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Energy efficiency and social justice: the European challenge of the Energy Performance of Buildings Directive

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Highlights:

- Analyses the EU Energy Performance of Buildings Directive social impact.
- Proposes a new Index, CBSVI, Composite Index on Buildings and Social Vulnerability.
- Compares national contexts through a four-cluster socio-economic approach based on CBSVI.
- Links energy efficiency to equity, affordability and housing policy.
- Assesses policy gaps using Italy as a detailed case study.
- Suggests measures to prevent inequality in the green transition.

Abstract: The ecological transition stands as one of the greatest challenges of our time—an epochal shift involving environmental, economic, and social dimensions. The EU Green Deal represents a milestone in European policy, aimed at drastically reducing greenhouse gas emissions across all sectors, including construction, one of the most environmentally impactful sectors. In this context, the aim of the EU Energy Performance of Buildings Directive (EPBD) 2024/1275 is to transform the European Union's building stock into a sustainable and efficient system by 2050. This requires a complex process of adaptation that goes far beyond technical matters, touching on the economic, political, and social dynamics of each EU Member State. This article examines the EPBD issues, analyzing its objectives, operational instruments, and the critical issues related to its practical implementation. A new composite index, the Composite Building and Social Vulnerability Index (CBSVI), is proposed, as well as a four-cluster classification, allowing a detailed comparison among Member States. The impact of EPBD on households, in relation to housing characteristics, economic conditions, and structural inequalities is analyzed. The case of Italy is discussed in detail, including the incentive policy and estimated costs and benefits for compliance. The conclusion is that without an equitable housing policy, the challenges posed by the EPBD may widen the gap between families who can afford the required upgrades and those who are left behind, raising issues of energy and housing poverty.

Keywords: energy efficiency; Energy Performance of Buildings Directive; European Green Deal; social inequality; energy poverty; housing policy; sustainable transition

1. Introduction

On April 14, 2024, the Economic and Financial Affairs Council (ECOFIN) of the European Union approved the Energy Performance of Buildings Directive (EPBD), initially proposed by the European Commission in 2021 and later revised through discussions in the European Parliament and Council. EPBD is part of the European Green Deal [1], the broad ecological transition initiative aimed at drastically reducing greenhouse gas emissions, primarily carbon dioxide and methane, by 2050, thus reaching net-zero emissions. This ambitious goal spans multiple sectors and includes intermediate targets such as a 55% reduction in greenhouse gas emissions by 2030 compared to 1990 levels, and a further net reduction by 2040.

The European Green Deal was officially presented on December 11, 2019. Since then, a range of legislative actions have defined and equipped the project with legal and financial instruments. The Green Deal perhaps constitutes the EU's most ambitious and comprehensive framework to date, redefining both the Union's capabilities and its identity.

Sectors and main actions of the European Green Deal are illustrated in Table 1.

Table 1. The EU Green Deal sectors and related actions.

Sector/Actions	Motivation	Action 1	Action 2	Action 3	Institutions/References
Climate	A legal obligation: reducing emissions by at least 55% by 2030 compared to 1990 levels	Enhancing taxation through data collection	Taxation measures	Maintenance strategies	European Commission—European Green Deal: Timeline; Council of the European Union—European Green Deal
Disaster prevention	Increased intensity of extreme weather events requires an upgrade of civil protection systems	Prevention	Response	Recovery	Council of the European Union—European Green Deal
Environment	Restoring biodiversity by 2030	Expanding protected areas	Rehabilitating degraded ecosystems	Monitoring progress	European Commission—EU Biodiversity Strategy for 2030
Agriculture	Promoting healthier consumption patterns	Sustainable food production	Adoption of digital and sustainable technologies	Research and innovation to develop high value-added products	European Commission—Farm to Fork Strategy
Industry	Particular emphasis on the pharmaceutical fashion and mechanical engineering sectors	Compliance with high social and labor standards	Adoption of digital and sustainable technologies	Research and innovation to develop high value-added products	European Commission—EU Industrial Strategy
Mobility	Mobility is responsible for 25% of the EU's GHG emissions; light-duty transport accounts for 71% of CO_2 emissions	Beginning in 2027, an emissions trading system will be applied, also extended to the aviation and maritime sectors	Reduction in emission levels of 55% for new passenger cars and 50% for vans by 2030	Ban on the sale of new internal combustion vehicles across the EU as of 2035	Regulation (EU) 2019/631 on CO_2 emission performance standards
Energy	Reducing greenhouse gas emissions by 30% by 2030	Energy efficiency	Investments in non-polluting technologies	-	European Climate Law Regulation (EU) 2021/1119
Buildings	Responsible for over one-third of emissions; buildings must achieve zero emissions by 2050	New buildings must achieve zero emissions by 2030	New reporting obligations	-	Directive (EU) 2024/1275 on the Energy Performance of Buildings
Sustainable finance	Redirecting private investments toward environmentally sustainable activities	New reporting obligations	Taxonomy regulations	-	Regulation (EU) 2020/852 on sustainable investment (Taxonomy Regulation)

Source: Own elaboration based on European Commission documents (European Green Deal—Strategy & Policy, EU Biodiversity Strategy for 2030, EU Industrial Strategy, Farm to Fork Strategy, Regulation (EU) 2019/631, Regulation (EU) 2021/1119, Directive (EU) 2024/1275, Regulation (EU) 2020/852).

Since 2024, the Green Deal has entered a new and more pragmatic phase. The emphasis has shifted from legislative design to implementation, as Member States begin to translate EU targets into national renovation plans and funding schemes. The European Commission has revised several measures within the Fit for 55 package to balance decarbonization goals with economic and social sustainability. A relevant part of the Fit for 55 package is a new separate carbon market, called ETS2, dedicated to buildings, road transport, and small fuel combustion. For the building sector, ETS2 will operate since 2027 on heating oil, natural gas for households and services (Regulation (EU) 2023/955). The purpose is to set a carbon price for the domestic use of pollutants. Being aware that low-income households will face heightened exposure to ETS2, revenues from ETS2 will finance the EU Social Climate Fund (SCF), operational from 2026—aims to cushion from the impact of rising energy and renovation costs.

The Green Deal targets are illustrated in Figure 1. The dashed line shows the total net emissions path, while each color band indicates the contribution of specific sectors to the overall reduction. As in Figure 1, the building sector directly accounts for 18% of the total carbon emissions. However, considering indirect emissions (from electricity and heat production for building operations) and embodied emissions (building materials, construction, renovation and demolition), the buildings sector finally accounts for 36%–40% of CO_2 emissions in the EU [1].

