



Effect of Wall Type on Building Energy Performance Class in Different Zones

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ABSTRACT

Energy efficiency in buildings is of central importance in Türkiye's energy strategies in terms of reducing external dependence and achieving sustainability goals. This study examines the effect of the external infill wall material (horizontal perforated brick, pumice block, and aerated concrete), a fundamental component of the building envelope, on the energy performance class (A-G) in six different climate zones of Türkiye, according to the TS 825 standards updated in 2024. For the analyses, a five-story apartment building model with ten apartments and a total floor area of 1440 m² was used as a reference, and calculations were performed using the Energy Performance of Buildings Software Program (BEP-TR 2). As a result of the simulations, it was observed that a decrease in the thermal conductivity (λ) of the wall material significantly reduced annual heating consumption, and the use of aerated concrete enabled the achievement of energy class "B" in all zones. These findings highlight the critical role of material selection in the process of complying with the Nearly Zero-Energy Buildings (nSEB) criteria, which become mandatory as of 2025.

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Introduction

Global Energy Crisis and the Built Environment

Today, efficient use of energy resources has become a global priority in terms of both economic sustainability and environmental protection. Worldwide, buildings consume approximately 40% of total energy and are responsible for 36% of global CO₂ emissions. International agreements signed to combat climate change necessitate a radical transformation in the building sector. In this context, reducing the energy intensity of buildings is considered one of the most critical steps in achieving carbon neutrality targets [1].

Türkiye's Energy Outlook and Legal Regulations

Türkiye, which meets a significant portion of its energy needs through imports, considers energy efficiency a matter of both national security and economic stability. Approximately one-third of the final energy consumption in our country originates directly from buildings. [2] To reduce this high consumption rate, regulations such as the Energy Efficiency Law No. 5627 and the Regulation on Energy Performance in Buildings have been implemented. These regulations legally require buildings to comply with thermal performance standards from the design stage onward. [3,4]

The Role of Building Envelope in Energy Performance

The most fundamental element determining a building's energy consumption characteristics is its envelope. Exterior walls, constituting 70–80% of the building's outer shell, are the components that experience the most intense heat exchange between the interior and exterior environments. Minimizing heat loss and gain largely depends on the thermal resistance of the infill materials in these walls. Therefore, the choice of wall material is not merely a structural preference but an engineering decision that directly determines the building's energy consumption over its life cycle.

Many studies have investigated the effects of wall types and components on heating and cooling energy needs. It has been shown that wall systems with low thermal transmittance values (U-values) significantly reduce heating energy consumption, especially in cold-climate zones. On the other hand, it is reported that in hot-climate zones, high insulation levels have a more complex effect on cooling energy needs; in some cases, they can increase cooling energy consumption by inhibiting the dissipation of internal heat gains [5-13].

TS 825 Standard and 2024 Revision

Due to its geographical location, Türkiye exhibits heterogeneous climatic conditions, necessitating zone-

specific solutions for selecting building materials [14]. In Türkiye, the legal framework for building energy performance is primarily defined by TS 825, "Heat Insulation Rules in Buildings" [15], and the Regulation on Energy Performance in Buildings [4]. The TS 825 standard aims, in particular, to limit the heating energy requirement by setting maximum U-values for building envelope elements according to climate zones. However, this standard primarily adopts a heating-energy-focused approach and addresses the cooling energy requirement only to a limited extent.

The four-zone climate system, which has been in use for many years, has been insufficient to fully reflect local climate differences. With the revision of the TS 825 standard, which came into effect in 2024, the number of climate zones were increased to six, ranging from very hot to extremely cold, and the maximum permissible thermal transmittance (U) values for buildings were significantly tightened.

The Building Energy Performance (BEP) and BEP-TR 2 calculation methods [16] address the annual energy needs of the building from a more holistic perspective; they evaluate energy consumption for heating, cooling, hot water, and lighting together. This approach more clearly reveals the individual effects of building elements in determining the building energy performance class.

The reports prepared for Türkiye by Ecofys [2] and IZODER [17] state that more cost-effective and energy-efficient solutions are possible by exceeding the current TS 825 U-value limits. These studies indicate that the lower U-value ranges recommended for different climate zones can reduce both energy consumption and carbon emissions over the long term. In this context, the selection of wall types and building materials is important not only for meeting regulatory requirements but also for improving the energy performance class.

