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*Data Descriptor*

# Thermal Transmittance Limits Dataset for New and Existing Buildings Across EU Regulations

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**Abstract:** Building energy regulations are essential for reducing energy consumption in the European Union (EU) and achieving climate neutrality goals. This data article supplements the "Overview of EU Building Envelope Energy Requirement for Climate Neutrality" by presenting a detailed dataset on building regulations across all 27 EU member states, with a focus on building envelope efficiency. The data include thermal transmittance limits for windows, walls, floors, and roofs, offering insights into regulatory differences and potential opportunities for harmonization. Information was sourced from the Energy Performance of Buildings Directive (EPBD) database, national reports, and scientific literature to ensure comprehensive coverage. Key aspects of each country's regulations are summarized in tables, covering both new constructions and renovations. The inclusion of Köppen–Geiger climate classifications allows for climate-specific analyses, providing valuable context for researchers, policymakers, and construction professionals. This dataset enables comparative studies, helping to identify best practices and inform policy interventions aimed at enhancing energy efficiency across Europe. It also supports the development of tailored strategies to improve building performance in different environmental conditions, ultimately contributing to the EU's energy and climate targets.

**Dataset:** Data directly related to this article are provided in the Supplementary Materials.

**Dataset License:** CC-BY 4.0

**Keywords:** building envelope; EPBD; policy; energy efficiency



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## 1. Introduction

The issue of energy consumption in buildings represents a pivotal concern for those seeking to devise effective energy strategies and facilitate the transition towards sustainable energy systems [1]. It is evident that buildings account for a considerable proportion of energy usage, namely approximately 40% within the European Union (EU), as well as 36% of greenhouse gas (GHG) emissions. Consequently, it can be argued that this sector holds immense potential in facilitating the EU's journey towards climate neutrality by 2050 [2]. This is particularly true in view of the significant potential for energy savings and emission reductions. In their pursuit of carbon neutrality, national governments rely on the engagement of public authorities at all levels, in addition to the involvement of non-governmental and societal stakeholders [3]. Without sufficient support and commitment from these parties, particularly at the sub-national level, the efficacy of overarching policies may be undermined. Moreover, poor coordination among different governmental entities can hinder the ability of local actors to effectively address emerging challenges [4].

However, it is notable that cities across the globe have identified their significant position in the fight against global climate change, with a commitment to reducing emissions and pursuing carbon neutrality [5,6]. The 2019 UN Climate Action Summit resulted in a commitment by 100 cities to take action against climate-related challenges. In light of these circumstances, a series of policy initiatives pertaining to energy and climate have been introduced in a bid to gradually improve the energy efficiency of buildings across the EU. The European Union has undertaken significant efforts to address climate change, with a particular focus on energy efficiency. These efforts are exemplified by the Green Deal [7,8], which aims to reduce EU GHG emissions by 55% by 2030 and achieve full carbon neutrality by 2050. In alignment with the objectives of the Green Deal, several EU policies related to energy efficiency have been implemented.

One such policy is the Energy Efficiency Directive [9], which aims to enhance energy efficiency across the entire energy chain, from production to end use. Another significant legislative framework is the Energy Performance of Buildings Directive (EPBD) [10–12], which prioritizes the reduction in energy consumption in buildings, the optimization of efficiency and the advancement of renewable energy sources. The Renewable Energy Directive [13] serves to facilitate the expansion of renewable energy across a range of sectors, while the Ecodesign Directive [14] establishes standards for product performance, thereby streamlining the compliance process for manufacturers. It is therefore evident that the EPBD is of critical importance for achieving decarbonization goals, with the objective of attaining a climate-neutral Europe by 2050. At the core of the aforementioned strategies is the utilization of Energy Performance Certificates (EPCs) to evaluate the energy efficiency of housing [15,16]. These legislative instruments provide Member States with a framework within which to develop EPC calculation methodologies that reflect the specific energy profiles of different geographical regions, taking account of the diverse climatic conditions prevailing across Europe [17].

