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TS 825: 2024 ve Pasif Ev Standartlarının Yalıtım Kalınlığı Açısından Karşılaştırılması ve Bina Enerji Performansı Üzerindeki Etkilerinin Değerlendirilmesi

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Öne Çıkanlar

- Pasif Ev standardı, TS 825'e göre yıllık enerji tüketimini iklim bölgesine göre %60 ile %75 oranında düşürmektedir.
- TS 825'te tüketim iklimle ciddi değişkenlik gösterirken, Pasif Ev tasarımı tüm şehirlerde enerji kullanımını 18-22 kWh/m^2 bandında sabitlemektedir.
- Pasif Ev kriterleri, yüksek yalıtım ve güneş kazancı sayesinde sıcak iklim bölgelerinde ısınma ihtiyacını tamamen ortadan kaldırabilmektedir.
- Dinamik simülasyonlar, Pasif Ev'deki sistem etkileşimlerini modellediği için analitik yöntemlere göre daha optimize ve düşük sonuçlar vermektedir.
- Çalışma, Türkiye'nin enerji hedefleri için TS 825'in "performans sınırlamalı" bir yapıya güncellenmesi gerektiğini vurgulamaktadır.

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Özet
Bu çalışmada, Türkiye'de binalarda enerji verimliliğinin artırılmasında önemli bir rol oynayan TS 825 Isı Yalıtım Gereksinimleri Standardı ile yüksek performanslı bir yaklaşımı temsil eden Pasif Ev standardı, dış duvarlarda kullanılan EPS yalıtım kalınlığı ve bunun bina enerji performansına etkileri açısından karşılaştırmalı olarak incelenmiştir.

Amaç
Çalışma kapsamında, Türkiye'nin altı farklı iklim bölgesini temsil eden Adana, Manisa, İstanbul, Eskişehir, Sivas ve Kars illerinde konumlandırılmış örnek bir konut binası modeli için OpenStudio –EnergyPlus kullanılarak dinamik enerji simülasyonları gerçekleştirildi. Dış duvar yalıtım kalınlıkları, TS 825:2024 standardının güncellenmiş U-değeri ile Pasif Ev standardına uygun yalıtımın U değerlerinin kıyaslanması amaçlandı. Simülasyon ve analitik hesaplama sonuçları karşılaştırıldı.

Sonuç
Bulgular, TS 825'in iklime bağlı değişken yalıtım kalınlıklarına karşın Pasif Ev standardının sabit ve daha yüksek performanslı bir yapı kabuğu talep etiğini gösterdi. Pasif Ev yaklaşımı, özellikle soğuk bölgelerde TS 825'e göre %60-75 oranında enerji tasarrufu sağlamaktadır. Çalışmada, Türkiye'nin verimlilik hedefleri için TS 825'in asgari şartlardan ziyade, bina performansını doğrudan sınırlayan bütüncül ve yüksek standartlı bir yapıya güncellenmesinin faydalı olacağı değerlendirilmiştir.

Anahtar Kelimeler: TS 825, Pasif Ev, Optimum Yalıtım Kalınlığı, Bina Enerji Performansı, Enerji Simülasyonu

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Research Article

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Comparison of TS 825: 2024 and Passive House Standards in Terms of Insulation Thickness and Evaluation of Their Effects on Building Energy Performance

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Highlights:

- The Passive House standard reduces annual energy consumption by 60% to 75% compared to TS 825, depending on the climate zone.
- While consumption varies significantly with climate in TS 825, Passive House design stabilizes energy use between 18–22 kWh/m² across all cities.
- Passive House criteria can completely eliminate heating demand in warm climates through high insulation and optimized solar gains.
- Dynamic simulations yield more optimized and lower energy results than analytical methods by accurately modeling Passive House system interactions.
- The study emphasizes the need to update TS 825 toward a "performance-limited" framework to meet Turkey's national energy targets.