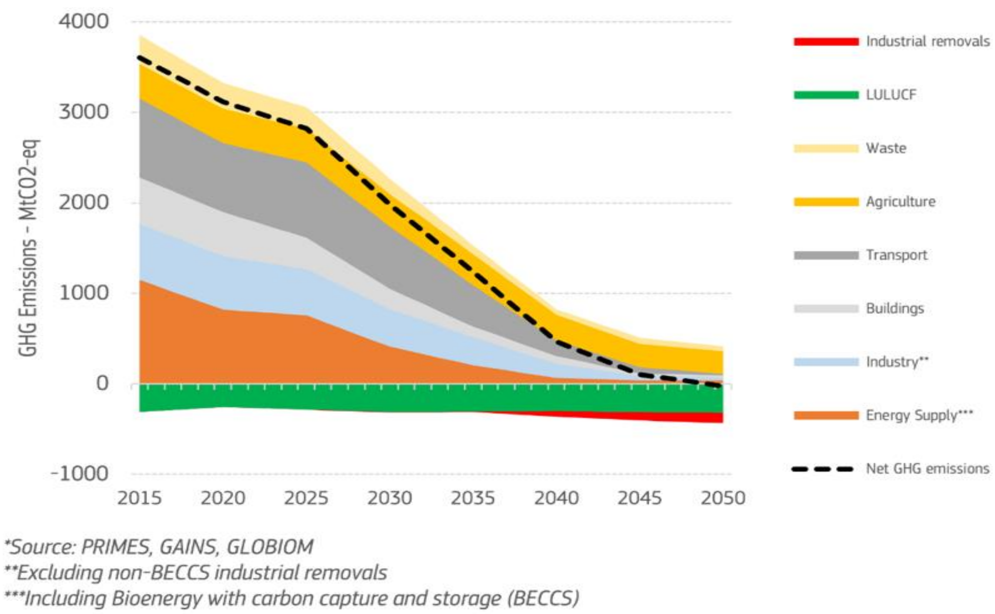

Figure 1. European Commission's proposal for greenhouse gas emission reduction for the period 2015–2050. Source: European Commission, PRIMES, GAINS, GLOBIOM modelling tools, EU 2020 reference scenario—Fit for 55 projection. Reproduced under EU Open Data License.

The EPBD, important part of the Green Deal, is specifically designed for the building sector. It establishes a common roadmap to improve the energy performance of buildings across Europe. Its objectives are organized around a set of milestones that guide the gradual decarbonization of the sector, as summarized in Table A1.

The Green Deal and EPBD rely on a top-down architecture of legislative packages and performance targets, which reflect its deeply technocratic nature. Such structuring risks worsening the short- and long-term impact of ecological measures on already vulnerable populations.

At this critical juncture, it is necessary to reframe the ecological transition not only as a technical and legal endeavor, but as a profoundly social one. This concern was already raised by Alexander Langer in 1994, when he argued that "the ecological transition will only succeed if it appears socially desirable."

In other words, an ecological transition can only take root if it is embraced as a positive and inclusive vision, rather than imposed from above.

Thirty years later, this message resonates strongly across Europe. In many regions, the transition is still perceived, especially by vulnerable groups, not as a shared horizon but as an imposed burden. Sociological studies have shown that when environmental policies are seen as technocratic, punitive, or disconnected from everyday realities, they risk undermining public support and reinforcing structural inequalities [2–4].

While the buildings sector is one of the most "polluting", it is also one of the most complex sectors to reform, given its central role in meeting one of society's most basic needs: housing. It must be noted that while the buildings sector accounts for 36%–40% of energy-related emissions, low-income households disproportionately live in low-efficiency dwellings.

This article aims to explore the relationship between political objectives, institutional instruments, and both the economic and social costs of implementation, especially how such burdens and benefits are distributed across different groups in society. The ecological transition is seen here not merely as a technological challenge, but as a social one, placing justice, accessibility, and inclusiveness at the heart of its implementation.

The paper is structured as follows. Paragraph 1 (Introduction) briefly outlines the contents of the Green Deal, of which the EPBD is an important part. Paragraph 2 reviews the relevant literature. Paragraph 3 presents a brief critical analysis of the EPBD objectives, trends and incentives. Paragraph 4 discusses the challenges across Member States and introduces the Composite Building and Social Vulnerability Index (CBSVI) and the related four-cluster classification, which regroups EU countries according to their housing structure, organisation and national policies. Paragraph 5 analyses the case of Italy in detail, with a focus on incentives, social stratification and the potential costs and benefits of compliance. Paragraph 6 concludes.

2. Literature review

In recent years, interest in the social dimensions of the green transition—particularly within the framework of the European Green Deal—has grown noticeably. The debate tends to follow two parallel tracks. On one side, the Green Deal is presented as an ambitious yet unavoidable roadmap to decarbonize the economy and ensure long-term sustainability. On the other side, especially within sociology and political ecology, there are warnings: without careful attention to inequality, the journey toward climate targets risks leaving entire segments of the population behind.

One of the most comprehensive attempts to address this concern comes from Ürge-Vorsatz *et al.* [5], who outline a framework linking energy efficiency directly to equity and affordability, in order to avoid emission-reduction measures deepening social divides. From a different but complementary perspective, Sovacool *et al.* [6] develop the notion of "energy justice," emphasizing that public trust depends not only on the technical merits of a policy, but also on how it is designed, explained, and communicated.

Landi and Rimondi [7] shift the focus to climate vulnerability, framing it not merely as a question of current resources, but as something entangled with long-standing patterns of exclusion embedded in urban planning. In doing so, they revisit and reinterpret the seminal work of Bullard [8] and Beck [9] on environmental risk and justice, placing it squarely within the context of EU climate governance.

More recent studies have turned their attention to perceptions and legitimacy. Barbosa & Almeida [4] argue that efficiency alone is insufficient: climate policies must also be experienced as fair and socially desirable if they are to endure. This resonates closely with Alexander Langer's [10] insight. Concerning the implementation, Forni *et al.* [11] highlight how uneven administrative capacity, bureaucratic delays, and fragmented governance can slow the translation of EU directives into real action. Their Italian case study illustrates how the path from Brussels' targets to local delivery is often blocked by coordination challenges.

But institutional mechanics is not the only barrier. Thomson *et al.* [3] warn that overly top-down, technocratic governance risks alienating precisely those most affected by climate change and its countermeasures. Hereu-Morales *et al.* [12] reaches a similar conclusion, documenting public backlash in situations where cushioning measures were too weak, poorly targeted, or poorly communicated.

Broader sociological perspectives—including Magnani [13]—frame vulnerability not only in material terms (income, housing stock) but also as a relational and cultural condition shaped by recognition, trust, local power relations and the way problems are publicly narrated. In a case study of a small Italian municipality, by Meneghin [14], the willingness to engage with energy renovation was closely tied to trust, perceived procedural fairness and a sense of agency. Many residents felt that decisions were made "elsewhere", with limited attention to local communities.