The development of EPCs varies across Europe. In northern and central regions, there is a focus on heating, whereas in southern nations, more complex systems are often employed that address both cooling and heating needs. The implementation of EPC schemes presents a number of challenges and requires a variety of approaches in different Member States. In order to facilitate the enforcement of EPBD provisions, the Concerted Action on Energy Performance of Building (CA EPBD) initiative [18] brings together representatives from various Member States to develop a unified framework for implementing EPBD policies. This framework encourages the sharing of information and compliance with specific regulations. The initiative prioritizes the promotion of exemplary practices, the harmonization of national protocols, and collaboration with other energy-related initiatives under the Intelligent Energy for Europe (IEE) program. The overarching objective of the Concerted Action EPBD (CA EPBD) is to standardize approaches, enhance policy enforcement, and facilitate the sharing of best practices among Member States with the aim of improving building energy efficiency [19].

The initial motivation for compiling this dataset arose from the need to provide a comprehensive overview of the thermal transmittance limits imposed on building envelopes across the EU. The robust data aggregation process used, which adopted diverse sources such as EPBD, building codes and scientific articles, was methodologically designed to increase the depth and reliability of the analysis.

The study also integrated the European climate macro-classification system—covering Nordic, Continental, Oceanic and Mediterranean climates—with the international Köppen–Geiger classification and, where applicable, internal national classifications. This integration provided a comprehensive perspective on European climate variability, reflecting local environmental patterns. The Köppen–Geiger classification, widely accepted in climate science for its detailed categorization of terrestrial climates based on precise thresholds and seasonal variations in temperature and precipitation, was essential for this analysis. This methodological approach allowed a differentiated comparison of thermal transmittance limits under different climatic conditions enriching previous studies by considering multiple climatic classification systems.

## 2. Materials and Methods

To acquire the data presented in the Supplementary Data File, a systematic and comprehensive approach was employed, incorporating various sources and methodological steps to ensure the accuracy and reliability of the dataset. The methodology followed is briefly illustrated in Figure 1. The following describes the experimental design and methods used:

- Data collection process:
  - The analysis began with an examination of the requirements set forth by the EPBD [12,20]. This directive serves as the foundational regulatory framework for energy performance standards across the EU.
  - Where EPBD information was not available, data were collected from national regulations, available online [21–26].
  - In cases where neither national data nor EPBD were available, the study relied on scientific literature to fill the gaps [27–29].


**Figure 1.** Methodological framework diagram.

These sources provided information regarding thermal transmittance limits of roofs, walls, floors, and windows for the EU member states. This comprehensive approach ensures that the parameters used are consistent with current standards and practices.

- Integration of climate classifications:
  - The European climatic zones (Nordic, Continental, Oceanic, and Mediterranean) were used to define the climate zones for each country. Additionally, the Köppen–Geiger climate classification system was overlaid to provide a more detailed climatic context.

- Compilation and verification:
  - All gathered data were compiled into twenty-seven Excel sheets, each dedicated to a specific EU nation. The compiled data were verified by cross-referencing multiple sources, including national databases, official government websites, and relevant scientific literature. Several rounds of internal review were conducted to ensure consistency, accuracy, and alignment with national regulations and climate classifications.
- Tools and software used:
  - Microsoft Excel, version 2409: used for compiling, organizing, and analyzing the data. Excel's functionalities facilitated the creation of structured datasets and allowed for easy manipulation and comparison of data across different countries.
  - The EPBD database was used to gather data.
  - Official national websites provided access to regulatory documents and building codes.
  - Scientific literature was used as an integration.

## 3. Description of the Dataset

The Supplementary Data File provides a comprehensive dataset detailing thermal transmittance limits for both new and existing buildings across all EU member states. These limits are outlined in accordance with the specific regulations of each nation, covering essential building components such as walls, windows, floors and roofs. The dataset includes twenty-seven Excel sheets, each dedicated to a specific EU country, making it a valuable resource for understanding the diverse regulatory environments within the EU.

For each country, the dataset defines the corresponding Köppen–Geiger climate zones and the applicable European climatic zones. In cases where a country has its own internal classification system, this is also included to provide a more detailed overview. Representative cities for each Köppen–Geiger climate zone are identified, allowing for precise geographic specificity. The transmittance limits for walls, roofs, windows, and floors are specified for both new constructions and existing buildings. Where applicable, additional classifications are provided to further refine the data.

