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The Effect of Residence Settlement Decisions on Energy Consumption in Site Areas

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A B S T R A C T

In the pursuit of ensuring the long-term viability of residential areas, sustainability emerges as a pivotal element to be considered. During the planning phase of a residential area, it is imperative to assess energy use and daylighting potential from a sustainability perspective. In order to elucidate the impact of layout designs on these critical factors, a standardized and replicable reference case was chosen as a model. An alternative residential floor plan was created and analyzed across four different settlement configurations and building envelope improvement scenarios. The effects of the layout scenarios on energy consumption, daylighting performance and illuminance level are evaluated. According to the results, it was found that linear building planning prevents overheating by shading each other, and the enhancement of the thermal transmittance coefficient (u-value) of the building envelope reduces energy consumption. In addition, sufficient distance between the blocks optimizes the use of solar energy and reduces the need for heating.

Site Alanlarında Konut Yerleşim Kararlarının Enerji Tüketimine Etkisi

M A K A L E   B İ L G İ S İ

***Anahtar Kelimeler**:*
Enerji tüketimi
Gün ışığı
Aydınlatma
Konut yerleşimi

Ö Z E T

Konut alanlarının uzun vadede yaşanabilirliğini sağlama arayışında, sürdürülebilirlik dikkate alınması gereken çok önemli bir unsur olarak ortaya çıkmaktadır. Bir konut alanının planlama aşamasında, enerji kullanımı ve gün ışığı potansiyeli ile aydınlanma seviyesinin sürdürülebilirlik perspektifinden değerlendirilmesi zorunludur. Yerleşim tasarımlarının bu kritik faktörler üzerindeki etkisini aydınlatmak için, standartlaştırılmış ve tekrarlanabilir bir referans vaka model olarak seçilmiştir. Alternatif bir konut kat planı oluşturulmuş ve dört farklı yerleşim konfigürasyonu ve kabuk iyileştirme senaryosu üzerinden analiz edilmiştir. Yerleşim senaryolarının enerji tüketimi ve gün ışığı performansı ile aydınlanma seviyesi üzerindeki etkileri değerlendirilmiştir. Sonuçlara göre, binaların doğrusal planlanmasının birbirini gölgeleyerek aşırı ısınmayı önlediği ve bina kabuğunun ısıl geçirgenlik katsayısının (u değeri) düşürülerek iyileştirilmesinin enerji tüketimini azalttığı tespit edilmiştir. Ayrıca bloklar arasında yeterli mesafe olması güneş enerjisi kullanımını optimize etmekte ve ısıtma ihtiyacını azaltmaktadır.

NOMENCLATURE

DF	daylight factor
g	solar heat gain coefficient
U_D	wall thermal transmittance
U_T	roof thermal transmittance
U_t	floor thermal transmittance
U_P	window thermal transmittance
W	watt

INTRODUCTION

Urban environments are shaped by a combination of spatial, environmental and social factors that influence urban organisation in response to changing human needs and ecological conditions. The examination of the spatial patterns arising from the relationships among urban morphology, physical structures, environmental conditions, and legal regulations is important for creating sustainable cities.

The structural and social dynamics that have emerged and evolved in the development of urban space have made it necessary to create methods to explain the ordered connections of urban fabric components while analyzing the emergent forms of organization of space. In this context, settlement types are examined at both the urban and building scale. At the building scale, the layout is shaped by variables such as the geometric form, the number of stories, the height and the orientation of the building, while at the urban scale, this layout is shaped by variables such as the aspect ratio of the street, the sky visibility factor, and the street orientation (Liu et al., 2023). In addition to environmental parameters such as heat, humidity, daylight, wind and noise, accompanying factors, including topography, landscape, transportation axes, and legal parameters, such as zoning rules, play a role in the design of settlements and buildings (Akdağ et al., 2017). Implementation decisions are made after analyzing the environmental and physical parameters that serve as inputs.

Economic development, differentiation of building systems, rapid production and the enactment of condominium law have led to an increase in the apartment building typology to meet the needs of the increasing population in cities. This brought apartment housing to the forefront as the dominant zoning element in urban areas (Gür and Dülgeroğlu, 2019). The evolution of societal understandings of housing, particularly the shifting demands for comfort and privacy, has led to a transformation in the typology of housing. This transformation has resulted in the emergence of diverse housing typologies, which are now found in various urban settings. These new housing typologies include collective housing, gated communities, and residences, each with its own unique characteristics and private outdoor and social facilities (Bolleter et al., 2024). Although these housing typologies are located in different geographical, climatic and cultural contexts, their spatial organisation principles of settlement forms comprehensively reveal how they respond to environmental conditions and social dynamics, and are addressed similarly within the scope of this study.
A fundamental requirement of housing projects has been to design social spaces in an optimal manner to promote the physical and mental well-being, comfort, and safety of users, to encourage social interactions, and to foster a sense of community. This phenomenon, which has also emerged as a marketing strategy, has given rise to the concept of housing estates with different settlement patterns on large parcels (Huang, 2006; Lee, 2011; Wu and Ge, 2020). The settlement pattern has an impact on urban energy consumption along with socioeconomic, social and cultural transformations. Urban zoning policies and development plans also affect energy demand in cities. Urban density, defined as the number of people living in a specific area, is another factor that contributes to spatial density. This density can vary depending on factors such as increasing building depth, increasing building height, reducing spacing, or increasing compactness (Ratti et al., 2003).