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ABSTRACT

This study comparatively examines the TS 825 Thermal Insulation Requirements Standard, a cornerstone of energy efficiency in Türkiye, and the high-performance Passive House standard regarding EPS insulation thickness in external walls and its impact on building energy performance. Dynamic energy simulations were conducted using OpenStudio–EnergyPlus for a representative residential building model across six distinct climate zones in Türkiye: Adana, Manisa, Istanbul, Eskişehir, Sivas, and Kars. Insulation thicknesses were determined based on the updated 2024 TS 825 U-value limits and Passive House performance criteria, with simulation results compared against analytical calculations. Findings reveal that while TS 825 insulation thicknesses fluctuate based on climatic conditions, the Passive House standard maintains consistently high insulation levels regardless of the climate. In terms of annual energy demand, the Passive House standard achieves a 60–75% reduction compared to TS 825, particularly in cold regions. The results demonstrate that TS 825 focuses on minimum requirements, whereas the Passive House standard provides a more rigorous and holistic framework that directly limits energy consumption. Consequently, the study emphasizes the necessity of evolving the TS 825 standard toward high-performance approaches to meet Türkiye's energy efficiency targets.

Keywords: TS 825, Passive House Standard, Optimum Insulation Thickness, Building Energy Performance, Energy Simulation

1. Introduction

Proper application of thermal insulation in buildings leads to both economic and energy savings. Thermal insulation reduces heating and cooling costs and provides a more comfortable indoor environment, resulting in lower energy consumption [1]. The external envelope of a structure—comprising walls, floors, roofs, and windows—exerts a critical influence on building energy efficiency, as approximately 70% of total heat loss occurs through these components [2]. Inadequate thermal transmittance values in practice can cause heat losses in building components and lead to moisture and mold formation on interior surfaces, thereby negatively affecting building performance. In addition, thermal bridges disturb thermal comfort, reduce thermal resistance, and increase overall energy consumption. As insulation thickness increases, heat loss decreases and energy efficiency improves; however, increased thickness also leads to higher costs. Therefore, the optimum insulation thickness should be targeted to balance energy savings and cost [3]. In Türkiye, the significant difference between energy production and consumption levels makes efficient energy use more important [4]. For this purpose, the TS 825 Thermal Insulation Requirements Standard is applied in Türkiye. Although this standard defines higher U-value limits compared to the Passive House approach, it serves as a mandatory reference for determining insulation thicknesses. In this study, the insulation thickness requirements proposed by the Passive House standard are compared with the limits defined by TS 825, and the effects of insulation thickness on building energy performance are evaluated.

When the sectoral distribution of energy consumption in Türkiye is examined, the residential sector accounts for a significant share of final energy consumption (20–22%), and this consumption mainly arises from residential energy needs such as space heating and air conditioning [5]. In building energy performance and energy consumption calculations, the largest share belongs to energy used to ensure thermal comfort [6]. Therefore, reducing heat losses in residential buildings is directly related to determining the appropriate insulation thickness. Studies on insulation thickness determination have shown different results for different climate regions in Türkiye. In a study conducted for Yalova, the required insulation thickness was found to be at the lowest level (approximately 2 cm) when the İZO TD wall type was used, whereas higher insulation thicknesses (approximately 3.3 cm) were required for BIMS block wall elements. In addition, it was observed that insulation was not required at an outdoor temperature of 15.5 °C, while the insulation demand increased as the temperature decreased, reaching approximately 4.5 cm at an outdoor temperature of −11 °C [7]. Economic evaluations carried out for Bursa climate conditions using EPS insulation resulted in optimum insulation thickness values ranging from 5.3 to 12.4 cm [8]. In a study considering different insulation materials and varying heating degree-day values for the provinces of Tunceli, Hakkari, and Kars, the optimum insulation thicknesses were determined as 0.079 m, 0.082 m, and 0.104 m, respectively. The same study reported that the ideal insulation thickness across Türkiye varies between 0.028 and 0.096 m [9]. In another study, it was stated that optimum insulation thickness increases with the severity of climate in different climate regions, and that the calculated values for Antalya, İstanbul, Elazığ, and Kayseri vary depending on wall type, insulation material, and fuel type [10].