This article sits at the intersection of these perspectives. Its aim is not to provide definitive answers, but to explore how the EPBD, as part of the broader Green Deal, interacts with national contexts marked by energy poverty and housing precarity. The goal is to expose the blind spots that emerge when environmental ambition is not matched by social sensitivity—reaffirming that climate resilience must be built with, rather than merely for (or even against) those most directly affected.

3. Analysis of the EPBD objectives, trends and incentives

As stated previously, EPBD establishes a common roadmap to improve the energy performance of buildings across Europe. Its objectives are organized around a set of milestones that guide the gradual decarbonization of the sector, as summarized in Table A1 in Appendix 1.

The decarbonization process of buildings has started and emissions from the use of fossil fuels in buildings decreased by more than 43% in the EU over the period 2005–2024. This progress was driven by higher energy efficiency standards for new buildings, efficiency improvements in existing buildings, measures to decarbonize the electricity sector and heating systems, and warmer temperatures. The trend towards declining emissions from the buildings sector is expected to continue over the longer term. The chart in Figure 2, updated November 2025, shows changes in greenhouse gas (GHG) emissions from fossil energy use in buildings between 2005 and 2021, by Member States. Possible further changes by 2030 are also reported according to Member State projections if only existing measures remain in place and if additional measures currently planned by Member States are implemented.

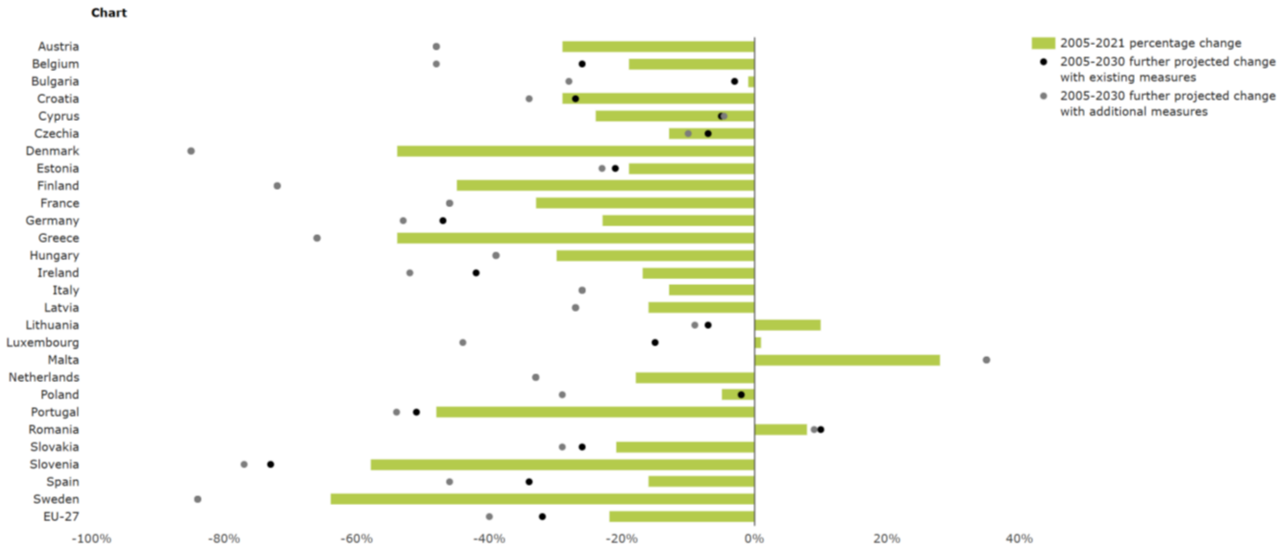

Figure 2. Past and projected greenhouse gas emissions from energy use in buildings by country. Source: EEA—Greenhouse gas emissions from energy use in buildings. Indicator assessment (updated November 2025).

However, historical, and projected emissions differ significantly from one Member State to another. Energy poverty affects more than 35 million Europeans who cannot afford adequate heating, cooling, or electricity. Building renovation could be one of the most effective structural solutions to reduce energy bills, improve health, and help Member States meet climate targets. Thus, a strong national policy, backed by effective measures, is mandatory. EPBD requires for each Member State to prepare a national plan that brings together regulatory measures, financial incentives and administrative tools.

Grant schemes and soft loans. All Member States have in place grant schemes and soft loans, *i.e.*, loans at a rate lower than the current one. Public grants can be the most effective mechanism for enabling vulnerable households to undertake energy renovation. Grants should cover 80%–100% of renovation costs, prioritizing insulation, window replacement, heating system upgrades, and heat pumps. Typically, long maturities (15–20 years) soft loans expand access for middle-income households who may not qualify for grants but cannot afford market-rate financing. State-backed guarantees may help to reduce the loan rate. However, scale and continuity of grants and guarantees may vary significantly year by year according to budget and are often dependent on change of Government and national policies. In addition to grant schemes and soft loans, Table 2 summarizes the national incentives and regulatory mechanisms currently adopted by Member States to support EPBD-related renovation. The comparison highlights the marked heterogeneity across the EU in terms of subsidies, tax deductions and information tools available to households.

Table 2. Incentives and regulatory mechanisms—EU Countries (2023).

Country	Tax Deductions	Guarantees	EEO/Utility	National Info Portal
Austria	~	✓	~	https://www.oesterreich.gv.at
Belgium	~	~	~	https://energy.belgium.be
Bulgaria		~	~	https://www.mrrb.bg
Croatia		~	~	https://www.fzoeu.hr
Cyprus		~	~	https://resecityportal.meci.gov.cy
Czechia		✓	~	https://www.sfzp.cz
Denmark	✓		✓	https://sparenergi.dk
Estonia		✓	~	https://kredex.ee
Finland	~	✓	~	https://www.ara.fi
France	✓		✓	https://france-renov.gouv.fr
Germany	✓	✓	✓	https://www.energiewechsel.de
Greece			~	https://exoikonomo2023.gov.gr
Hungary			~	https://nko.gov.hu
Ireland		✓	~	Sustainable Energy Authority of Ireland | SEAI
Italy	✓		~	https://www.efficienzaenergetica.enea.it SIAPE—Sistema Informativo sugli Attestati di Prestazione Energetica
Latvia		✓	~	https://www.altum.lv
Lithuania		✓	~	https://www.betalt.lt
Luxembourg	✓	✓		lu-2020-ltrs-official-en-translation-EU-.pdf
Malta			~	https://www.servizz.gov.mt
Netherlands	~		✓	https://www.rvo.nl
Poland	✓		~	https://czystepowietrze.gov.pl
Portugal			~	https://www.fundoambiental.pt
Romania			~	https://www.afm.ro
Slovakia			~	https://www.siea.sk
Slovenia			~	https://www.ekosklad.si
Spain	✓		~	https://www.idae.es
Sweden	✓		✓	https://energimyndigheten.se

NOTES: ✓ = official data, ~ = limited or non official data. The level of governance is almost universally, made exception for Germany (Federal), Belgium (Regional) and Austria (Federal + Lander).