Urban block typology also has an impact on solar heat energy utilization and heating and cooling load intensity (Cody et al., 2018; Zhang et al., 2019). The unique building typologies and energy use within the same urban fabric can be differentiated (Chen et al., 2020; Shi et al., 2019). Morphological characteristics have a strong modification effect on the microclimate (He et al., 2020; Rode et al., 2014; Steadman et al., 2014), which is a crucial consideration in the context of low-energy urban planning and design. Urban morphology, together with the microclimate, affects the energy needs of buildings. Specifically, an increase in floor area ratio has been observed to result in a decrease in heating load, and this phenomenon is comparable to its effect on the cooling load. Furthermore, research has revealed that heating demand in residential areas characterized by high building density is more influenced by solar radiation (Li et al., 2021).

In the study of Tereci et al. (2013), where area density, layout, building typology (such as apartment blocks, row houses, multi-family houses, high-rise buildings), construction year and national thermal standards are considered within the scope of urban settlement typology differentiation, it is stated that the increase in settlement density increases heating demand and compact, multi-apartment apartment blocks provide the lowest operational CO_2 emissions per capita in Stuttgart, Germany (Tereci et al., 2013). In the study conducted in China, the impact of urban forms created with different types of residential buildings on energy consumption and solar energy potential was analyzed. The results showed that building density, open space ratio, building height/width ratio and average perimeter- area ratio greatly affect the energy consumption of the residential block (Liu et al., 2023). Examining the relationship between urban form and building energy performance, Quan et al. emphasized that such a generalization should not be made contrary to the common knowledge in the literature that urban energy density increases energy use intensity, and that building energy use intensity is related to the geometry, typology or building function of the neighborhood, which in turn depends on many factors such as materials, HVAC systems, user behavior, etc. (Quan et al., 2016). In the study conducted by Manioğlu et al. (2023), variables such as building heights, block row lengths, road and backyard widths were evaluated to examine the effects of building and settlement patterns on heating and cooling loads within the city. The results show that in the study conducted for Istanbul, minimum heating loads were realized in 5-storey buildings and minimum cooling loads were realized in 10-storey buildings. The study further determined that heating loads exhibited a decrease with increasing building distances, while cooling loads demonstrated a decrease with decreasing distances. The analysis revealed that north/south settlement patterns yielded the lowest energy loads, while east/west options exhibited a greater sensitivity to directional variability. In the study conducted by Erdemir Kocagil and Koçlar Oral (2019), which was carried out in Istanbul, a city located within the moderate-humid climate region, 18 distinct scenario alternatives were subjected to analysis. These alternatives involved the production of combinations of design parameters, including plan type, number of floors, H/W ratio (the ratio of building heights to building distances), and settlement type. The study concluded that solar access exerts a significant influence on the energy performance of buildings. Consequently, the study suggests the adoption of settlement textures with low H/W ratios, which facilitate enhanced solar access, as a strategy to enhance energy performance in buildings.

The size of the floor area of buildings also significantly affects the cooling load. In a study conducted by Natanian and Auer (2018) by simulating urban form with building typologies with different floor areas in the Mediterranean climate, they stated that increasing the floor area ratio, which is the ratio of the total floor area of the building to the total area of the land on which the building is located, reduces the cooling load in both office and residential buildings (Natanian and Auer, 2018). In addition, Li et al. (2020) found that building orientation, building height-to-width ratio, perimeter area ratio and building height ratio are among the main factors affecting energy consumption in a study on residential and public buildings (Li et al., 2020). Geometric characteristics of building blocks are also among the factors affecting energy consumption. Strømann-Andersen and Sattrup found that the geometric characteristics of building blocks have an impact on the energy consumption of office and residential buildings, ranging up to 30% and 19%, respectively (Strømann-Andersen and Sattrup, 2011). Compactness and higher density can also increase energy demand due to limitations in natural ventilation, lighting and solar gains, which are desirable in cold climates (Hui, 2001). In another study, in hot climates where cooling dominates, higher building densities reduce energy demand (Mindali et al., 2004). As can be seen from this, climatic conditions lead to different results in the relationship between settlement decisions and energy demand. It is understood from the literature study that all factors affecting the ambient temperature such as climate, orientation, vegetation around the building, insulation status of the building, density of people inside the building, equipment used, building size, number of floors, user behaviors affect the heating and cooling load, and that detailed analyzes should be made in this regard during the design phase by evaluating the settlement decisions together according to the climate conditions.

In Yuzhong District, Chongqing, China, a database of information on building shapes through satellite imagery was created. A set of archetypes representing heating and cooling energy demand was identified through cluster analysis (Xinyi et al., 2018). In the study by Xia and Li (2021), a Grasshopper-based automatic morphology based on plot ratio, density and height values was created to evaluate the energy consumption and solar radiation access of residential urban blocks. In a study conducted in Hangzhou, China, a morphology database was created with 96 housing clusters and morphological parameters upon energy use intensity (EUI) were optimized according to annual electricity consumption, but the effect of morphology types was not evaluated separately. (Feng et al., 2024).