Other studies in literature analyzed optimum insulation thicknesses for six insulation materials, different energy sources, and four climate regions, reporting that the optimum values vary over a wide range from 2.8 cm to 45.1 cm [11]. In a comprehensive evaluation covering all 81 provinces of Türkiye, optimum EPS insulation thicknesses ranging from 1 to 20 cm were calculated; however, it was stated that these thicknesses do not reach the levels required by the Passive House standard [12]. Previous studies have reported that optimum insulation thickness depends on climatic conditions and that higher insulation thickness is required in colder regions [13]. Similarly, studies conducted for different wall types and insulation materials have shown that optimum insulation thickness varies significantly with climate region, and that thickness exceeding 20 cm can be optimum for EPS and XPS in some regions [14]. Existing studies mostly focus only on optimum insulation thickness and do not provide a comprehensive comparison that jointly evaluates the current U-value requirements, wall components, and required insulation thicknesses of TS 825:2024, a national standard, and the Passive House standard, an international high-performance standard. The approach adopted in this study quantitatively examines how the two standards produce different results in terms of EPS insulation thickness across different climate regions in Türkiye by comparing the updated 2024 values of TS 825 with the U-values prescribed by the Passive House standard. In this way, the effects of insulation thickness selection on building energy performance are evaluated in a more systematic manner.

2. Material And Method

2.1. Simulation Method

Simulations were conducted to determine the optimum insulation thickness in accordance with the TS 825 and Passive House standards for six climate regions. The definition of simulation parameters and the modeling processes were carried out using the OpenStudio software interface, while the calculations were performed with the EnergyPlus simulation engine integrated into OpenStudio. In this study, a detached residential building with a usable floor area of 103 m² and a 2+1 floor plan was defined as the reference building, and this dwelling was in cities representing six different climate regions, positioned near the city center. The floor plan of the reference building is shown in Figure 1.

In the residential building, the insulation materials used for the roof, floor, and external walls are glass wool, XPS, and EPS, respectively. The properties of the materials used in the building were determined in accordance with the values specified in the TS 825 standard. The construction layers and material properties of the roof, floor, and external walls used in the simulated building are presented in Figures 2, 3, and 4, and in Tables 1, 2, 3, 4, 5, and 6, respectively.

Table 1. Roof Construction Material Properties

Material	Thickness (cm)	Thermal Conductivity (W/m·K)	Density (kg/m³)	Specific Heat (J/kg·K)
Glass Wool	Variable	0.04	70	1030
Reinforced Concrete	15	2.5	2400	2000
Interior Plaster	2	1	1800	1000

Table 2. Total Roof U-Value

Material	Adana	Manisa	İstanbul	Eskişehir	Sivas	Kars
Total Roof U-Value (TS 825)	0.337	0.299	0.299	0.237	0.196	0.192
Total Roof U-Value (Passive House Standard)	0.149	0.149	0.149	0.149	0.149	0.149

Table 3. Floor Construction Material Properties

Material	Thickness (cm)	Thermal Conductivity (W/m·K)	Density (kg/m³)	Specific Heat (J/kg·K)
Lightweight Concrete	10	1.1	1800	1000
Leveling screed	2	1.4	2000	1000
XPS insulation	variable	0.035	35	1450
Screed	3	1.4	2000	1000
Hardwood fiberboard	0.5	0.13	600	1700

Table 4. Total Floor U-Value

Material	Adana	Manisa	İstanbul	Eskişehir	Sivas	Kars
Total Floor U-Value (TS 825)	0.4	0.345	0.345	0.288	0.224	0.231
Total Floor U-Value (Passive House Standard)	0.148	0.148	0.148	0.148	0.148	0.148

Table 5. External Wall Construction Material Properties

Material	Thickness (cm)	Thermal Conductivity (W/m·K)	Density (kg/m³)	Specific Heat (J/kg·K)
Exterior plaster	0.8	0.35	900	1000
EPS insulation	variable	0.05	35	1450
Intermediate plaster	3	1.6	2000	1000
Horizontally perforated brick	25	0.36	700	1000
İnterior plaster	2	1	1800	1000

Table 6. Total External Wall U-Value

Material	Adana	Manisa	İstanbul	Eskişehir	Sivas	Kars
Total External Wall U-Value (TS 825)	0.45	0.399	0.399	0.247	0.183	0.118
Total External Wall U-Value (Passive House Standard)	0.149	0.149	0.149	0.149	0.149	0.149