Energy Efficiency Obligations (EEOs), *i.e.*, regulatory schemes that require energy suppliers or utilities to deliver a certain amount of energy savings each year, are rare, and practiced mostly in "virtuous" Countries. If well designed, EEOs should deliver energy savings, with a mandatory share dedicated to vulnerable consumers.

The introduction of ETS2 in 2027 will raise fossil heating costs, making heating more expensive, so renovations are essential for long-term affordability. All Member States should channel Social Climate Fund resources toward grants, heat pump deployment, and insulation measures specifically targeting low-income households.

4. Challenges across member states

The heterogeneous impact of EPBD cannot be understood through isolated variables such as income, climate or energy prices. Differences in building performance, renovation feasibility and social vulnerability emerge instead from structural combinations of factors. For this reason, the analysis adopts a clustered comparative approach, inspired by assessments developed by the EEA and the JRC [15]. The approach groups Member States according to the dimensions that jointly shape the distributive effects of the Directive.

To support this comparative reading, a new CBSVI is proposed. The index captures both the material characteristics of the housing stock and the socio-economic constraints that determine households' capacity to comply with EPBD renovation requirements. A synthetic description of the seven dimensions of the CBSVI follows.

(1–2) Building age (pre-1945; 1946–1970)

Southern and Eastern Member States tend to show a much higher concentration of dwellings constructed before 1970, while several Northern and Western countries underwent earlier waves of renovation. Construction-period data from the European Commission's Building Stock Observatory provide the basis for distinguishing buildings erected before 1945 and those built between 1946 and 1970 [16]. Although 1980 is sometimes cited as a technical turning point, the 1970 threshold better reflects the sociological shift from pre-war to post-war development. The two categories are normalized independently to account for their different renovation challenges and concur as two distinct parameters.

(3) Tenure structure

Eurostat EU-SILC data [17] allow us to differentiate ownership-based systems from rental markets, while Housing Europe provides key information on whether rental sectors are dominated by institutional landlords or small private owners [16]. Comparative housing literature further highlights how institutional landlords tend to exhibit greater renovation capacity and easier access to credit, whereas systems based on small private ownership face higher distributive risks during renovation cycles [18,19]. This distinction matters because the incidence of renovation costs, whether borne by landlords or passed to tenants, varies substantially depending on the underlying tenure regime.

(4) EPC system limitations (structural impossibility of using F–G shares)—GHG intensity of electricity (proxy for renovation depth)

Direct information on the share of dwellings in EPC classes F–G are not available in a harmonized format across Europe. Differences in national EPBD methodologies prevent meaningful cross-country comparisons [20]. For this reason, consistent with the methodological discussion in Appendix 2, the analysis does not use EPC classes directly. Thus, the GHG of electricity generation is used as a structural proxy for renovation depth. This indicator is strongly correlated with the prevalence of low-efficiency buildings in national housing stocks and captures fundamental decarbonization constraints [21]. Moreover, GHG intensity of electricity may reflect changes in time in the National energy strategies such as Poland's planned shift from coal to nuclear energy.

(5) Affordability constraints

Affordability is captured through the ratio of median equalized disposable income to national price levels (PPP-adjusted), using Eurostat ILD and price-level datasets [22,23]. Countries where real income is low relative to price levels face structurally higher renovation burdens and more limited capacity to invest.

(6) Energy poverty

Energy poverty is represented through established EU-SILC indicators such as the inability to keep the home adequately warm and arrears on utility bills [24]. These variables capture exposure to multiple forms of vulnerability and are directly relevant to EPBD compliance, since households with limited energy access are also those less able to finance renovation costs.

(7) Public spending on housing support

This dimension is derived from Eurostat COFOG data [25]. For Italy, where the COFOG classification does not provide complete disaggregation, OECD PH3.1 is used as a methodological bridge, ensuring comparability without inflating exposure [26]. Higher levels of spending in this category indicate the presence of welfare mechanisms capable of cushioning renovation pressures.

All seven dimensions are normalized using min–max rescaling (0–1), ensuring cross-country comparability. Weights reflect the causal relevance of each dimension. Tenure structure receives the strongest weight due to its impact on the transmission of renovation costs to households. The resulting CBSVI supports transparent, replicable country comparison.

A Country classification can be made according to the CBSVI but at the same time maintaining specific configurations shaped by each Country structural characteristics. These asymmetries align with comparative findings in research on European housing regimes and in analyses such as the Capable_IO1 Handbook [27]. Figure 3 illustrates the EU-27 map shaded according to each country's CBSVI value. Darker tones correspond to higher structural vulnerability, capturing the combined effect of building age, tenure regimes, affordability constraints and energy-mix characteristics. This visualization provides an immediate overview of the geographical distribution of renovation burdens under the revised EPBD. These structural cleavages imply that a uniform application of the EPBD may generate unequal burdens unless national renovation plans incorporate strong redistributive and targeted support mechanisms.

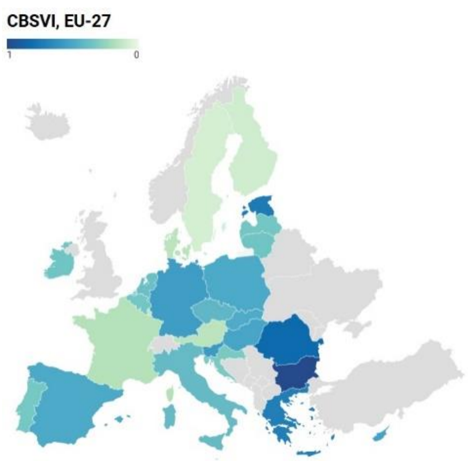

Figure 3. Geographical distribution of CBSVI scores across the EU-27. Source: Authors' elaboration based on EC Building Stock Observatory, Eurostat (EU-SILC, COFOG), OECD SOCX and EEA GHG intensity data.

4.1. Classification of clusters and analysis

Member States can then be grouped into four structural clusters. Table 3 below reports the updated classification, reflecting the final composite index values for each country.

Table 3. Cluster classification based on the CBSVI.