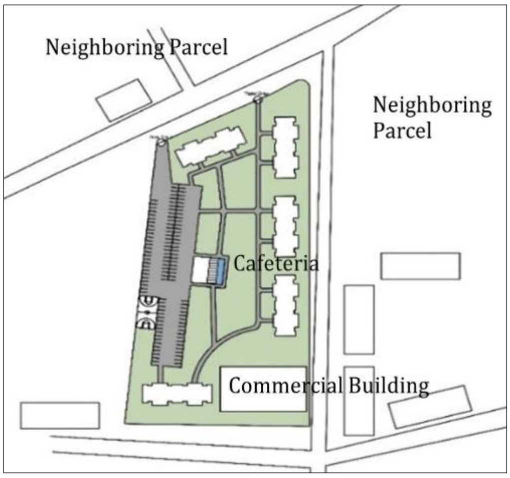
This review presents a lack of energy assessments in the literature concerning the settlement organization typology of buildings. The prevailing energy studies conducted in such compounds primarily evaluate building typology, building density in the area, and the physical characteristics of the buildings, as well as the distances between them. Furthermore, the majority of existing studies focus on gridal or compact urban layouts and are quite limited in terms of energy analyses of linear, road-parallel settlement patterns commonly seen in Konya, as shown in Figure 1. This study aims to fill this gap by focusing on this original settlement type and investigating the impact of differences in block types and orientations. This study is distinct from other extant studies in this respect.

MATERIALS AND METODS

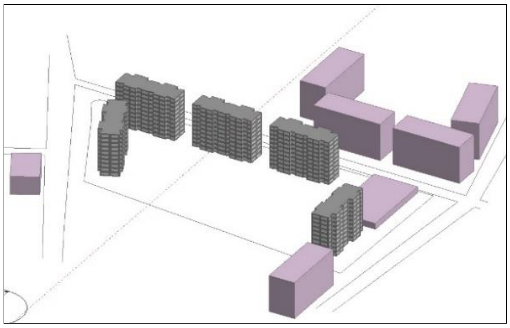
Within the scope of the study, the effects of different settlement typologies and envelope improvement of buildings on heating, cooling, total load and daylight potential, illuminance level were analyzed. The objective is to determine suitable alternatives by energy intensity, with these energies varying according to the settlement typology and to examine the impact of improvements made to the building envelope on energy consumption. To evaluate the effect of building envelope improvements, insulation thicknesses were adjusted to meet the U-values recommended in TS 825:2008 and TS 825:2024 standards. In this study, a project from Konya was selected for the comparison based on the availability of the necessary information, as an existing building evaluation will be utilized for the analysis. The reference case is a selected site that functions as a widely used settlement plan in Konya, as evident from the collage of multi-story housing estate layouts in Figure 1, wherein buildings are placed along the periphery and a social area is left in the center. This site, located in Konya, will serve as the focal point for our analysis.

Figure 1. Collage of common multi-story housing estate layouts in Konya(redrawn from Konya City Information System (2025)

Since the settlement typology is the main variable, the research focused on residence projects with the same plan type and consisting of several blocks. Two different residence typologies providing these conditions were selected, and the impact of the change in the settlement typology of the blocks on energy consumption, daylight performance, and illuminance level was evaluated.



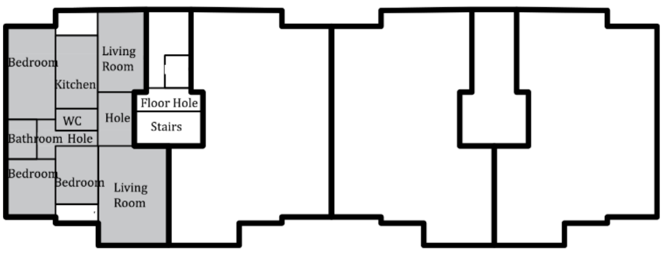
(a)



(b)

Figure 2. Site Plan (a) and 3D Model (b) of the Reference Case

In this study, a gated community in Konya province, which was built in 2011 as a public housing complex, is taken as an example with its layout plan and 3D visualization in Figure 2. The site layout consists of five independent residential buildings and a cafeteria. Each residential building consists of two adjacent blocks. In the blocks, there are two flats on each floor. There are a total of 200 flats on the site. Each flat has two facades. In the current settlement, the flats are either north-south or east-west facing, depending on the location of the block in the settlement. The building alternatives utilized in the study are based on the existing blocks (two flats on one floor) and four flats on one floor scenarios, as shown in Figure 3. In both scenarios, the flat sizes are equivalent, the plan scheme is 4+1, and there are five independent buildings. The number of flats and the number of floors (building height) are kept constant.



(a)

(b)

Figure 3. Schematic Plan of Existing Flats (a) and Alternative Plan with Four Flats on One Floor (b)

In the current layout of the site, the buildings are placed parallel to the parcel boundaries, and the central area of the buildings, which are positioned considering the setback distances from the boundary, is arranged as a green area, cafeteria, playground, sports field, and pedestrian paths. Since there is a power station (electrical transformer building) in the western part of the land, buildings have not been built on the western side of the land. This area has been utilised as a car park and basketball court. In the southwestern part, there is a commercial building consisting of a market and shops facing the street. The commercial building does not have an internal connection with the site, but it is included in the project. The power plant was not taken into consideration when creating alternatives. Other buildings around the site were modelled and included in the environment to evaluate the effects of shading, and the prevailing wind direction is north-northeast.

Designbuilder 6.1.0.006 program was used to simulate the building energy performance. DesignBuilder, an EnergyPlus-based simulation program, has been used in many studies in the literature and has an interface that shows the general structure of the building model during energy consumption analysis (Liu et al., 2021). It is used for energy, carbon, lighting, comfort, and control purposes. Its application in three-dimensional building modelling involves encompasses dynamic energy simulation at the building and settlement scales.