The Nearly Zero-Energy Buildings (nSEB) Target

The most recent and ambitious step in Türkiye's energy strategy is the transition to the Nearly Zero-Energy Buildings (nSEB) concept [18]. As of January 1, 2025, all buildings with a total construction area of over 2000 m² must meet the nSEB criteria and have at least an energy performance class of "B". This transition process encourages the re-evaluation of traditional building methods and materials (such as uninsulated perforated bricks) and the use of innovative materials with lower thermal conductivity.

In addition to the general thermal properties of building envelope components, the effect of thermal bridges has also been widely discussed in the literature. Thermal bridges occurring at structural discontinuities such as columns, beams, and slab-wall junctions are known to significantly affect the overall thermal performance of building envelopes. These localized heat transfer paths may lead to increased heat losses and deviations between calculated and actual energy consumption. Several studies have emphasized that thermal bridges can considerably

increase building energy demand, particularly in reinforced concrete structures [19,20].

International standards such as ISO 10211 [21] and EN ISO 14683 [22] provide detailed and simplified methodologies, respectively, for the assessment of thermal bridge effects, highlighting their importance in accurate energy performance evaluations. However, in simplified national calculation approaches such as TS 825 [15] and BEP-TR 2 [16], thermal bridge effects are generally considered indirectly through overall heat transfer coefficients.

In this context, when all building parameters other than wall type are kept constant, the relative influence of thermal bridges on comparative evaluations is expected to remain similar across scenarios, allowing a consistent assessment of wall material performance.

Previous studies on the impact of wall materials and building envelope properties on energy performance have reported varying findings depending on climatic conditions, modeling approaches, and boundary assumptions. While many studies emphasize that reducing the thermal transmittance (U-value) of wall systems significantly decreases heating energy demand, particularly in cold climates [12,13], some studies indicate that excessive insulation levels may lead to increased cooling loads in warmer zones due to reduced heat dissipation of internal gains [9,10].

In addition, methodological differences among studies—such as the use of steady-state versus dynamic simulation tools, simplified versus detailed thermal modeling, and variations in occupancy and internal gain assumptions—result in differences in reported energy performance outcomes [6,7]. Many existing studies are also limited to specific climate zones or focus primarily on heating energy, without comprehensively addressing cooling energy demand [11].

In this context, there remains a need for a systematic and comparative evaluation of wall material performance under updated climatic classifications. The recent revision of TS 825, which expands the number of climate zones from four to six, provides an important opportunity to reassess building envelope performance under more refined climatic conditions [17]. Therefore, this study aims to fill this gap by evaluating the effect of commonly used wall materials on both heating and cooling energy demands across all six climate zones using a consistent methodological framework.

Aim and Scope of the Study

Accordingly, this study aims to address this research gap by evaluating the impact of commonly used exterior wall materials in the Turkish construction sector—namely horizontal perforated brick, pumice block, and aerated concrete—on building energy performance across the six updated climate zones defined in TS 825 (2024 revision). The analysis is carried out using the BEP-TR 2 methodology for a reference apartment building with a total floor area of 1440 m², considering annual heating, cooling,

and primary energy consumption. The findings are intended to support designers and decision-makers in improving building energy performance and achieving the 2025 Nearly Zero Energy Building (nZEB) targets.

Materials and Methods

This study was conducted to determine the effects of different wall types on the building energy performance class in various climate zones of Türkiye, using the BEP-TR 2 calculation method employed under the Regulation on Energy Performance in Buildings. The analyses were performed under the same reference building geometry and usage scenario, aiming to demonstrate clearly the effects of wall-type-dependent variables on energy performance.

Calculation Methodology: BEP-TR 2

The national calculation methodology, approved by the Ministry of Environment, Urbanization and Climate Change of the Republic of Türkiye and based on the "Regulation on Energy Performance in Buildings" [4], was used to determine the energy performance class of buildings. The calculations were carried out using the BEP-TR 2 software, which is fully compliant with current legislation. This software uses an integrated approach to calculate the building's heating, cooling, ventilation, lighting, and sanitary hot water needs, and to the building's total annual primary energy consumption and, consequently, its CO₂ emissions.