Cluster 1—Very Low Vulnerability (CBSVI ≤ 0.20)	
Country	**CBSVI**
Finland	0.11
Sweden	0.12
Luxembourg	0.10
Denmark	0.18
Cluster 2—Low-to-Mid Vulnerability (0.21–0.45)	
Country	**CBSVI**
Austria	0.21
France	0.22
Germany	0.28
Netherlands	0.29
Ireland	0.32
Croatia	0.34
Czechia	0.36
Belgium	0.38
Poland	0.42
Latvia	0.43
Lithuania	0.44
Portugal	0.45
Cluster 3—High Vulnerability (0.46–0.70)	
Country	**CBSVI**
Italy	0.46
Slovakia	0.46
Malta	0.47
Spain	0.48
Hungary	0.49
Cyprus	0.52
Slovenia	0.56
Cluster 4—Very High Vulnerability (CBSVI ≥ 0.71)	
Country	**CBSVI**
Estonia	0.71
Greece	0.78
Romania	0.84
Bulgaria	0.96

Source: Authors' elaboration based on Building Stock Observatory (EC), Eurostat (EU-SILC, COFOG), OECD SOCX, EEA (GHG intensity) and national housing statistics.

Each cluster presents distinct sociological implications, reflecting the intersection between housing systems and energy transition demands. The following points summarize their main characteristics. Methodology, sources, indicators and weighting scheme are detailed in Table A2 in Appendix 2.

The four-clusters classification is based on distribution-based thresholds rather than fixed quartiles. Natural breaks in the CBSVI values were used to avoid arbitrary splits and to group together countries with genuinely similar structural vulnerabilities. For this reason, the "High Vulnerability" group begins at 0.46 instead of 0.50: the CBSVI distribution shows a clear gap between 0.45 and 0.46, and using rigid midpoints would have separated Member States with almost identical characteristics.

The four clusters reveal distinct combinations of structural constraints that shape the distributive effects of the EPBD. While the CBSVI is a composite indicator, its sociological interpretation reflects longstanding cleavages in European housing systems, welfare capacity and energy governance.

(1) Cluster 1—Very low vulnerability

Countries in this group combine relatively modern building stocks with strong regulatory capacity and robust welfare systems. Sweden and Finland have consistently prioritized energy efficiency, while Denmark pairs long-term renovation strategies with ambitious climate targets. Although electricity prices remain high in Denmark, strong redistributive tools mitigate distributive tensions. High institutional trust and consolidated renovation governance support broad acceptance of EPBD requirements. Luxembourg benefits from high household income and sustained public investment. However, even though Luxembourg is among the EU Member States with the lowest rates of energy poverty, around 5 000 households in the country are unable to heat their homes appropriately or need to rely on State benefits to pay their fuel bills. The main cause of an inability to pay fuel bills is the fact that rents have been rising at a significantly faster rate than purchasing power in recent years, particularly in the lower income brackets.

(2) Cluster 2—Low-to-mid vulnerability

This group includes countries such as France, Germany, the Netherlands, Ireland, Austria, Belgium, as well as Czechia, Croatia, Poland, Latvia, Lithuania and Portugal. In these contexts, outdated housing stock and strong homeownership cultures place renovation responsibilities primarily on private households, while rental sectors remain comparatively small or segmented. Public support schemes are more developed than in high-vulnerability clusters, but may still leave middle- and low-income owners exposed to significant upfront costs. Although most countries in Cluster 2 are characterized by a strong ownership culture, Germany represents an exception within the group. Its comparatively low homeownership rate and highly structured rental sector do not align with the tenure dynamics typically observed in this cluster. Germany's inclusion is instead driven by other structural dimensions of the CBSVI, such as the age and characteristics of the building stock, affordability constraints, and the decarbonization challenges of its energy mix, which place it closer to this group in terms of overall vulnerability. This highlights that cluster membership reflects multidimensional structural conditions rather than a single housing regime indicator. In Poland, vulnerability is compounded by the widespread use of household coal boilers, though planned nuclear expansion may gradually alter this trajectory. In Portugal, government support often covers large fractions of the cost: many programs reimburse 50%–70% of eligible renovation costs but bureaucracy and poor information hinder the process. Renovation demand competes with new construction: rising demand for housing, new builds, and cost inflation in construction can overshadow renovation of existing stock—especially for private owners.

(3) Cluster 3—High vulnerability

Countries in this group combine deteriorated building stocks with limited fiscal space and energy systems still partly reliant on fossil fuels. Fragmented condominium governance and lower institutional trust hinder renovation uptake, exacerbating urban–rural divides and exposing low-income households to rising energy costs. In Italy, a significant share of the building stock is old and energy-inefficient. According to a recent survey, about 51.8% of residences for continuous occupancy fall into the lowest energy-efficiency categories (classes F and G), while incentive schemes such as the Superbonus have produced a Matthew effect, with higher-income households benefiting disproportionately [20,28]. Similar constraints affect Spain, where ageing multifamily buildings and complex ownership structures slow renovation cycles. These factors create substantial barriers to EPBD compliance unless accompanied by sustained financial support and targeted redistribution.

(4) Cluster 4—Very high vulnerability

This cluster includes countries where structural weaknesses are more pronounced: Bulgaria, Romania and Estonia. High levels of energy poverty, weak affordability and fragile housing stocks create substantial barriers to renovation. The intersection of poor infrastructure, limited investment capacity and rising energy prices results in significant EPBD implementation burdens. Without targeted financial support, renovation obligations risk exacerbating socio-spatial inequalities and energy hardship.

In conclusion, the clusters show that the EPBD's distributive impact is not determined by income or climate alone, but by the interaction between housing structures, welfare capacity and national energy systems. Recognizing these socio-political cleavages is essential to ensure that decarbonization policies reinforce cohesion rather than deepen existing inequalities.

5. The case of Italy

Another important issue concerns the type of housing involved in renovation. Are we upgrading single-family homes or apartment blocks? As the European Commission notes, "the type of housing affects the energy performance of space heating, as different insulation characteristics imply different specific energy consumption due to the varying surface area in contact with the outside. For example, a semi-detached house theoretically consumes less per square meter than a detached house." In other words, the shape and structure of a building matter. Multi-family blocks also disperse less heat in winter, and gain less in summer, because of the way heat circulates through shared walls.

Upgrading a detached house is usually simpler than renovating an entire block of flats. The difference is not only in the cost. In a single home, the decision rests with one owner or, at most, two households. In a block, the entire building must agree, which involves meetings, votes and often disagreements that can block projects before they even start; an example to follow can be Portugal, where reduction in the quorums for majority decisions in co-owned multi-family dwellings is favored, (if of course accompanied by an adequate information). In Italy, this divide is visible in the diffusion of photovoltaic systems. In apartment buildings, panels are typically present only when installed during construction, and retrofitting them later is rare. In single-family homes, retrofitting is common. A recent case study in the Veneto region, Meneghin [14], confirms this: most dwellings equipped with panels were older single or semi-detached houses, and the panels had been added after construction.