In this study, a standard three-person household model with an average energy consumption profile was adopted. The simulations were carried out for the provinces of Adana, Manisa, İstanbul, Eskişehir, Sivas, and Kars, representing six different climate regions of Türkiye, and hourly meteorological data sets in EPW (EnergyPlus Weather) format were used for each climate region. The residential geometry was created using the OpenStudio software. The dimensions of the building components used in the simulation model were determined based on standard architectural dimensions; accordingly, door dimensions were defined as 0.90 × 2.10 m. Window dimensions vary depending on room size: living room windows are 2.50 × 1.50 m, room windows are 2.00 × 1.50 m, and bathroom windows are 0.50 × 0.50 m. The definitions of per-capita floor area usage, average internal heat gains per person, lighting, and annual electricity consumption used in the calculation of the total energy use of the dwelling were based on the internal heat gain values specified in the TS 825 standard. In the simulation, a scenario assuming continuous occupancy of the dwelling was considered, and the weekday occupancy schedule was defined as full occupancy between 17:00 and 09:00 (all household members at home) and partial occupancy between 09:00 and 17:00 (one person at home). Energy consumption profile was defined as follows:

- **00:00–07:00:** Minimum consumption due to sleeping hours (base load),
- **09:00–17:00:** Daytime use (variable load between 15% and 60%),
- **19:00–23:00:** Peak usage (80% load).

For Sundays, a special schedule was defined with high energy use throughout the day (09:00–23:00).

In defining the building envelope properties, the TS 825 standard was taken as the basis. The U-values (thermal transmittance coefficients) of windows and doors were assigned according to the relevant climate region. Roof and floor insulation thicknesses were determined based on the minimum thickness values that satisfy the maximum U-value limits specified in the TS 825 standard. To determine the optimum insulation thickness for external walls, the thickness of the EPS insulation material varied iteratively in increments of 0.5 cm, starting from the initial value that meets TS 825 requirements, and a series of simulations was conducted. In the mechanical system configuration, a natural gas-fired boiler was defined as the heating source, while electric air-conditioning units were used for cooling. The capacities of the heating and cooling systems were calculated based on the peak thermal loads of the building using the auto sizing function of the simulation software. An efficiency value of 0.913 was assigned for the boiler, and a COP value of 3.0 was used for the electric air-conditioning system. Thermostat set points were adjusted in accordance with TS 825 assumptions, with 20 °C for heating and 26 °C for cooling. In addition, the limit values prescribed by the Passive House standard were analyzed comparatively together with the TS 825 standards. The Passive House standard imposes limits on annual total heating and cooling energy demand and primary energy consumption rather than component-based U-value restrictions. In this context, the simulations were evaluated comparatively by also considering window performance criteria that vary according to climate regions.

2.2. Analytical Calculation Method

2.2.1. Layer Thermal Resistance

The thermal resistance of each material layer against heat transfer is calculated by dividing the layer thickness (d) by the thermal conductivity of the material (λ):

$$R_i = \frac{d_i}{\lambda_i} \quad (1)$$

This expression is applied separately to each layer that forms the building element. In the TS 825 standard, internal and external surface resistances (Rsi and Rse) are also mandatory parameters. Although the same calculation method is used in the Passive House standard, much lower U-value targets are defined. Therefore, layer thicknesses and the thermal conductivity values of insulation materials are determined according to stricter criteria.

2.2.2. Total Thermal Resistance

The total thermal resistance of a building element is obtained by summing the resistances of all layers together with the internal and external surface heat transfer resistances:

$$R_{toplam} = R_{si} + \sum R_i + R_{se} \quad (2)$$

In the TS 825 standard, the internal and external surface heat transfer resistances (Rsi and Rse) are defined as constant values (Rsi = 0.13 m²·K/W, Rse = 0.04 m²·K/W). The Passive House approach is also based on the same fundamental principles for total thermal resistance calculation. In this study, to ensure comparability, the Rsi and Rse values defined in TS 825 were also used for the Passive House evaluations.

2.2.3. Thermal Transmittance Coefficient (U-Value)

The thermal transmittance coefficient (U-value) of a building element is calculated as the inverse of the total thermal resistance:

$$U = \frac{1}{R_{total}} \quad (3)$$

The U-value represents the amount of heat transferred per unit area and per unit temperature difference through a building element (W/m²·K). The TS 825 standard defines maximum allowable U-value limits for specific climate regions. In contrast, the Passive House standard adopts a very high-performance approach, with U-values reduced to levels below 0.15 W/m²·K. Therefore, as insulation thickness increases, the U-value significantly improves, leading to a reduction in annual energy demand.

2.2.4. Annual Heating and Cooling Energy

The annual heating or cooling energy demand of a building is calculated using the total heat transfer coefficient of the building elements and Degree-Day data [15].

$$Q = \frac{K_{top}}{\eta} * HDD * \frac{24}{1000} \quad (4)$$

In Equation (4), Q represents the annual heating or cooling energy demand of the building (kWh/year). K_{top} is the total heat loss coefficient of the building envelope (W/K). HDD represents the heating degree-day value of the related climate region (K·day), while η indicates the overall efficiency of the system.