Furthermore, the dataset indicates the year of the reference documents used for the transmittance values, ensuring that the data are contextualized within its historical framework. Each entry also includes citations for the sources of these data, whether they are national regulations, EPBD requirements, or scientific literature. This meticulous documentation supports the reliability and traceability of the information, making it a robust tool for researchers, policymakers, and professionals in the field of building energy efficiency.

As an example of the data presented in the Supplementary File, the table for Slovenia is provided (Table 1). This table lists representative cities for the Köppen climate zones, the corresponding climate zones (Köppen, European and National), and the transmittance values for roof, wall, floor, and window for both new and existing buildings. Additionally, the link to the EPBD from which the values were sourced and the year to which the values are updated is included.

By comparing maximum and minimum transmittance limits for structural elements like ceilings, walls, floors, and windows across European Member States, significant variability in requirements emerges. This reflects differences in both climate and construction practices, making direct comparisons challenging. Addressing these disparities through greater harmonization could enhance clarity, efficiency, and sustainability in building standards, supporting EU energy and environmental goals.

For new buildings, Poland has the highest transmittance limits, while countries like Portugal, France, Spain, Italy and Greece show greater internal variability, reflecting climate-specific regulations. This variability is even more pronounced in existing buildings, particularly in countries like Italy and Portugal with climatic subdivisions. Such differences, especially for windows and roofs in Mediterranean nations, underscore the challenge of aligning regulations with evolving energy efficiency objectives.

The EPBD website was updated when the article was in the review process. Therefore, the dataset file was updated in order to incorporate the new information given.

**Table 1.** Summary table of transmittance values for Slovenia.

| **City** | **Koppen Climate Zone** | **EU Climate Zone** | **National Climate Zone** |
|---|---|---|---|
| Ljubljana | Cfb | Continental | - |
| Jesenice | Dfb (bordering on Cfb) | Continental | - |
| Kranjska Gora | Dfc | Continental | - |
| Ukanc | ET (bordering Dfc) | Continental | - |
| **Energy performance** | **Limitations for new and existing buildings** | | |
| | **New building** | | **Existing Building** |
| | **Status 2020 (as in current PURES 2010)** | **Proposed new U-values max. (NZEB)** | **Minimum requirement for renovation (same as new building)** |
| U-value roof [W/m$^2$K] | 0.2 | 0.18 | 0.2 |
| U-value walls [W/m$^2$K] | 0.28 | 0.2 | 0.28 |
| U-value floor [W/m$^2$K] | 0.35 | 0.35 | - |
| U-value window [W/m$^2$K] | 1.3 | 1 | 1.3 |
| **Link** | https://confluence.external-share.com/content/18675/ca_epbd_v_database_2020_(public)/1861813055/2209349633 (accessed on 26 October 2024) | | |
| **Year (status)** | 2020 | | |

## 4. Limitations

The dataset presents several limitations that must be considered. Firstly, it primarily addresses thermal transmittance limits, which are just one component of building regulations, and does not offer a comprehensive view of overall building energy efficiency. Challenges in obtaining consistent and current data from national sources mean that not all EU member states provided readily accessible or recent regulatory documents, which could lead to gaps or inconsistencies in data quality. Where national regulations are not available, reliance on scientific literature may introduce variations due to differing methodologies or interpretations. Additionally, although the dataset includes the year of reference documents, changes in building regulations over time could mean that the data do not always reflect the most current standards. While the integration of the Köppen–Geiger climate classification provides a broad climatic context, it may not fully account for all local microclimates or regional variations, potentially leading to oversimplifications. Finally, the dataset might be biased towards countries with more comprehensive regulatory frameworks, possibly underrepresenting those with less detailed documentation.

## 5. Conclusions

This dataset provides a rich and comprehensive resource for understanding thermal transmittance limits across the European Union, incorporating data from all twenty-seven member states. It captures the diverse regulatory frameworks and climate conditions throughout the EU, making it a valuable tool for in-depth comparative analyses. Such analyses are instrumental in identifying best practices and guiding the alignment of standards across different regions.