Building Model Specifications

The analyses employed a standard apartment block as a reference to represent the existing housing stock and typical construction practices in Türkiye. Within the scope of the study, a reference building was defined for use in energy performance analyses. The reference building was considered a rectangular, multi-story structure intended for residential use. The building geometry, number of floors, floor height, and usable areas were kept constant in all scenarios, thereby ensuring that the results were solely attributable to the wall type.

Indoor thermal comfort conditions were defined in accordance with the BEP-TR 2 calculation principles and TS 825 standard. The heating set-point temperature was taken as 20°C and the cooling set-point temperature as 26°C. Internal gains, occupancy schedules, and ventilation rates were adopted from the standard reference building assumptions defined in BEP-TR 2 and were kept the same for all climate zones.

The thermal properties of other building envelope components (roof, floor, and windows) were defined to comply with the maximum allowable U-values specified in TS 825 for each climate zone. Although the primary focus of the study is on the effect of wall material without additional external insulation, all envelope components were modeled in accordance with TS 825 requirements to ensure regulatory consistency. Thus, the influence of wall type on energy performance could be isolated while maintaining realistic building conditions. The reference building assumptions used in the simulations are summarized in Table 1.

Table 1. Key reference building assumptions

Parameter	Value	Standard
Heating set-point	20°C	BEP-TR 2 / TS 825
Cooling set-point	26°C	BEP-TR 2
Internal gains	Standard	BEP-TR 2
Ventilation	Natural (default)	BEP-TR 2
Envelope components	TS 825 compliant	TS 825

Architectural Structure: The building is a five-story structure comprising a ground floor and four upper floors, with two apartments on each floor, totaling ten apartments.

Geometric Data: The total floor area of the building is 1,440 m², the net room height is 3 meters, and the total heated volume is 4,320 m³.

Roof: The roof is pitched with an area of 288 m².

Mechanical Systems: For heating and hot water needs, the natural gas-fueled "Individual Combi Boiler" system, the most common individual solution in Türkiye, is defined in the model [23].

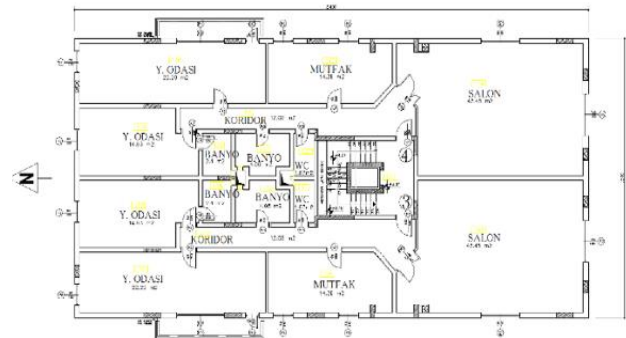


Figure 1. Building floor plan

The building's floor plan is shown in Figure 1, and its cross-sectional views from two directions are given in Figures 2 and 3.

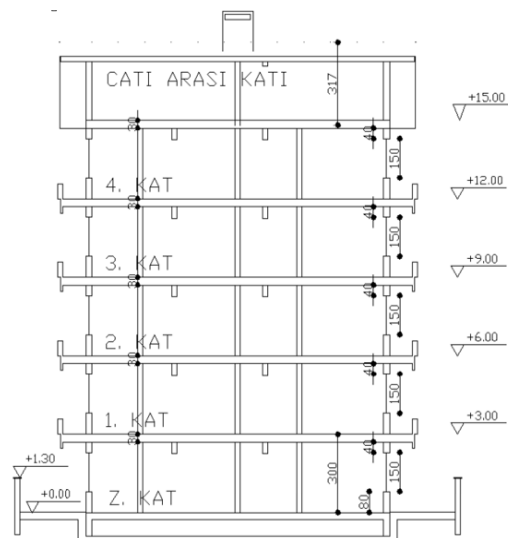


Figure 2. Building section view-1

The building has 5 floors, a total floor area of 1,440 m², a room height of 3 m, a pitched roof, and a roof area of 288 m². These features of the building are presented in Table 2.