3. Results And Discussion

Within the scope of the TS 825 and Passive House standards, external wall insulation thicknesses and window thermal transmittance (U-value) limits were examined comparatively. Our findings are specific to the building that is simulated in this study. The data obtained were evaluated in terms of their effects on the thermal performance of the building envelope and annual energy consumption. In addition, the approaches adopted by the standards for different climate regions were discussed. The differences between the results obtained by analytical calculations and simulation methods were also examined.

3.1. Evaluation of Insulation Thicknesses According to the TS 825 Standard

According to the TS 825 standard, insulation thicknesses increase depending on the climatic conditions of the cities. As shown in Table 7, the EPS insulation thickness is 5.6 cm in Adana, which represents a hot climate region, and gradually increases toward colder climate regions, reaching 23 cm in Kars. Similarly, XPS and glass wool insulation thicknesses also show an increasing trend as the climate becomes colder. This indicates that TS 825 adopts an approach focused on reducing heat losses through the building envelope. When the window U-values are evaluated, it is observed that the same value (1.8 W/m²·K) is used for Adana, Manisa, İstanbul, Eskişehir, and Sivas, while a lower limit value of 1.5 W/m²·K is defined only for Kars. This shows that, within the scope of TS 825, window thermal performance requirements are defined similarly for most cities, and stricter window U-value requirements are applied only for Kars, which represents the coldest climate region. In contrast, insulation thicknesses in the TS 825 standard show more significant variations depending on climate conditions and are treated as a more variable design parameter compared to window performance.

3.2. Evaluation of Insulation Thicknesses According to the Passive House Standard

As shown in Table 8, the Passive House standard specifies the same insulation thicknesses and window U-values for all evaluated cities. For all regions, the insulation thicknesses are defined as 29 cm for EPS, 22.5 cm for XPS, and 26 cm for glass wool. For the window component, a U-value range of 0.5–1.3 W/m²·K is used for all cities. This indicates that the Passive House standard aims for a high and constant thermal performance of the building envelopes rather than defining minimum requirements that vary by climate region. The fact that insulation thicknesses do not change regionally shows that the standard adopts a performance-based and standardized design approach. The window U-value of 0.7 W/m²·K, although higher than that of opaque building elements, allows a balanced overall thermal performance of the building envelope when combined with high-performance window frame systems. When the results in Table 2 are evaluated in general, it is clearly seen that the main objective of the Passive House standard is to achieve low and consistent energy performance independent of climatic conditions.

3.3. Comparison of annual energy consumption according to standards

When the annual energy consumption values calculated according to TS 825 and Passive House standards in Table 9 are examined, it is seen that the differences are related to the building envelope properties and the results obtained for different climate zones. In TS 825 standard, insulation and building envelope performance are defined within the framework of minimum requirements. Therefore, as outdoor temperatures decrease, heat losses increase, leading to higher annual energy consumption. According to simulation results, the annual energy consumption under TS 825 is 53.52 kWh/m² in Adana, while it reaches 88.21 kWh/m² in Kars, which represents the cold climate region. A similar trend is observed in analytical calculations; the value calculated as 27.91 kWh/m² for Adana rises to 45.5 kWh/m² in Kars.

Table 7. Insulation Thicknesses According to TS 825 Standards

City	EPS (cm)	XPS (cm)	Glass Wool (cm)	window U value (W/m². K)
Adana	5.6	7.6	11	1.8
Manisa	5.6	9	12.5	1.8
İstanbul	5.6	9	12.5	1.8
Eskişehir	11	11	16	1.8
Sivas	16	14.5	19.5	1.8
Kars	23	17	20	1.5

Table 8. Insulation Thicknesses According to Passive House Standards

City	EPS (cm)	XPS (cm)	Glass Wool (cm)	Window U value (W/m². K)
Adana	29	22.5	26	1.1
Manisa	29	22.5	26	1.3
İstanbul	29	22.5	26	1.1
Eskisehir	29	22.5	26	1.0
Sivas	29	22.5	26	0.7
Kars	29	22.5	26	0.5