Since the study was conducted in Konya province, the location selection in the Designbuilder program was made as Turkey. Since the climate data of Konya province is not available in the library of the Designbuilder program, the climate file with monthly and hourly data, such as temperature and wind, was transferred to the DesignBuilder program with .epw extension format (EnergyPlus TM weather format). The climate data utilized in the program has undergone analysis in the Climate Consultant program, which is designed for the analysis of weather data. Monthly means of Konya weather data, which give general information on the climate in Konya are presented in Table 1. This chart demonstrates that Konya experiences a cold winter and hot summer, and the year is marked by consistently dry weather conditions.

Table 1. Monthly means of Konya weather data (Created using Climate Consultant 6.6)

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz. Radiation (Avg Hourly)	162	236	295	371	416	467	462	474	383	242	232	80	Wh/m²
Direct Normal Radiation (Avg Hourly)	81	189	162	198	269	370	340	391	329	233	215	90	Wh/m²
Diffuse Radiation (Avg Hourly)	129	144	201	247	245	222	238	220	191	124	146	47	Wh/m²
Global Horiz. Radiation (Max Hourly)	475	594	750	783	841	844	835	830	766	672	531	434	Wh/m²
Direct Normal Radiation (Max Hourly)	460	628	675	669	761	768	646	691	787	877	795	703	Wh/m²
Diffuse Radiation (Max Hourly)	296	339	428	512	507	511	485	444	474	359	322	237	Wh/m²
Global Horiz. Radiation (Avg. Daily Total)	1582	2486	3507	4838	5877	6820	6630	6369	4693	2655	2307	765	Wh/m²
Direct Normal Radiation (Avg. Daily Total)	794	1981	1941	2589	3801	5407	4890	5252	4038	2547	2135	857	Wh/m²
Diffuse Radiation (Avg. Daily Total)	1258	1522	2374	3228	3452	3252	3408	2962	2339	1367	1453	444	Wh/m²
Global Horiz. Illuminance (Avg. Hourly)	18917	26725	33267	40988	45474	50896	50116	51631	42239	27081	26306	9158	lux
Direct Normal Illuminance (Avg. Hourly)	8342	19325	16413	19708	25765	34069	31890	37240	3245	23575	22048	9304	lux
Dry Bulb Temperature (Avg. Monthly)	0	0	1	9	14	21	20	21	18	10	1	0	°C
Dew Point Temperature (Avg. Monthly)	-3	-5	-4	1	6	10	7	8	6	3	-3	-4	°C
Relative Humidity (Avg. Monthly)	76	72	64	59	56	49	43	44	47	61	70	77	%
Wind Direction (Monthly Mode)	290	290	110	320	290	290	340	160	290	160	290	140	degree
Wind Speed (Avg. Monthly)	1	1	1	1	1	1	1	1	1	1	1	1	m/s
Ground Temperature (Avg. Monthly of 3 m Depths)	6	3	2	2	4	8	12	15	17	16	14	10	°C

The site plan and floor plan of the reference case were transferred to the Designbuilder program, and the blocks were modelled. The blocks in the first and second cases have the same material type and thickness in accordance with the TS825:2008 standard shown in Table 2 and the TS825:2024 standard shown in Table 3. The Konya province is located in Region 3 according to the TS825:2008 standard and in Region 4 according to the TS825:2024 standard. The selection of materials and thicknesses for the blocks' walls, roofs, ground, and windows was made according to these regions.

Table 2. U Values Recommended as Maximum Values by Region in Accordance with Standard TS825:2008

	Wall	Roof	Ground	Window
	UD (W/m²K)	UT (W/m²K)	Ut (W/m²K)	UP (W/m²K)
Region 1	0,7	0,45	0,7	2,4
Region 2	0,6	0,4	0,6	2,4
Region 3	**0,5**	**0,3**	**0,45**	**2,4**
Region 4	0,4	0,25	0,4	2,4

Table 3. U Values Recommended as Maximum Values by Region in Accordance with Standard TS825:2024

	Wall	Roof	Ground	Window	
	UD (W/m² K)	UT (W/m²K)	Ut (W/m²K)	UP (W/m²K)	g
Region 1	0,45	0,35	0,4	1,8	≤0,45
Region 2	0,4	0,3	0,35	1,8	≤0,45
Region 3	0,4	0,3	0,35	1,8	≤0,45
Region 4	**0,35**	**0,25**	**0,3**	**1,8**	**≥0,55**
Region 5	0,25	0,2	0,25	1,8	≥0,55
Region 6	0,25	0,2	0,25	1,8	≥0,55

The residential building was used for 24 hours in the study. The heating energy requirement was met by a natural gas boiler, and the cooling energy requirement was met by a zonal electric split air conditioning system. At the same time, natural ventilation is active during cooling periods. The dimensions, area, number of stories, transparency ratio, user density and HVAC operation mode of the blocks are the same. Building detailed information and layers of the building envelope are shown in Tables 4-5-6.