In Italy, the main driver for renovations is the system of fiscal incentives (see Table 2). These incentives have also supported the expansion of domestic photovoltaic installations [28]. To use a tax deduction, a household needs sufficient taxable income. The higher the income, the larger the potential deduction. This is a classic case of the Matthew effect: wealthier households find it easier to comply with EPBD requirements, especially when compared to those living in apartment blocks or low-income owners of detached homes.

Energy poverty is often a long-term condition rather than a temporary one. Countries with lower levels of public expenditure on housing tend to show higher rates of persistent energy deprivation [15]. Technical targets are therefore not enough unless accompanied by serious social support measures. Without these, the EPBD may reinforce existing inequalities.

For this reason, climate policy requires forms of justice in both distribution and decision-making. Carrosio and De Vidovich [18] argue that a fair ecological transition must combine environmental goals with inclusive governance and redistribution, especially where inequalities are already deep. Data confirm this: Bulgaria, Greece and Romania, which have weaker welfare systems, also display the highest rates of persistent energy poverty [19]. Energy transition policies will increase social divides unless the concept of energy justice is acknowledged and put into practice [6]. Energy poverty is never just a technical problem; it is a social injustice rooted in housing vulnerability and broader inequality [3]. In Italy, three out of four families live in apartment blocks. In 2021, 70.8 percent of households were owners and 20.4 percent rented. Among the poorest fifth, nearly one in three lived in rented accommodation [16]. This is the social context within which any renovation strategy must operate.

5.1. Analysis of potential costs and benefits for compliance

The cost of upgrading buildings to comply with the EPBD varies widely by building type, floor area, initial energy class and the specific interventions required. Renovation costs also depend on the age of the building, the state of the envelope and the climatic zone in which the property is located [29].

Scenario analyses carried out by sectoral observatories and research centres estimate that upgrading Italy's entire residential building stock to EPBD standards may require between €1.1 and €1.75 trillion over a ten-year period [22,23,30]. These projections are subject to uncertainty—they rely on different modelling assumptions and timelines—but they all suggest that the average financial effort per household would be substantial.

Of course, the financial effort should also be viewed in light of the potential energy savings that deep renovation can deliver. Studies on poorly performing residential buildings generally report reductions in heating demand in the order of 30%–55%, with higher values in single-family houses that lack insulation or use outdated heating systems [5,26,28]. Evidence from recent Italian renovation programs points in the same direction, with substantial efficiency gains for dwellings that undergo comprehensive upgrades rather than isolated measures [28]. These reductions do not fully compensate for the upfront investment, yet they can substantially lower annual expenditure for households that already face high energy burdens.

5.1.1. Complete renovation packages

Simulations for old residential units, where baseline energy performance is usually poor, are reported in Table 4 [22]. Costs range from essential interventions (such as heating system replacement and insulation) to full renovation packages, which may include heating, insulation, window replacement and roof works.

Table 4. Estimated renovation costs by property type.

Building type	Representative floor area	Total cost (€)	Cost per m^2 (€)	Construction period
Condominium apartment	105 m^2	40,000–55,000	380–523	1960–1979
Single-family house	120 m^2	56,800–76,800	473–640	1961–1975

Source: Own elaboration based on Cresme–Symbola (2024) [22]. Net of VAT. Estimates refer to typical 1960s–1970s residential units with poor baseline energy performance. Values net of VAT.

These figures represent lower and upper bounds. The lower bound reflects essential interventions such as external insulation and heating-system replacement, while the upper bound corresponds to comprehensive renovation packages that include insulation, window substitution, heating upgrades and, where required, roof works.

5.2. Estimated market prices for partial measures

Table 5 provides the total cost of full renovation packages. To complete the information, other sectoral sources, including ENEA [28], provide indicative market prices for specific retrofit measures. These estimates, drawn from supplier price lists and technical reports, are not directly comparable to the full package totals because they refer to single interventions rather than integrated renovation projects.

Table 5. Indicative market prices for selected single retrofit measures (Italy).

Type of intervention	Price in €/m^2	Notes
Thermal insulation (external wall cladding)	180–400	
High-efficiency boiler replacement	up to 16,000	
Windows	10,000–15,000	depending on number and type
Photovoltaic system (3 kW)	7500–10,500	

Source: Authors' elaboration based on ENEA [28] and national market price lists for residential retrofit measures.

Actual costs may vary depending on location, building condition, and procurement method.

To illustrate the potential financial and environmental benefits of energy-efficiency upgrades, Table 6 summarizes indicative reductions in heating demand, annual bill savings, and estimated CO_2 emission reductions for typical 1960s–1970s residential units.

Table 6. Estimated heating-demand reductions, annual bill savings, and CO_2 emission reductions for typical 1960s–1970s dwellings.

Building type	Baseline heating demand (kWh/year)	Expected reduction (%)	Energy saved (kWh/year)	Annual bill savings (€)*	CO_2 saved (tCO_2/year)**	Notes
Apartment (condominium)	12,000	30%–50%	3,600–6,000	€320–€530	0.73–1.21	Typical 1960s–1970s units, poor insulation
Single-family house	18,000–20,000	35%–55%	6,300–11,000	€560–€970	1.27–2.22	Higher savings due to larger envelope losses

*Assumptions: average retail gas price 0.089 €/kWh for domestic customers in the free market, including network charges and taxes (ARERA, MR 343 2024; GP 353 2023 [31,32]). Estimates refer to typical 1960s–1970s residential units with poor baseline efficiency and gas-fired heating systems. ** CO_2 reductions are calculated using standard emission factors for natural gas combustion (ISPRA, National Inventory Report). Source: CRESME & Symbola (2024), La riqualificazione energetica del patrimonio abitativo italiano. Data refer to baseline heating demand of pre-1975 units with poor envelope performance. Monetary savings are computed using ARERA's average retail gas price for domestic customers. CO_2 reductions are calculated using standard emission factors for natural gas combustion (ISPRA, National Inventory Report).

In Italy, with a total of 23 million households, the national median household net income in 2023 was €30,239 [33]. Households at risk of poverty, *i.e.* those whose net income is below 60% of the national median net income, are 5.5 million and their net income is below €18,143. In this range we also find households in absolute poverty, that is households unable to afford the minimum necessary goods and services required for basic living. They are over 2.2 million or 8.4% of the households.

An example follows showing that the incentive measures can be effective only for households with an income well over the median. See Table 7 below where the fiscal gains, accompanied by a loan and the savings in the energy bills are considered. The simulation applies to a condo apartment and a single-family house, as in Table 4. Fiscal incentives: 65% of total cost+10%VAT, split in 10 years; 10 years loan 3% for the whole amount. Energy savings from Table 5.

Table 7. Financing of partial and full retrofitting packages.