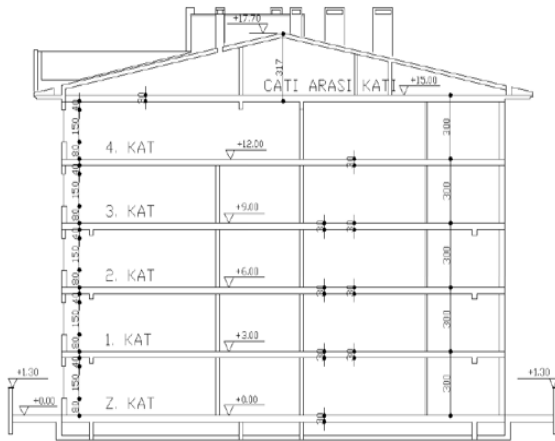


Figure 3. Building section view-2

Table 2. Building design features

Characteristic	Value
Number of apartments	10
Total floor area	1,440 m ²
Room height	3 m
Number of floors	5
Roof type	Pitched roof
Roof area	288 m ²
Volume	4,320 m ³
Heating system	Individual combi boiler
	Horizontal perforated brick 20 cm
Wall type & thickness	Pumice block 20 cm
	Aerated concrete 20 cm

Climate Zones and Selected Provinces

According to the TS 825 (2008) standard, Türkiye was divided into four climate zones (Figure 4); with the 2024 revision, Türkiye's climate map was expanded from four to six zones for a more precise assessment (Figure 5). In this study, the provinces in Table 2, each representing a climate zone, were selected, and analyses were carried out using data from these provinces. The provinces selected from each climate zone for the study are given in Table 3.

Table 3. Provinces selected from each climate zone

Climate Zone	Selected Province	Characteristic
Zone1	Antalya	Very hot
Zone2	İzmir	Hot
Zone3	İstanbul	Temperate
Zone4	Ankara	Cold
Zone5	Sivas	Very cold
Zone6	Erzurum	Extremely cold

Separately evaluating climate zones is important for revealing that the effects of wall types on energy performance vary regionally. Heating energy needs

predominate in cold climate zones, while cooling energy needs predominate in hot climate zones.

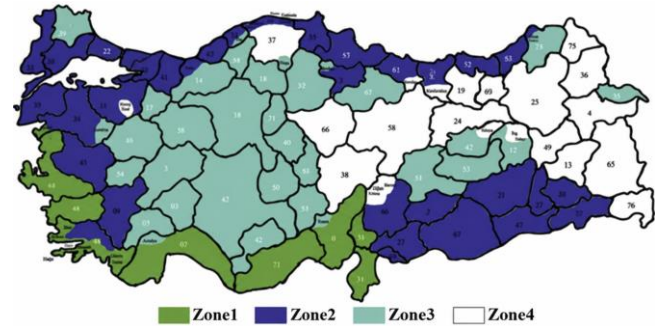


Figure 4. Climate zones of Türkiye according to TS825 (2008)

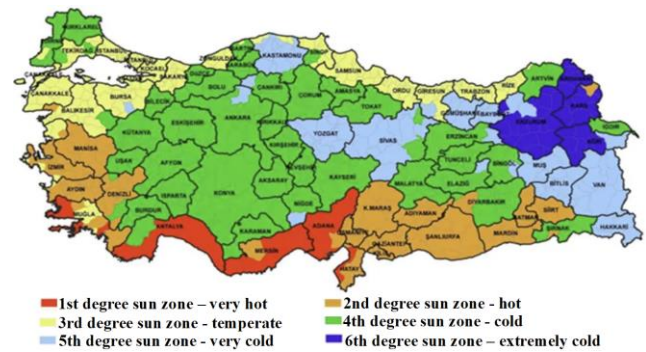


Figure 5. Climate zones of Türkiye according to TS825 (2024)

Wall Types Analyzed and Thermal Calculations

Building energy performance calculations were performed using the BEP-TR 2 software infrastructure, which is used within the scope of the Building Energy Performance Regulation. In the calculations, the building's annual heating and cooling energy requirements and primary energy consumption were determined. All parameters except wall type were kept constant to examine the effects of wall type on energy performance.

The BEP-TR 2 calculation method evaluates energy consumption for heating, cooling, hot water, and lighting together when determining the building's energy performance class.