Table 4. General Information on Building Model

Data on Building Model	Units	Input	Schedule
Building Function		Residence	
Number of Storeys		10 (Ground floor+9 stories)	
Zone Height	m	3.5	
Transparency ratio of facades	%	25	
Compactness ratio buildings		0,8193 (A plan-type) 0,8178 (B plan-type)	
Occupancy	Person/m^2	0.02[a]	
Heating Setpoint Temperatures	^{0}C	19[b] / 20[c]	
Cooling Setpoint Temperatures	^{0}C	26[c]	
Infiltration/Constant Rate	ac/h	0.9	
Lighting	(W/m^2)	6.5[d]	It works between 19.00-24.00 in June, July, August and September, and between 06.00-08.00 and 17.00-24.00 in October-June On (7/24)
Lighting type		Suspended	
Miscellaneous equipment (white goods, electronic devices, kitchen appliances)	(W/m^2)	13.03[e]	
HVAC		Radiator Heating,	From October to June, the radiator is in full operation between 07.00-12.00 and 18.00-24.00 and partial operation between 12.00-18.00 and 24.00-07.00
Natural Ventilation		Split air conditioner	In June, July, August, and September, the split air conditioner is partially operated between 12.00-18.00 In June, July, August, and September, partially Operated from 07.00-10.00 and 19.00-22.00

[a] *"According to the Turkish Statistical Institute" (TUIK, Population and Housing Research Report, 2017)*
[b] *"According to TS825" (Turkish Standards TS 825, 2008)*
[c] *"According to TS825" (Turkish Standards TS 825, 2024)*
[d] *"According to ASHRAE 90.1-2022"*
[e] *"ASHRAE Fundamentals Handbook (2021)*

Table 5. Layers Details of Building Envelope According to TS825:2008

Wall Layers				
		d (m)	λ (W/mK)	UD (W/m^{2}K)
Outside layer	Exterior plaster	0,02	0,82	**0,45<0,5***
	Finishing plaster	0,01	0,72	
	XPS Extrude Polystyrene	0,05	0,034	
	Adhesive Plaster	0,03	0,8	
	Brick	0,19	0,3	
Inside layer	İnterior plaster	0,02	0,72	
Ground Layers				
		d (m)	λ (W/mK)	Ut (W/m^{2}K)
Outside layer	Gravel	0,15	0,36	**0,34<0,45***
	Concrete	0,1	1,13	
	Plaster	0,1	0,82	
	Polyurethane	0,01	0,028	
	Cast Concrete	0,1	1,4	
	XPS Extrude Polystyrene	0,06	0,034	
	Plaster	0,05	0,82	
Inside layer	Wood	0,003	0,14	
Roof Layers				
		d (m)	λ (W/mK)	UT (W/m^{2}K)
Outside layer	Gravel	0,05	0,36	**0,25<0,3***
	Foam	0,05	0,25	
	XPS Extrude Polystyrene	0,12	0,034	
	Concrete	0,05	1,5	
	Floor	0,15	2,2	
Inside layer	Plaster	0,02	0,72	

Window System					
		d (m)	visible transmittance	solar heat gain coefficient (g)	UP (W/m^2K)
Outside layer	Glass	6	0,88	**0,5**	**2,3<2,4***
	Air	12			
Inside layer	Glass	6	0,88		
	Wooden Frame				

Table 6. Layers Details of Building Envelope According to TS825:2024

Wall Layers					
		d (m)	λ (W/mK)		UD (W/m2K)
Outside layer	Exterior plaster	0,02	0,82		0,32<0,35*
	Finishing plaster	0,01	0,72		
	XPS Extrude Polystyrene	0,08	0,034		
	Adhesive Plaster	0,03	0,8		
	Brick	0,19	0,3		
Inside layer	İnterior plaster	0,02	0,72		
Ground Layers					
		d (m)	λ (W/mK)		Ut (W/m2K)
Outside layer	Gravel	0,15	0,36		0,29<0,3*
	Concrete	0,1	1,13		
	Plaster	0,1	0,82		
	Polyurethane	0,01	0,028		
	Cast Concrete	0,1	1,4		
	XPS Extrude Polystyrene	0,08	0,034		
	Plaster	0,05	0,82		
Inside layer	Wood	0,003	0,14		
Roof Layers					
		d (m)	λ (W/mK)		UT (W/m2K)
Outside layer	Gravel	0,05	0,36		0,23<0,25*
	Foam	0,05	0,25		
	XPS Extrude Polystyrene	0,13	0,034		
	Concrete	0,05	1,5		
	Floor	0,15	2,2		
Inside layer	Plaster	0,02	0,72		
Window System					
		d (m)	visible transmittance	solar heat gain coefficient (g)	UP (W/m2K)
Outside layer	Low-e Glass	6	0,84	0,56≥ 0,55*	1,7<1,8*
	Air	12			
Inside layer	Glass	6	0,88		
	PVC Frame				

** Standard limit value*

The baseline is named as the reference alternative. Settlement alternatives were generated using the buildings/blocks that constitute the reference case, and these designs were named as A. The alternative of the block type, which has two flats on each floor in the reference case, is considered as 4 flats on one floor, and the layout alternatives are generated and defined as B. The layout types were determined as grid, linear (types a and b) and radial by taking K. Liu et al. (2023) and Akdağ et al. (2017) as examples. In this case, the directions differ and the relationship among the block's changes. In addition, to examine the 45° east and west orientations of all blocks in the layout, 45° east and west oriented alternatives for the blocks in each plan type were also created. Table 7 shows the site plans and three-dimensional models of the alternative cases. Tables 8 and 9 show the site plans and three-dimensional models of the alternative cases oriented 45° east and west.