	Total cost+VAT 10%	Fiscal gain/year	Saving in the energy bill	Soft loan term/year*	Balance/year
Apartment (condominium)	44,000-60,500	2860	320	−5158	−1978
		3932,5	530	−7092	−2839
Single-family house	62,480−84,480	4061,2	560	−7234	−2613
		5491,2	970	−9903	−3442

*The choice of 3% is based on current market rates; loan maturity can be higher. Source: Authors' elaboration based on CRESME & Symbola [22], ENEA [28], and ISTAT income data (2023–2024) [34]. Fiscal incentives refer to standard Italian tax deduction schemes; energy savings are derived from Tables 5 and 6.

Knowing that a fair yearly repayment burden for a loan, relative to the borrower's annual income, is around 20% ("cessione del quinto"), for a median household this amounts to €6,047. From Table 7 (column 5), this appears acceptable for households living in condominium apartments but quite difficult for those in single-family houses.

Sixty-five percent of the cost of retrofitting or restoration is offset through fiscal incentives, and soft loans are available. However, fiscal incentives are effective only for households that do file an income tax return and that are eligible for bank loans. Official estimates of households that do not file any income tax return are not available; a rough approximation—based on the share of individuals who do not file and the average number of household members—yields a realistic estimate of 2.6–3.1 million households, which are most likely those within the range of absolute poverty. In conclusion, while median-income families can partially afford renovation costs—though with difficulty—2.6–3.1 million families cannot. For these households, 100% grants should be considered. Without a serious policy to support this segment of the population, the social divide risks widening further. In 2024, the share of people in Italy at risk of poverty or social exclusion amounted to 23.1% of the population. These households face persistent constraints in accessing credit and in co-financing renovation investments, which significantly limit their capacity to comply with EPBD requirements in the absence of strong public support.

Against this background, the economic benefits of renovation remain highly context-dependent. Climate zone, energy carriers, dwelling size and baseline efficiency jointly shape the extent to which energy-efficiency measures translate into lower energy bills [5]. In colder regions, or in households relying on more expensive fuels or electricity, expected savings tend to be proportionally larger.

Consumer organizations, including Codacons [30], have also raised concerns about dwellings that are structurally unable to meet EPBD targets, warning that these cases may face even higher costs or more complex interventions.

Ultimately, the EPBD requires Member States to develop national plans that combine regulatory tools with financial support mechanisms, while taking into account local building characteristics and the heterogeneous nature of national housing stocks.

6. Conclusions

The EPBD marks a significant milestone in Europe's path toward ecological transition, yet its translation into practice risks deepening social and territorial divides. By leaving enforcement entirely in the hands of national governments, the EU has opened the door to uneven and potentially fragmented implementation. In countries where climate policy already struggles to gain traction, this discretion can result in minimal protection for households most exposed to energy and housing poverty.

While the exemptions for historic buildings and very small dwellings offer some relief, they barely address the structural barriers faced by lower- and middle-income families. Without targeted financial support and accessible renovation schemes, compliance will remain out of reach for many, further entrenching inequalities. In the case of Italy, the Italian government's choice to reject any form of subsidy illustrates this risk in concrete terms: in a context already marked by fragile welfare systems, such a stance risks widening the divide between households able to upgrade and those effectively excluded from the transition.

As highlighted throughout this analysis, the intersection between energy efficiency goals and social vulnerability cannot be an afterthought. Delivering on the directive's promise requires binding national targets matched with strong incentives, transparent governance, and cross-level coordination between EU institutions and Member States. Only by embedding equity into the core of climate policy—and ensuring that the transition is both socially desirable and economically accessible—can the EPBD move from a formal commitment to a driver of genuinely inclusive and sustainable change.

Data availability statement

The analysis presented in this article is entirely based on publicly available institutional datasets. All data used in the Composite Building and Social Vulnerability Index (CBSVI), as well as in the comparative country analysis, were derived from official sources, including:

- EU Building Stock Observatory (European Commission / DG Energy);
- Eurostat–EU-SILC and household income indicators;
- European Environment Agency–GHG intensity and energy indicators;
- Joint Research Centre EPC database, where available;
- ISTAT (Italy) and national statistical offices.

All datasets are aggregated at national level and do not include individual-level or sensitive microdata. No proprietary or restricted datasets were used in this study. Full details on indicators, transformations and weighting procedures are reported in Table A2 in Appendix 2.

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Authors’ contribution

Conceptualization, G.M. and S.S.; methodology, G.M. and S.S.; validation, S.S.; formal analysis, G.M.; investigation, G.M.; resources, S.S.; data curation, G.M.; writing—original draft preparation, G.M.; writing—review and editing, S.S.; visualization, G.M.; supervision, S.S.; project administration, S.S.; funding acquisition, S.S. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

Appendix 1

Table A1 outlines the main measures, their respective targets, and legal sources, arranged by enforcement timeline.

To implement these goals, each Member State must prepare a national plan that brings together regulatory measures, financial incentives and administrative tools. A key requirement of the Directive is the creation of a national database on building performance. This database will be used to monitor current energy consumption and to assess progress toward the national and EU-wide targets, following standards such as EN ISO 52000-1. As noted by Barbosa [4], the capacity of Member States to meet these obligations depends not only on the technical aspects of the EPBD but also on the strength of their administrative systems and the consistency of their renovation policies.

This approach gives Member States some flexibility: each country must reduce the average primary energy consumption of its residential building stock, but it can design its own national trajectory by taking into account the characteristics of its housing sector, ownership structures and institutional capacity. For non-residential buildings, however, the Directive introduces Minimum Energy Performance Standards (MEPS), which apply uniformly across the EU.

Directive (EU) 2024/1275 also brings a substantial overhaul of the Energy Performance Certificate (EPC) system. The intention is to make national certificates more comparable and easier to interpret, which today is difficult because each country uses different criteria. Under the new rules, EPCs must rely on a shared set of indicators and include a minimum set of information, such as a clearer energy classification and data on both operational consumption and the emissions embedded in construction materials. For many Member States, especially where EPCs have been treated mainly as a formality, this change represents an important shift that should make comparisons across countries more credible and renovation decisions less arbitrary.

Table A1. Roadmap of key deadlines and obligations introduced by EPBD for the decarbonization of the building sector.