In this study, the heating and cooling energy needs directly affected by the wall type, and their effects on primary energy consumption, served as the basis for analysis. The calculation results were evaluated in relation to energy performance classes. Within the scope of the study, three alternatives Horizontal Perforated Brick, Pumice Block, and Aerated Concrete, which are the most preferred external infill wall materials in the Turkish construction sector, were analyzed at a uniform thickness of 20 cm. The thermal transmittance (U-value) of the walls was calculated according to Equation (1) below using the thermal conductivity values (λ) given in TS 825 Annex-E.

In each scenario, the building geometry, usage profile, and mechanical systems were kept the same; only the type of exterior wall was changed. This method clearly demonstrated the effect of wall type on energy performance. The results were compared under the headings: heating energy requirement, cooling energy requirement, primary energy consumption, and energy performance class. The findings are presented using tables and figures; the results are discussed within the framework of the literature and current legislation.

$$U = 1/(R_i + \sum \left(\frac{d}{\lambda}\right) + R_c + R_{gap}) \quad (1)$$

In this equation, R_i and R_c represent the internal and external surface thermal resistances, respectively, and R_{gap} represents the air gap resistance between the material layers. The basic thermal characteristics of the materials used in the analysis are presented in Table 4.

Table 4. Thermal characteristics of wall materials

External Infill Wall Type	λ (W/mK)	Thermal transmittance (W/m ² K)
Horizontal perforated brick	0.33	1.26
Pumice block	0.21	0.89
Aerated concrete	0.11	0.52

Results and Discussion

The data obtained from the analyses were examined in three main categories: heating energy consumption, cooling energy consumption, and total primary energy consumption. These findings clearly demonstrate the effect of changes in building envelope materials on energy performance classes (A-G) across different climatic zones in Türkiye. All analyses were conducted under the same building geometry and usage scenario, and the results are intended to reflect only the effects attributable to wall type.

The Effect of Wall Type on Heating Energy

Analysis results indicate that heating energy consumption increases dramatically from zone 1 (Antalya) to zone 6 (Erzurum), as expected. However, this rate of increase varies with the thermal conductivity coefficient (λ) of the wall material.

Table 5 shows the comparative annual heating energy requirements for each wall type across climate zones. The table shows that wall types with a low thermal transmittance (U-value) reduce heating energy requirements across all climate zones. This reduction is more pronounced in cold-climate zones with high heating degree-day values. In particular, it has been determined that aerated concrete and pumice block walls require less heating energy than traditional brick walls.

Figure 6 shows the percentage increase in heating energy consumption for other wall types relative to aerated concrete.

Table 5. Calculated annual heating energy consumption.

Climate Zone	Heating Consumption (kWh/year)		
	Horizontal perforated brick	Pumice block	Aerated concrete
Zone 1	51,645.68	42,449.13	32,641.77
Zone 2	68,518.78	57,394.77	45,455.08
Zone 3	116,936.97	100,609.79	82,948.76
Zone 4	150,477.95	129,888.16	107,842.01
Zone 5	200,053.15	173,106.01	144,469.81
Zone 6	283,667.67	246,642.82	232,553.43

Accordingly, in zone 1, which is "Very Hot," the heating energy consumption of pumice block walls was 30% higher than in aerated concrete and 58% higher than in horizontal perforated brick walls. In zone 2, termed 'Hot', these increases were 26% for pumice blocks and 51% for horizontal perforated brick.

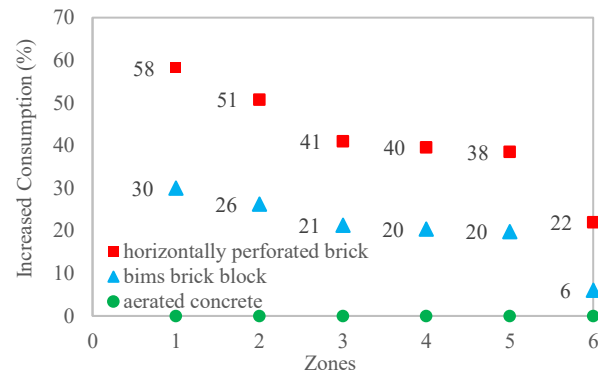


Figure 6. Percentage increase in heating energy consumption relative to aerated concrete.