Table 7. Alternative Settlement Design Scenarios

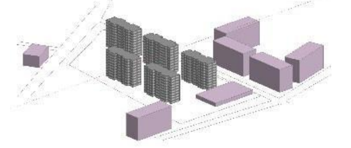
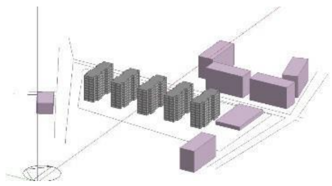
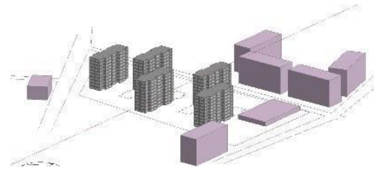
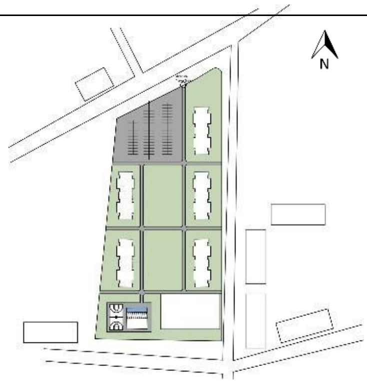
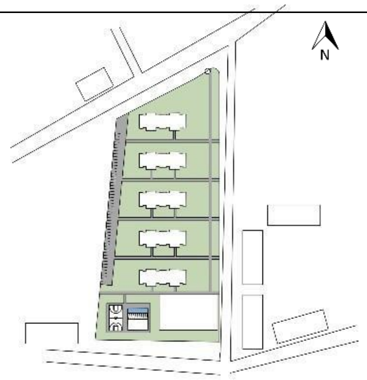
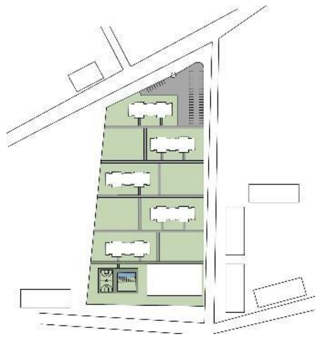
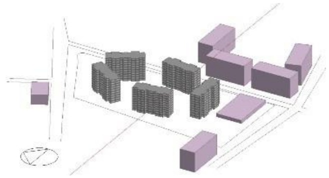
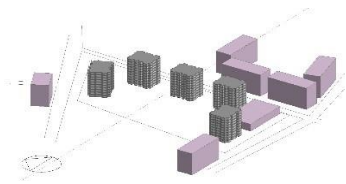
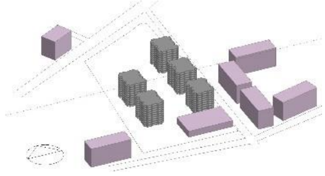
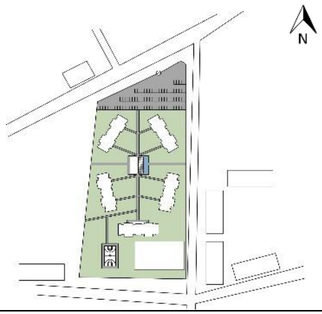
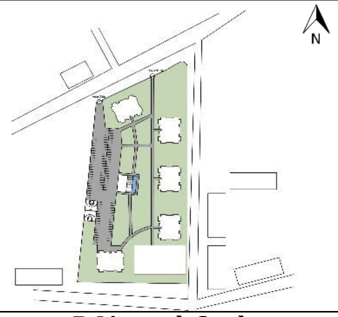
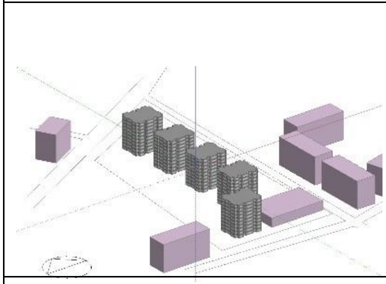
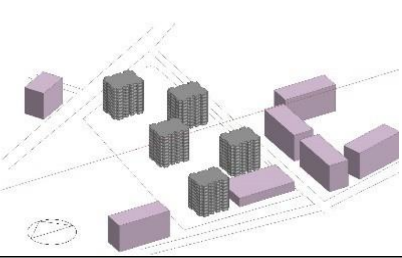
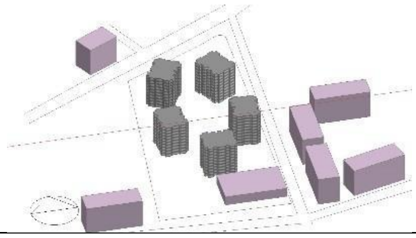
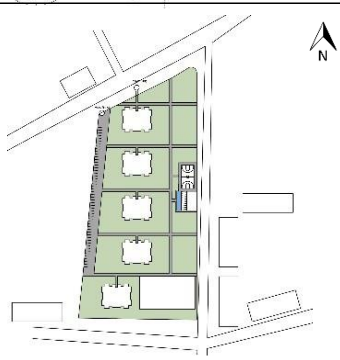
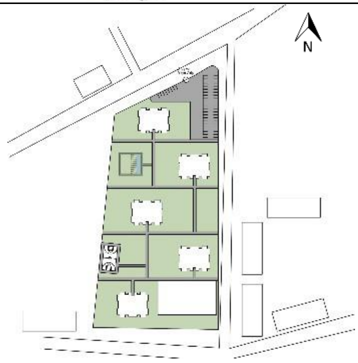
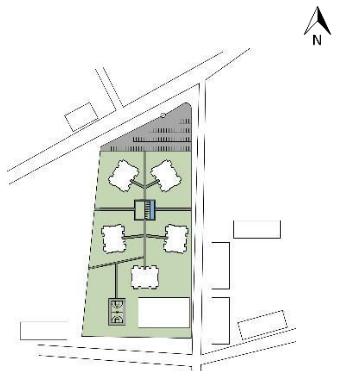
A-Grid Plan Settlement	A-Linear-a Settlement	A-Linear-b Settlement
		