Deadline	Measure	Target	Source/Legal Basis
2026	National Renovation Plan	Member States	Directive (EU) 2024/1275
2026	Renovation Passport	Member States	Directive (EU) 2024/1275
2028	EPC (Energy Performance Certificate) obligation for buildings offered for sale or rent	All buildings (residential)	Directive (EU) 2024/1275
2028	Zero-emission building (ZEB) requirement for new public buildings	New public buildings	Directive (EU) 2024/1275
2028	GWP (Global Warming Potential) disclosure in EPCs for buildings >1000 m²	Buildings >1000 m²	Directive (EU) 2024/1275
2029	Mandatory solar panels on new public and non-residential buildings	New public and non-residential buildings	Directive (EU) 2024/1275
2030	ZEB requirement for all new residential buildings	New residential buildings	Directive (EU) 2024/1275
2030	Mandatory solar panels on all new residential buildings	New residential buildings	Directive (EU) 2024/1275
2030	GWP disclosure in EPCs for all new buildings	All new buildings	Directive (EU) 2024/1275
2030	16% reduction in primary energy use in residential buildings	Residential buildings	Fit for 55 Package
2033	Energy upgrade of 16% of worst-performing non-residential buildings	Non-residential buildings (class F and G)	Directive (EU) 2024/1275
2033	Energy upgrade of residential buildings from class G to class E	Residential buildings (class G)	Directive (EU) 2024/1275
2040	Intermediate milestone for a zero-emission building stock	Entire building stock	Directive (EU) 2024/1275
2040	Phase-out of standalone fossil fuel boilers	All new heating appliances	Regulation on Ecodesign for Sustainable Products (ESPR), EU agreement 2023
2050	Complete decarbonisation of building stock	Entire building stock	Directive (EU) 2024/1275

Source: Own elaboration based on Directive (EU) 2024/1275, the Fit for 55 Package, and the Regulation on Ecodesign for Sustainable Products (ESPR, 2023).

One of the most relevant innovations concerns the obligation to disclose the GWP of new buildings. Instead of considering only the energy used during the life of the building, the Directive requires an estimate of the emissions generated throughout the construction process, from the extraction and production of materials to their transport and installation (the so-called A1 to A5 stages). In practice, this moves the EPBD toward a more complete life-cycle approach and encourages the use of materials with a lower climate footprint. As operational emissions decrease in the coming decades, these hidden emissions will become proportionally more important, so making them visible is essential.

The Directive also introduces the Renovation Passport, a building-specific roadmap that outlines the steps needed to bring a dwelling in line with long-term EU objectives. When the revised EPC, the requirements on life-cycle and GWP reporting, and the renovation planning tool are considered together, they offer households and public authorities a more coherent and predictable framework than the fragmented national systems currently in place. The broader intention is clear: to make the climate impact of construction easier to see. Materials such as cement, steel and glass, along with transport and on-site works, often generate more emissions during construction than the building will consume in years of operation. By bringing these values into the open, the EPBD makes them measurable and comparable.

Appendix 2

A2.1. Regulatory foundations

The methodological choices adopted in this article are anchored in the current EU regulatory architecture on building performance and data reporting. Articles 19 and 20 of Directive (EU) 2024/1275 introduce a revised framework for Energy Performance Certificates (EPCs), including updated requirements for comparability, quality control and digitalisation. Article 22 establishes the obligation for each Member State to develop a national, machine-readable database for the energy performance of buildings, where EPCs and related information must be recorded, aggregated and transmitted annually to the EU Building Stock Observatory. According to the Guidance Documents released on 30 June 2025 by the European Commission, common templates for these datasets will be mandatory from 2027 [23,33]. This regulatory evolution has direct methodological implications. At present, there is no harmonised EU-wide dataset for the distribution of EPCs by energy class (A–G). Existing EPC registries are based on heterogeneous national methodologies, which hinder meaningful cross-country comparison. According to the Guidance Documents released by the European Commission on 30 June 2025, common data templates and machine-readable EPC aggregates will only become mandatory from 2027 onwards.

A2.2. CBSVI

CBSVI is constructed as a multidimensional indicator capturing structural constraints that determine the distributive impact of the EPBD across Member States. Seven dimensions are included, each reflecting a distinct mechanism of vulnerability:

Building Age: Older dwellings are structurally harder to renovate due to insulation challenges, outdated materials, hidden defects and architectural constraints. The two-period split (pre-1945 and 1946–1970) reflects major historical waves of construction across Europe.

Tenure Structure: High prevalence of homeownership with limited private rental availability reduces mobility, constrains renovation feasibility and increases exposure to energy poverty for specific groups. Tenure regimes create long-term distributional effects because adaptation costs fall differently on owners, tenants and landlords.

EPC System Limitations (GHG Intensity of Electricity used as a proxy): Given the lack of harmonized EPC data, EPCs cannot be used quantitatively. Their relevance is retained indirectly, through variables that influence EPC outcomes (building age, heating systems, envelopes, energy mix). The GHG Intensity of Electricity is used as a proxy. This is a crucial structural parameter for the decarbonization of heating systems and for the cost of electrification under the EPBD.

Affordability Constraints (Housing Costs over Income): Countries with structurally low income-to-cost ratios face higher renovation burdens and lower capacity to invest.

Energy Poverty Indicators: Inability to keep the home adequately warm, arrears on utility bills, and related variables provide a direct measure of vulnerability.

Public Spending on Housing Support: Housing-related cash benefits (% of GDP) reflect a state's capacity to cushion renovation costs for low-income households.

Indicator definitions and transformation procedures follow established practices for composite indicators, as outlined in the OECD/JRC Handbook on Constructing Composite Indicators [27].

Table A2. The seven dimensions of CBSVI.

Dimension	Sources	Reference year	Weights
Building Age (pre-1945)	[35]	2023–2024	0.09
Building Age (1946–1970)	[35]	2023–2024	0.09
Tenure structure	[35]	2022	0.20
EPC System Limitations (GHG Intensity of Electricity)	[36]	2022	0.17
Affordability Constraints (Housing Costs over Income)	[37,38]	2022–2023	0.17
Energy Poverty Indicators (SILC)	[24,31,32,37]	2022–2023	0.17
Public Spending on Housing Support	[39]	2021–2022	0.11

A2.3. Weighting scheme and composite score

Given the formative nature of vulnerability (*i.e.*, dimensions that contribute causally rather than reflectively), weights are assigned based on theoretical relevance and consistency with EU literature. Tenure structure receives the highest weight due to its impact on the transmission of renovation costs to households.

The CBSVI composite score is computed as the weighted sum of normalized indicators.

A2.4. Cluster methodology

Four clusters are obtained using natural breaks, which align with known European housing regimes (Nordic, Continental rental-based, Southern ownership-based, Eastern mixed systems). These clusters capture structural diversity rather than impose arbitrary thresholds and provide geographical and sociological interpretability.

A2.5. Robustness and limitations

The methodology is replicable using publicly available datasets. Limitations include lack of harmonized EPC dataset; varying sample sizes in SILC; differences across tenure definitions, temporal misalignment between some datasets (2022–2024).

These limitations are mitigated through triangulation across sources and transparency in operationalization.

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