorial attractiveness
Building stock	Share (%) of dwellings in excellent maintenance condition Share (%) of buildings with 1–2 storeys Share (%) of buildings built after 2005 Beds in non-hotel accommodation (bed capacity)

Source: IRPET elaborations.

Within the first group are included: IRPEF taxable income per taxpayer, used as a proxy for economic well-being and households' capacity to invest; average house prices, an indicator of real estate market conditions and, indirectly, of the quality and attractiveness of the housing supply; hotel tourist overnight stays per resident, which measure the intensity of the area's tourism vocation and the degree of non-residential use of the building stock.

Among the demographic and territorial variables, the model includes resident population, to control for the municipality's demographic size; the share of individuals aged 65 and over, indicative of the age structure and potential differences across housing types; a dummy variable for provincial capitals, used to test for an urban effect; a dummy capturing inner areas, intended to reflect structural gaps between central and peripheral territories; and an indicator of territorial attractiveness measured through net migration.

Finally, structural variables of the building stock include: the share of dwellings in excellent maintenance condition, as a direct indicator of building quality; the percentage of buildings with one or two storeys or built after 2005, capturing both the incidence of smaller buildings—generally associated with lower energy performance—and more recent construction, typically in better condition; and, lastly, the number of beds in non-hotel accommodation, included as a further indicator of tourism pressure on the residential stock.

The choice to use beds in non-hotel accommodation as an explanatory variable for a territory's tourism vocation responds to the need to capture a dimension of tourism pressure that is closely linked to the residential building stock. Unlike traditional hotels, the non-hotel segment (for example, short-term rentals) is characterized by the use of properties originally intended for residential purposes, often subject to renovations, changes of use, or energy retrofits.

In this sense, non-hotel bed capacity is a particularly appropriate indicator for analyzing dynamics affecting the number of EPCs, as it reflects not only the intensity of tourism activity, but also the extent to which the residential building stock is involved in tourism-driven valorization processes. An expansion of non-hotel supply may therefore translate into a greater need for energy certification, both to comply with legal requirements and to make properties more competitive in the tourist rental market.

To test the idea that tourism pressure acts as a relevant factor in energy-efficiency upgrading processes, we will therefore focus on the model results related to both tourist overnight stays and beds in non-hotel accommodation. For both indicators—which represent tourism demand and accommodation supply, respectively—a positive correlation with the dependent variable is expected.

6.2 Results

Estimation results show that the energy performance of the housing stock is significantly associated mainly with economic, real estate, and structural variables, while purely institutional or demographic variables are less relevant once the other dimensions are controlled for. In particular, IRPEF income per taxpayer displays a positive and statistically significant coefficient, indicating that territories characterized by higher income levels tend to show higher values of the dependent variable. This result is consistent with the hypothesis that greater economic resources foster investments in renovations, energy retrofits, and improvements in housing quality.

Hotel tourist overnight stays per resident are also positively associated with the dependent variable. This suggests that areas with a strong tourism vocation tend, on average, to have a more energy-efficient building stock. Moreover, the regression results indicate that beds in non-hotel accommodation are likewise positively associated with the number of EPCs referring to renovated or energy-retrofitted dwellings.

Table 18. Estimation results for the number of EPCs per capita related to dwellings undergoing renovation works or energy retrofits.

	Coefficient	P>|t|	
Tourist overnight stays per resident (per 1,000 inhabitants)	0.0232	0.0070	**
IRPEF taxable income per taxpayer (per 1,000 taxpayers)	0.0004	0.0000	***
Population (thousands of inhabitants)	0.0000	0.0084	**
Provincial capital (dummy)	0.0011	0.7090	
Share (%) of people aged 65 and over	0.0084	0.0066	**
Inner areas (dummy)	-0.0012	0.4150	
Average house prices	0.0000	0.0100	**
Share (%) of dwellings in excellent maintenance condition	0.0047	0.0084	**
Beds in non-hotel accommodation	0.0009	0.0075	**
Attractiveness (net migration balance)	0.0001	0.9160	
Share (%) of buildings with 1–2 storeys	-0.0006	0.8680	
Share (%) of buildings built after 2005	0.0279	0.0250	*
Costant	-0.0018	0.7250	

Source: IRPET elaborations.

However, the two variables appear to operate through different channels. In the case of hotel tourist overnight stays, the effect on the number of EPCs referring to renovated dwellings seems to be attributable mainly to an indirect mechanism. High levels of hotel overnight stays reflect greater tourism attractiveness and local economic activity, which may translate into higher income and increased investment in the real estate sector. Rising local income may be associated with more real estate transactions and with renovation or energy retrofit interventions, which in turn generate greater demand for energy certificates.

By contrast, the number of beds in non-hotel accommodation seems to exert a direct effect on the number of EPCs referring to renovated dwellings, consistent with the hypothesis that tourism demand can directly stimulate upgrading and valorization interventions in the residential building stock. Moreover, in a context of strong competition, property owners may have stronger incentives to improve the energy characteristics of dwellings in order to increase the attractiveness of their offer. In this case, the estimated relationship therefore reflects an immediate link between using the property for accommodation purposes and the issuance of EPCs.

Average house prices also show a positive and significant coefficient, confirming a relationship between property values and energy performance. In this respect, housing prices appear to reflect—at least in part—the structural quality and energy efficiency of buildings.

Particularly relevant is the effect of the share of dwellings in excellent maintenance condition, which is positively and significantly associated with the dependent variable. Finally, the share of more recent buildings has a positive coefficient, consistent with the hypothesis that newer construction—subject to stricter energy regulations—contributes to improving the overall performance of the local building stock.