		
A-Radial Settlement	**B-Reference Case**	**B-Grid Plan Settlement**
		
		
B-Linear-a Settlement	**B-Linear-b Settlement**	**B-Radial Settlement**
		
		

Table 8. Alternative Settlement Design Scenarios Oriented 45° East

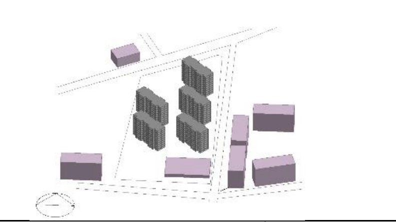
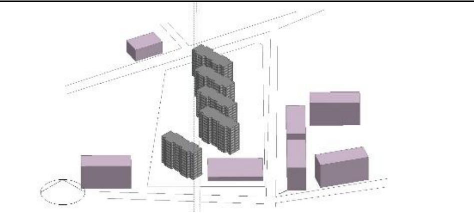
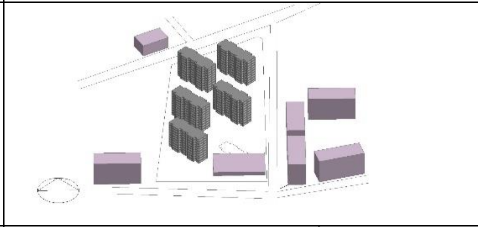
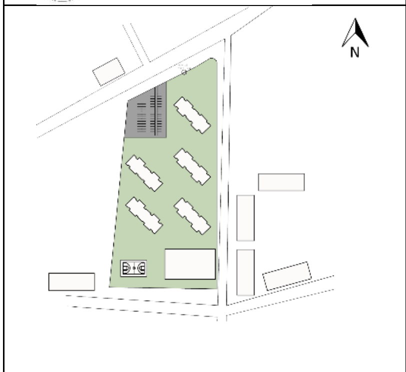
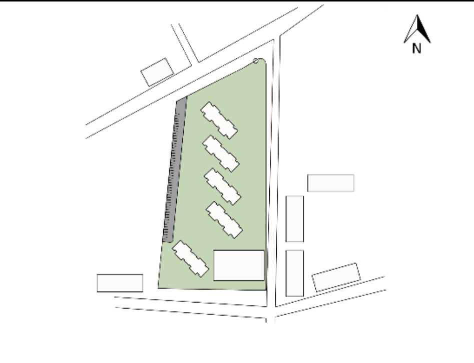
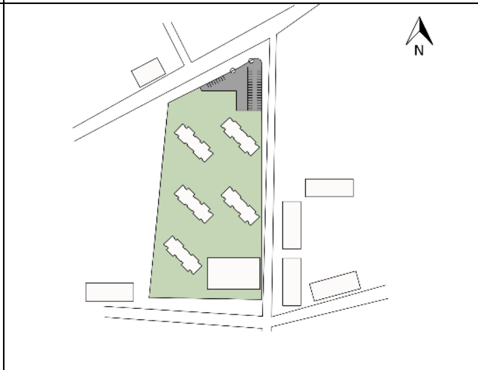
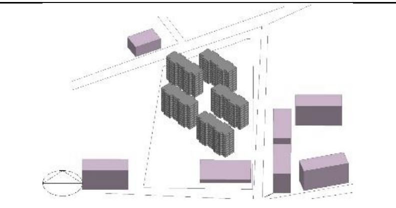