In zones 3, 4, and 5, which are "Temperate," "Cold," and "Very Cold," the rate of increase was approximately 20% for pumice blocks compared with aerated concrete and approximately 40% for horizontal perforated brick. In zone 6 (Extremely Cold), the increase was 6% for pumice blocks compared to aerated concrete and 22% for horizontal perforated brick. If the rate of increase decreases as we move from zone 1 to zone 6, then the increase in consumption is inversely related to that rate. For example, a 30% increase in zone 1 corresponds to a consumption difference of 9,807.36 kWh/year, whereas a 6% increase in zone 6 corresponds to 15,089.39 kWh/year.

The Effect of Wall Type on Cooling Energy

Cooling energy requirements are a crucial determinant of building energy performance, particularly in hot and temperate climate zones. Table 6 presents annual cooling energy consumption by wall type. The analysis indicates that the effect of wall type on cooling energy requirements depends on climatic conditions. Unlike heating loads, cooling loads are determining factors only in zones 1 and 2 (Antalya and İzmir). While annual cooling requirements are almost zero in zone 6 (0–2.9 kWh/year), they range from 33,000–35,000 kWh/year in zone 1.

Table 6. Calculated annual cooling energy consumption.

Climate Zone	Cooling Energy Consumption (kWh/year)		
	Horizontal perforated brick	Pumice block	Aerated concrete
Zone1	35,362.89	34,458.86	33,644.68
Zone2	28,766.97	28,367.82	28,164.49
Zone3	3,800.43	4,716.44	5,920.57
Zone4	9,022.20	9,417.27	10,292.89
Zone5	1,882.32	2,128.39	2,525.43
Zone6	0.00	0.00	2.90

A noteworthy finding is that materials with low thermal conductivity (aerated concrete and pumice) do not reduce cooling loads as they reduce heating loads. In some zones (e.g., Zone 3), the cooling load of an aerated-concrete building (5,920 kWh/year) was higher than that of a brick building (3,800 kWh/year). This can be explained by the fact that the same low thermal conductivity in materials that helps retain heat indoors in winter impedes the dissipation of internal heat gains in summer. This finding is consistent with results reported in the literature, which show that building envelope design in hot climates should not focus solely on reducing heat losses. The TS 825 standard's approach, which focuses primarily on heating energy, may have limited applicability in hot zones. In contrast, evaluations using the BEP-TR 2 method provide more realistic results by also accounting for cooling energy requirements.

Effects on Primary Energy Consumption and Building Energy Performance Class

According to the Regulation on Energy Performance in Buildings, the sum of the annual “heating”, “cooling”, “hot water”, “lighting” and “ventilation” consumptions of the building is called primary energy consumption and this is considered one of the basic criteria in determining the building energy performance class [4]. For this reason, this study evaluated not only the energy consumption of wall types but also their effects on primary energy consumption and the building energy performance class. Table 7 shows the primary energies calculated for each climate zone and wall type. During the calculation of primary energy, all variables except wall type were kept constant. Thus, the effect of wall type on primary energy was determined.

Table 7. Calculated annual primary energy consumption.

Climate Zone	Primary Energy Consumption (kWh/year)		
	Horizontal perforated brick	Pumice block	Aerated concrete
Zone1	112,061.42	101,960.84	91,339.30
Zone2	122,315.84	110,792.68	98,649.67
Zone3	145,897.32	130,486.14	114,029.25
Zone4	184,579.77	164,385.05	143,214.52
Zone5	227,045.65	200,344.58	172,105.41
Zone6	308,798.72	271,773.86	232,553.43

Figure 7 shows the percentage increase in primary energy consumption of other wall types relative to aerated concrete. Accordingly, in the "Very Hot" region (Zone 1), primary energy consumption was 12% higher in pumice block walls and 23% higher in horizontal perforated brick walls compared with aerated concrete. Across zones 1–6, primary energy consumption increased linearly, reaching increases of 17% for pumice block walls and 33% for horizontal perforated brick walls, relative to aerated concrete in zone 6.

According to the Code on Energy Performance of Buildings [4], to obtain Energy Performance Certificate (EPC), the building's energy performance must be determined and its classification established. The energy performance of a building is determined in terms of directly consumable energy sources, here defined as primary energy. Building energy performance is determined by comparing the annual energy consumption and carbon dioxide emissions per square meter of the actual building with the corresponding values for the reference building. The energy consumption calculation method is applied to both the actual building and the reference building, and the consumption and emission values are calculated.