The inclusion of the Köppen–Geiger climate classification adds significant value by enabling climate-specific assessments of energy efficiency requirements. This allows for a tailored approach to energy performance that takes into account local climatic conditions, ensuring that policies are both relevant and effective.

The dataset can be used by researchers to conduct comparative studies on the regulatory differences across countries and regions. For example, policymakers can analyze how countries with similar climate zones but differing regulations address thermal transmittance limits, which may highlight best practices for standardizing regulations. Architects and engineers can use the dataset to design buildings that meet both local energy efficiency standards and climate-specific requirements. Additionally, it supports decision-making in the renovation of existing buildings by providing reference data on regulatory requirements for thermal transmittance, helping professionals align with national standards.

Beyond its benefits for researchers, this dataset serves as a critical resource for policymakers, architects, engineers and construction professionals. It aids in the development and refinement of building regulations, supports adherence to current standards and contributes to the broader objectives of reducing energy consumption and greenhouse gas emissions within the EU's building sector.

By offering detailed insights into thermal transmittance limits and their interplay with various climatic and regulatory contexts, the dataset facilitates informed decision-making and strategic planning. It is a key asset in advancing sustainable building practices and supporting the EU's climate and energy goals.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/data9110127/s1.

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## References

1. D'Agostino, D.; Congedo, P.M.; Albanese, P.M.; Rubino, A.; Baglivo, C. Impact of climate change on the energy performance of building envelopes and implications on energy regulations across Europe. *Energy* **2024**, *288*, 129886. [CrossRef]
2. Maduta, C.; D'Agostino, D.; Tsemekidi-Tzeiranaki, S.; Castellazzi, L.; Melica, G.; Bertoldi, P. Towards climate neutrality within the European Union: Assessment of the Energy Performance of Buildings Directive implementation in Member States. *Energy Build.* **2023**, *301*, 113716. [CrossRef]
3. Salvia, M.; Reckien, D.; Pietrapertosa, F.; Eckersley, P.; Spyridaki, N.-A.; Krook-Riekkola, A.; Olazabal, M.; De Gregorio Hurtado, S.; Simoes, S.G.; Geneletti, D.; et al. Will climate mitigation ambitions lead to carbon neutrality? An analysis of the local-level plans of 327 cities in the EU. *Renew. Sustain. Energy Rev.* **2021**, *135*, 110253. [CrossRef]
4. Fuhr, H.; Hickmann, T.; Kern, K. The role of cities in multi-level climate governance: Local climate policies and the 1.5 °C target. *Curr. Opin. Environ. Sustain.* **2018**, *30*, 1–6. [CrossRef]