Institutional and territorial variables, such as being a provincial capital and therefore a large urban area or, conversely, being located in an inner area, are not statistically significant. This suggests that, once economic and structural conditions are controlled for, such characteristics do not exert an independent effect on buildings' energy performance.

Similarly, net migration, building typology (one- or two-storey buildings), and simple demographic size do not show a statistically significant impact in the estimated model.

Overall, the findings indicate that the dependent variable is mainly influenced by factors related to territorial wealth—including the level of tourism intensity—by the functioning of the real estate market, and by the structural quality of the building stock, rather than by strictly institutional or demographic characteristics.

7. Conclusions

This study has examined the role of tourism pressure in the energy retrofit of the residential building stock in Tuscany, using a broad and detailed information base derived from Energy Performance Certificates (EPCs). The descriptive analysis first confirmed the structural weaknesses of the regional housing stock, characterized by an ageing built environment, generally low energy performance, and a strong concentration of properties in the least efficient classes. At the same time, the data point to a recent positive dynamic, with an increase in certifications linked to renovation and energy-efficiency interventions and a gradual improvement in average energy indicators—also reflecting the strong impulse provided by national incentive policies.

The empirical analysis shows that energy upgrading processes in the housing stock are significantly influenced by economic, real estate, and structural factors. Within this framework, tourism pressure emerges as a relevant variable: both hotel tourist overnight stays per resident and non-hotel bed capacity are positively associated with the number of EPCs referring to dwellings undergoing renovation or energy retrofit works. These results suggest that, in areas with a stronger tourism vocation, competition in the rental market—especially short-term rentals—and the need to enhance properties for income purposes may translate, directly or indirectly, into a greater propensity to invest in the energy quality of buildings. Tourism therefore acts as a driver of efficiency improvements, alongside other key factors such as income levels, housing prices, and the maintenance condition of the building stock.

From a public policy perspective, the evidence suggests several relevant implications. First, in highly attractive tourist areas there is a potential for private investment that could be further steered toward building decarbonization objectives through targeted regulatory and incentive instruments—for example, minimum energy standards for tourist rentals or dedicated programmes to retrofit buildings used in the non-hotel accommodation sector. Second, the results indicate that the relationship between tourism and energy efficiency is neither automatic nor uniform, but depends on the socio-economic context and the structure of the building stock. This reinforces the need for differentiated policies able to account for the specific constraints of historic areas and less dynamic territories. Finally, the systematic use of EPC data is confirmed as a fundamental tool to monitor the evolution of energy performance and to assess policy effectiveness, providing a solid empirical basis for integrating energy transition strategies with tourism development and urban regeneration policies.

References

Arenhart R.S., Martins T. , Ueda R .M., Souza A. M, Zanini R. R. (2024), Energy use and its contributors in hotel buildings: A systematic review and meta-analysis, Plos One, October 24, 2024, https://doi.org/10.1371/journal.pone.0309745

Arfa, F. H., Zijlstra, H., Lubelli, B., & Quist, W. (2022). *Adaptive Reuse of Heritage Buildings: From a Literature Review to a Model of Practice*. International Journal of Architectural Heritage.

Damigos, D. (2023). *How much are consumers willing to pay for a greener hotel industry? A systematic literature review*. Sustainability, 15(11), 8775.

ENEA (2024). Report dati mensili al 31.12.2024. Disponibile su: https://www.efficienzaenergetica.enea.it/images/detrazioni/Avvisi/Report_31_12_2024.pdf

ENEA & Federalberghi (2024). *Guida per l'efficienza energetica nel settore alberghiero*.
European Directive 2010/31/EU sulla prestazione energetica degli edifici (*EPBD*).– Quadro normativo che impatta anche il settore turistico.

Forni L., Giarda E., Sommer S. (2025), "Are Incentives for Energy Retrofitting Regressive? Evidence from the Italian Superbonus and Ecobonus", SSRN Working Paper.

Giarda, E., Giuglini, F., e Penza, M. (2025). Comportamento e atteggiamenti delle famiglie verso misure di efficienza energetica in Italia: nuove evidenze dai dati dell'indagine. Working paper SSRN. Disponibile all'indirizzo: https://ssrn.com/abstract=5261413.

Singh, A., Mishra, Y., Yadav, S. (2024). *Toward sustainability: interventions for implementing energy-efficient systems into hotel buildings*. Engineering Proceedings.

Ufficio Parlamentare di Bilancio (2023). Audizione sugli effetti macroeconomici e di finanza pubblica derivanti dagli incentivi fiscali in materia edilizia. Disponibile su: https://www.upbilancio.it/wp-content/uploads/2023/03/UPB_Audizione-incentivi-fisc_edil_2023.pdf
UNWTO e UNDP (2018). *Sustainable tourism and the sustainable development goals*. Journey to 2030. Journal of Sustainable Tourism. January 2018 , ISBN: 978-92-844-1939-5

Vafaie, F., Remøy, H., & Gruis, V. (2023). *Adaptive reuse of heritage buildings: systematic review of success factors*. Habitat International.

Vardopoulos, I., Giannopoulos, K., Papaefthymiou, E., Temponera, E., Chatzithanasis, G., Goussia-Rizou, M., Karymbalis, E., Michalakelis, C., Tsartas, P., & Sdrali, D. (2023). *Urban buildings sustainable adaptive reuse into tourism accommodation establishments: A SOAR analysis*. Discover Sustainability, 4, Article 50. https://doi.org/10.1007/s43621-023-00166-2

Zhang, Q., Md Ali, Z., & Zainal Abidin, N. (2025). *Sustainable adaptive reuse of historic buildings: development of a framework from systematic review*. npj Heritage Science.