Table 9. Comparison of Annual Total Energy Consumption: TS 825 vs. Passive House

City	Total Annual Energy Consumption (TS825) (kWh/m²)	Total Annual Energy Demand (Passive House) (kWh/m²)	Annual Total Energy Use (TS825) (kWh/m²)	Annual Total Energy Demand (Passive House) (kWh/m²)
	Simulation		**Analytical**	
Adana	53.52	21.72	27.91	18.49
Manisa	61.52	20.39	33.9	23.12
İstanbul	78.02	19.42	40.3	25.90
Eskisehir	79.40	20.95	45.4	30.52
Sivas	83.12	21.34	42.3	36.99
Kars	88.21	22.17	45.5	41.62

In contrast, the Passive House standard limits the impact of climate conditions on energy consumption significantly. This is because building envelope performance is determined by high insulation levels, the reduction of thermal bridges, and high air tightness criteria. This situation is clearly seen in the simulation results, where annual energy consumption in all cities remains within a range of 18–22 kWh/m². This demonstrates that the Passive House standard provides balanced and climate-independent energy performance. When the standards are directly compared, the primary reason why the Passive House standard provides lower energy consumption than TS 825 is that heat losses are more limited due to stricter design requirements. According to simulation results, the Passive House standard reduces annual energy consumption by approximately 60% in Adana and 75% in Kars compared to TS 825. This higher reduction in cold regions occurs because Passive House design criteria limit heat losses more effectively when the temperature difference between the indoor and outdoor environments increases. It should be noted that the findings obtained in this study are valid for the specific reference residential building considered and may differ for buildings with different architectural layouts, usage patterns, or construction characteristics.

3.4. Comparison of analytical and simulation results in TS 825 and Passive House standards

In Table 9, it is observed that annual energy consumption values obtained through the simulation method are higher than the analytical method for all cities under the TS 825 standard. For example, in Adana, the simulation result is 53.52 kWh/m², while the analytical calculation is 27.91 kWh/m², representing an increase of 91.8%. Similarly, the difference is 81% in Manisa, 94% in Istanbul, and 75% in Eskişehir. In Kars, which represents the cold climate region, the difference between simulation and analytical results is 42.71 kWh/m², reaching a percentage difference of 93.9%.

The TS 825 analytical analysis provides a simplified approach by only considering transmission heat losses through the building envelope. In contrast, simulation-based TS 825 calculations include window losses, infiltration, internal and solar gains, and utilization coefficients, leading to higher annual heating energy demands. Therefore, while manual calculations and simulation results do not match exactly, they remain consistent and within the same order of magnitude. When examining the results for the Passive House standard, the relationship between the analytical and simulation methods is reversed. In Adana, the simulation result is 21.72 kWh/m² and the analytical result is 18.49 kWh/m², a difference of approximately 17.5%. However, in Istanbul, the simulation value is 19.42 kWh/m² while the analytical value is 25.90 kWh/m², meaning the simulation result is 25% lower. This difference increases up to 48% in Kars. The lower energy consumption predicted by the simulation method in the Passive House standard is due to the dynamic modeling of high insulation levels, heat recovery ventilation, and system interactions. Since analytical methods represent these interactions only to a limited extent, they predict higher energy consumption, especially in cold climates.

3.5. Analysis of heating and cooling energy use within the scope of Passive House and TS 825 performance criteria

In Table 10, annual heating and cooling energy consumption for different degree-day regions are compared based on the Passive House standard and the TS 825 approach. A fundamental criterion of the Passive House standard is that the annual heating and cooling energy demand must not exceed 15 kWh/m²·year.The table results show that energy consumption remains within these limits under the Passive House approach, especially in low and medium degree-day regions. For example, in Adana, the annual heating energy consumption is calculated as 0 kWh/m² according to the Passive House standard, while it is 20 kWh/m² according to TS 825.The main reason for this difference is that the Passive House approach can eliminate heating demand through high insulation levels, heat recovery ventilation, and the effective use of solar gains. In contrast, the TS 825 standard is based on minimum insulation requirements and does not define a performance goal to reduce heating energy near zero, even in warm climate regions. Furthermore, TS 825 does not set a numerical upper limit for heating and cooling energy consumption. For instance, the heating energy consumption of 66 kWh/m² year calculated for Istanbul according to TS 825 is well above the Passive House limit and is considered high in terms of energy efficiency.