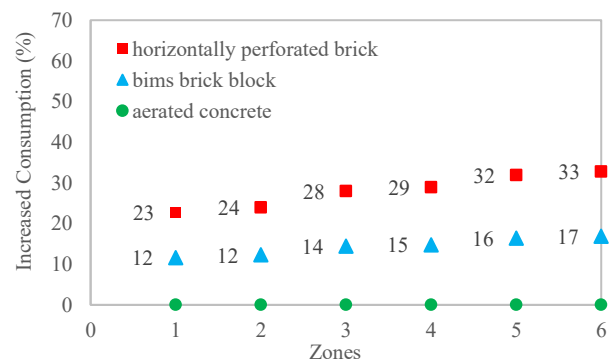


Figure 7. Rates of increase in primary energy consumption in other wall types compared to aerated concrete

The building energy performance classification is determined by comparing the primary energy demand of the reference building with the energy consumption of the designed building. The building energy performance and greenhouse gas emission classes defined in the aforementioned regulation comprise seven levels: A–G. Figure 8 shows the appearance of these classes defined in the regulation.

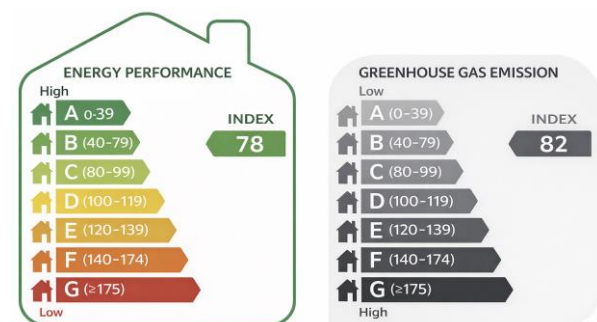


Figure 8. Building energy performance and greenhouse gas emission classes defined in code [4]

Table 8 shows the building-performance class ranges determined by comparing the building's calculated primary energy consumption with the energy demand indicator (RI) for the reference building, while Table 9 presents the energy performance classes of the buildings according to wall type, based on the ranges given in Table 8. Overall, the data in Table 8 indicate that aerated concrete has the lowest primary energy consumption across all climate zones, followed by pumice blocks and horizontal perforated bricks.

The most striking finding from the analyses is that the building with perforated brick walls could not achieve an energy class C in any climate zones. In contrast, the use of pumice blocks raised the building to class B (B71–B73), while the use of aerated concrete moved the building to higher, more efficient levels of class B (B61–B65).

Table 8. Building performance class ranges according to primary energy consumption.

Energy Performance Class	Energy Performance Index (EP)
A	EP < 0.40 RI
B	0.40 RI ≤ EP < 0.80 RI
C	0.80 RI ≤ EP < 1.0 RI
D	RI ≤ EP < 1.20 RI
E	1.20 RI ≤ EP < 1.40 RI
F	1.40 RI ≤ EP < 1.75 RI
G	1.75 RI ≤ EP

*RI: Reference Indicator

Table 9. EPC values in the building according to wall type

Climate Zone	Energy performance classes according to wall type		
	Horizontal perforated brick	Pumice block	Aerated concrete
Zone1	C80	B73	B65
Zone2	C80	B72	B64
Zone3	C80	B72	B63
Zone4	C80	B71	B62
Zone5	C81	B72	B62
Zone6	C82	B72	B61

Evaluation in Terms of nSEB Criteria

The Nearly Zero-Energy Buildings (nSEB) criteria, which will become mandatory in 2025, require buildings to achieve at least energy class B. Analyses show that the traditional 20-cm perforated-brick application, without an additional insulation layer (external wall insulation), cannot meet the nSEB requirements in any zone.

Economic and Environmental Impacts

Material selection in buildings is not only a technical preference but also a decisive factor in the life-cycle costs and environmental footprint of buildings. The data obtained in this study reveal the following financial and ecological implications of energy savings.

Operating Costs and Payback Period: The annual difference in heating energy consumption between buildings constructed with horizontal perforated brick and those constructed with aerated concrete in zone 6 (Erzurum) was estimated at approximately 51,114 kWh. Considering current energy unit prices, this amount of savings translates into an 18% reduction in the annual heating costs for building occupants. It is predicted that the difference in the initial investment cost of materials such as aerated concrete or pumice blocks will be amortized within a short time, especially in climate zones 4, 5, and 6, because of low operating costs.