5. Pan, A.; Zhang, W.; Shi, X.; Dai, L. Climate policy and low-carbon innovation: Evidence from low-carbon city pilots in China. *Energy Econ.* **2022**, *112*, 106129. [CrossRef]
6. Kern, K. Cities as leaders in EU multilevel climate governance: Embedded upscaling of local experiments in Europe. *Environ. Politics* **2018**, *28*, 125–145. [CrossRef]
7. Act, S.M. *Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions*; European Commission: Ispra, Italy, 2011.
8. Kayaçetin, N.C.; Hozatlı, B. Whole life carbon assessment of representative building typologies for nearly zero energy building definitions. *J. Build. Eng.* **2024**, *95*, 110214. [CrossRef]
9. European Commission. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, Amending Directives 2009/125/EC and 2010/30/EU and Repealing Directives 2004/8/EC and 2006/32/EC. 2023. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0027-20230504&qid=1687869958720 (accessed on 9 June 2024).
10. European Commission. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings (Recast). 2018. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02010L0031-20210101 (accessed on 9 June 2024).
11. European Commission. Directive 2018/844/EU of the European Parliament and of the Council of 30 May 2018 amending directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. *Off. J. Eur. Union*. 2018, pp. 75–91. Available online: http://data.europa.eu/eli/dir/2018/844/oj (accessed on 26 October 2024).
12. The Concerted Action EPBD. Available online: https://www.ca-epbd.eu/about (accessed on 26 October 2024).
13. European Commission. Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU). 2015/652. Available online: http://data.europa.eu/eli/dir/2023/2413/oj (accessed on 26 October 2024).
14. European Commission. Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast). 2009. Available online: http://data.europa.eu/eli/dir/2009/125/oj (accessed on 26 October 2024).
15. European Commission. Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings. *Bruss. Off. J. Eur. Commun.* **2002**, *4*, 65–71.
16. D'Agostino, D.; Tzeiranaki, S.T.; Zangheri, P.; Bertoldi, P. Data on nearly zero energy buildings (NZEBs) projects and best practices in Europe. *Data Brief* **2021**, *39*, 107641. [CrossRef] [PubMed]
17. Congedo, P.M.; Baglivo, C.; D'Agostino, D.; Albanese, P.M. Overview of EU building envelope energy requirement for climate neutrality. *Renew. Sustain. Energy Rev.* **2024**, *202*, 114712. [CrossRef]
18. Concerted Actions EPBD. Concerted Action EPBD—Enabling the Implementation of the Energy Performance of Buildings Directive. Available online: https://www.ca-epbd.eu/ (accessed on 9 June 2024).
19. Intelligent Energy Europe. Available online: https://energy.ec.europa.eu/topics/energy-efficiency/financing/eu-programmes/previous-funding_en (accessed on 9 June 2024).
20. European Commission. Energy Efficient Buildings: Energy Performance of Buildings Directive. Available online: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performancebuildings-directive_en (accessed on 9 June 2024).
21. Luxembourg Building Code (2017 Update). Available online: https://www.iea.org/policies/8648-luxembourg-building-code-2017-update (accessed on 26 October 2024).
22. Ministarstvo Graditeljstva I Prostornoga Uređenj. Available online: https://narodne-novine.nn.hr/clanci/sluzbeni/dodatni/438515.pdf (accessed on 26 October 2024).
23. Services Division Building Regulations Office Malta, Technical Guidance, Conservation of Fuel, Energy and Natural Resources (Minimum Requirements on the Energy Performance of Buildings Regulations, 2006). Available online: https://www.bing.com/ck/a?!&&p=ee94d88d6e16bce4JmltdHM9MTY5NTc3MjgwMCZpZ3VpZD0yMTk1ODMyOC05MGJkLTYyZDAtMzQ5MC05MTRkOTE4ZTYzNzYmaW5zaWQ9NTE5Ng&ptn=3&hsh=3&fclid=21958328-90bd-62d0-3490-914d918e6376&psq=malta+thermal+transmittance+limit&u=a1aHR0cHM6Ly9lcGMuZ292Lm10L2ZpbGUuYXNweD9mPTI0&ntb=1 (accessed on 26 October 2024).
24. Ministerio de Transportes, Movilidad Y Agenda Urbana, Documento BásicoHE, Ahorro de Énergia. Available online: https://www.codigotecnico.org/pdf/Documentos/HE/DccHE.pdf (accessed on 26 October 2024).
25. Noteikumi Par Latvijas Būvnormatīvu LBN 002-15 "Ēku Norobežojošo Konstrukciju Siltumtehnika". Available online: https://likumi.lv/ta/id/275015#piel0 (accessed on 26 October 2024).
26. Noteikumi Par Latvijas Būvnormatīvu LBN 003-19 "Būvklimatoloģija". Available online: https://likumi.lv/ta/id/309453-noteikumi-par-latvijas-buvnormativu-lbn-003-19-buvklimatologija (accessed on 26 October 2024).
27. Donatas, A.; Zenonas, T.; Robertas, V. Correlation Analysis of Thermo-Insulation Layer Thickness and Its Payback Period of the Typical Pitched Roof Detail. *Procedia Eng.* **2013**, *57*, 120–126. [CrossRef]

28. Dan, D.; Tanasa, C.; Stoian, V.; Brata, S.; Stoian, D.; Gyorgy, T.N.; Florut, S.C. Passive house design—An efficient solution for residential buildings in Romania. *Energy Sustain. Dev.* **2016**, *32*, 99–109. [CrossRef]
29. Ferreira, J.; Pinheiro, M. In search of better energy performance in the Portuguese buildings—The case of the Portuguese regulation. *Energy Policy* **2011**, *39*, 7666–7683. [CrossRef]