Table 10. Heating and cooling energy demand according to Passive House Standards

Region	Heating Load (kWh/m²)	Cooling Load (kWh/m²)	Heating Load (kWh/m²)	Cooling Load (kWh/m²)
	Passive House		TS 825	
1. Degree-Day Region (Adana)	0	15	21	20
2. Degree-Day Region (Manisa)	0.5	14	33	15
3. Degree-Day Region (İstanbul)	1	13	66	6
4. Degree-Day Region (Eskisehir)	4	11	63	8
5.Degree-Day Region (Sivas)	9	5	60	8
6. Degree-Day Region (Kars)	11	5	71	2

4. Conclusions

In this study, simulation results for TS 825 and Passive House standards were compared. Additionally, the differences between simulation and analytical calculation methods were evaluated for both standards. The results show that energy consumption calculated via simulation is higher than analytical calculations under TS 825. In contrast, for the Passive House standard, simulation methods provide lower and more optimized results. This indicates that both the chosen standard and the calculation method play a decisive role in evaluating a building's energy performance. Findings regarding heating and cooling energy use show that the Passive House standard follows a stricter approach by setting a clear numerical limit on annual energy consumption. On the other hand, TS 825 focuses on minimum requirements and does not include criteria to limit total energy consumption.

In conclusion, while the Passive House standard provides a stricter framework that directly limits building energy performance, TS 825 ensures minimum insulation requirements without limiting total energy use. Therefore, to meet energy efficiency goals in Turkey, it is essential to update TS 825 with a more holistic approach and increase its compatibility with high-performance standards.

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6. Appendices

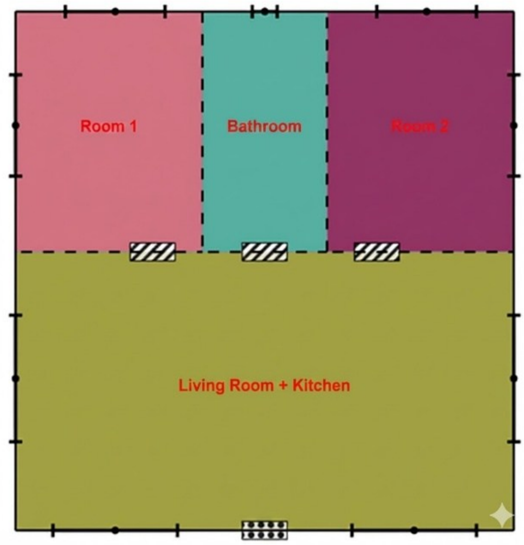

Figure 1. Residential Floor Plan

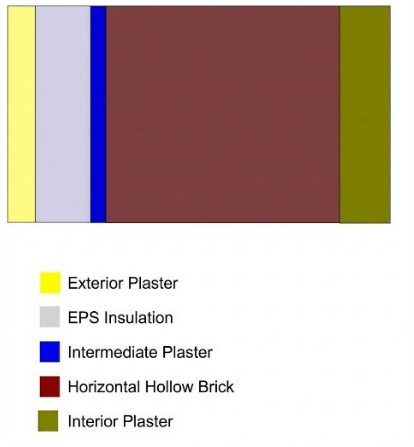

Figure 2. Roof Construction Materials

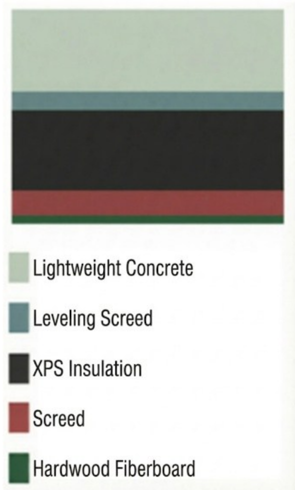

Figure 3. Floor Construction Materials

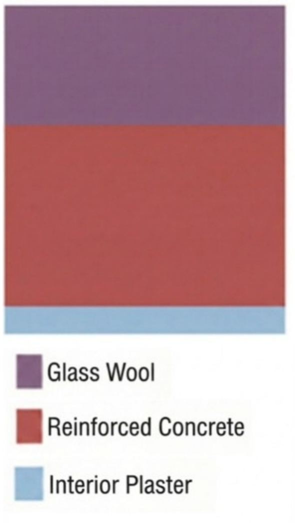

Figure 4. External Wall Construction Materials