Carbon Footprint and Emission Reduction: Buildings are responsible for 36% of global CO₂ emissions [1]. This study found that aerated concrete reduced primary energy consumption to the lowest level across all zones. In particular, the reduction in primary energy consumption in Zone 6 from 308,798 kWh/year to 232,553 kWh/year represents a significant decrease in the building's annual carbon emissions. This directly contributes to Türkiye's emissions reduction targets under international climate agreements.

Conclusions

This study analyzes the effects of horizontal perforated brick, pumice block, and aerated concrete block on building energy performance using the BEP-TR 2 methodology based on six climate zones currently used in Türkiye. The numerical results are presented below.

Energy Consumption: The lowest heating energy consumption was observed for aerated concrete. In Zone 1, which is "Very Hot," the heating energy consumed in pumice block walls was 30% higher than in aerated concrete, and 58% higher in horizontal perforated brick.

These ratios showed a decreasing trend as we moved from Zone 1 to Zone 6; in Zone 6 (Extremely Cold), the increase in heating energy consumption for pumice blocks compared with aerated concrete was 6%, while for horizontal perforated brick it was 22%.

Although the rate of increase in heating consumption declined from Zone 1 to Zone 6, heating energy consumption in Zone 6 remains high. Therefore, the consumption difference corresponding to a 30% increase in Zone 1 was 9,807.36 kWh/year, while the consumption difference corresponding to a 6% increase in Zone 6 was 15,089.39 kWh/year.

The effect of wall type on cooling energy varies across climate zones; however, aerated concrete and pumice block walls, which have low thermal conductivity, did not provide as sharp a reduction in cooling energy consumption as they did for heating.

Energy Performance Classification (EPC): Based on building energy classifications determined by primary energy consumption, the lowest EPC value for buildings with perforated brick walls was C80 in climate zones 1–4.

For buildings with pumice blocks, the lowest EPC value was B71, obtained in climate zone 4.

Finally, the lowest EPC value for buildings with aerated concrete walls was calculated to be B61 in climate zone 6.

Aerated concrete exhibited the lowest primary energy consumption. In Zone 1, primary energy consumption was approximately 12% higher for pumice block walls and 23% higher for horizontal perforated brick walls than for aerated concrete walls. These ratios increased from zone 1 to zone 6; in zone 6, primary energy consumption of pumice blocks was 17% higher than in aerated concrete and 33% higher than in buildings with horizontal perforated brick.

Economic and Environmental Impacts: The difference in initial investment costs between materials such as aerated concrete and pumice blocks is expected to be amortized within a short period, particularly in climate zones 4–6, owing to lower operating costs.

The use of aerated concrete reduces primary energy consumption to the lowest level across all zones, thereby significantly reducing the building's annual carbon emissions. This directly contributes to Türkiye's emission reduction targets under international climate agreements.

nSEB Compliance: In the evaluation according to the nSEB criteria (minimum class B energy performance), which will become mandatory as of 2025, pumice block and aerated concrete infill walls were found to meet the minimum Class B requirement without additional external insulation, whereas horizontal perforated brick walls did not meet this requirement.

All calculations performed and results obtained within the scope of this study were used solely to assess the effect of differences in thermal conductivity among external infill wall materials (horizontal perforated brick, pumice block, and aerated concrete) on the building's energy class. During the building's construction phase, regardless of the chosen filling material, the maximum thermal transmittance coefficient (U) limits specified in the TS 825 (Thermal Insulation Rules for Buildings) standard for the project's climate zone must be met. Therefore, regardless of the inherent insulation capacity of infill wall materials, the use of thermal insulation (e.g., external wall insulation) with the thickness and quality stipulated by the standard for each zone is a legal requirement and should be considered in conjunction with other building components (windows, roof, and floor), which are outside the scope of this study.

Ethics committee approval and conflict of interest statement

There is no need to obtain permission from the ethics committee for the article prepared,

The authors declare no conflicts of interest related to this article.

Authors' Contributions

Hasan Erdoğan: Study concept and design, conducting analyses, preparing the article draft

Serkan Engin: Study concept and design, interpretation of analysis results, critical review and revision of the article

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