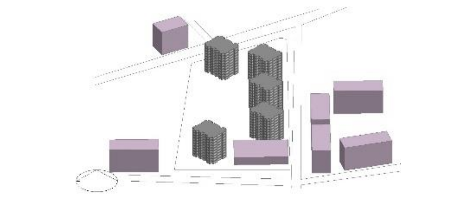
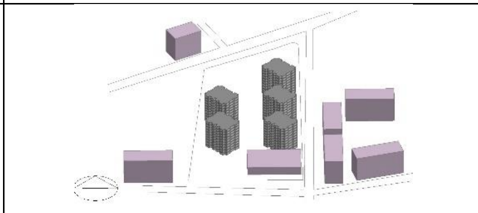
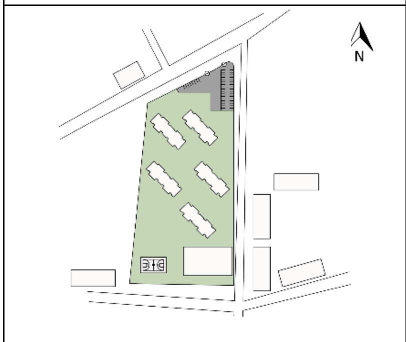
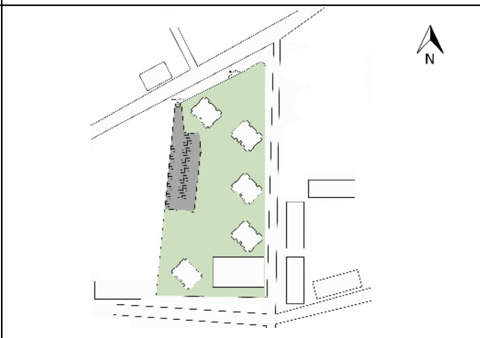
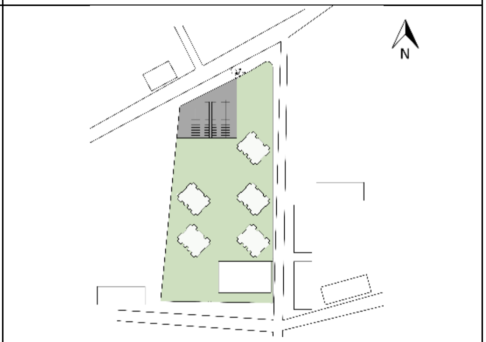
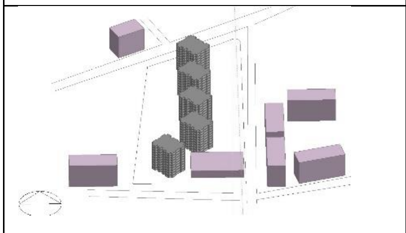
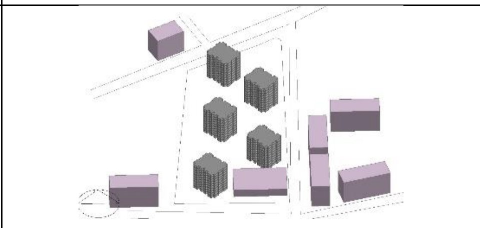
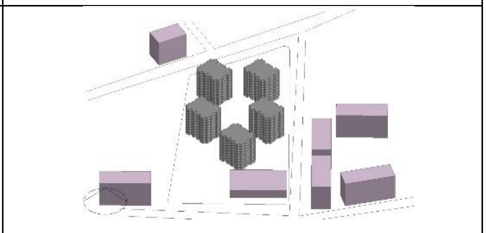
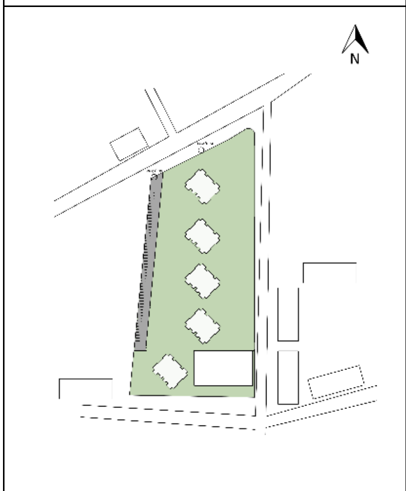
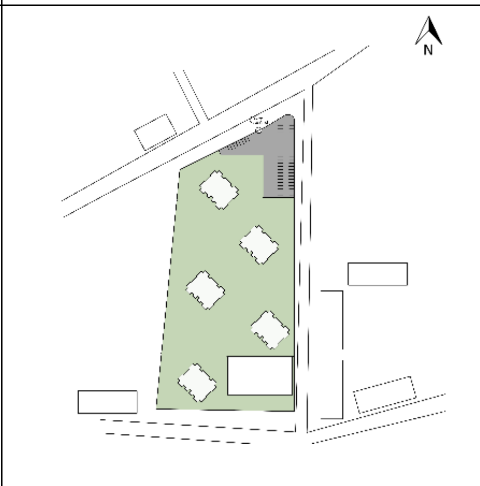
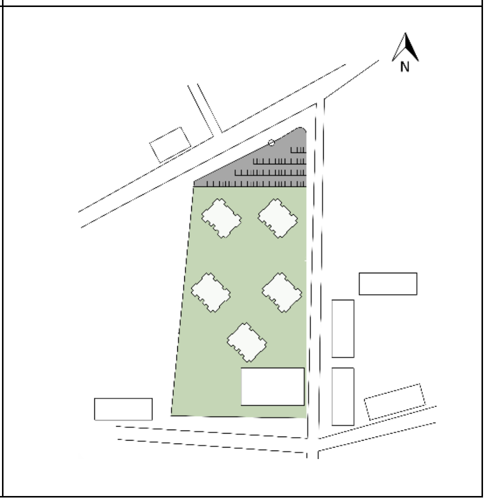
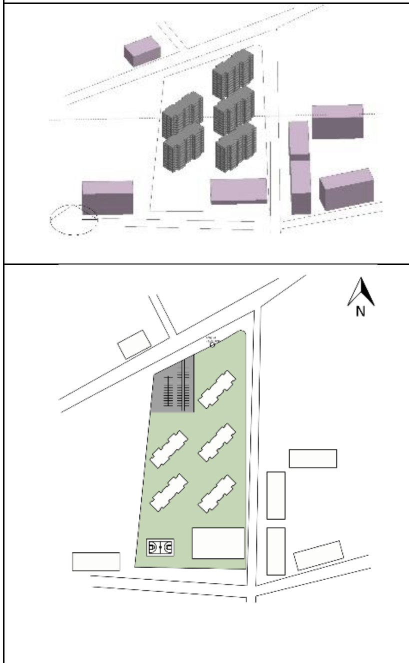
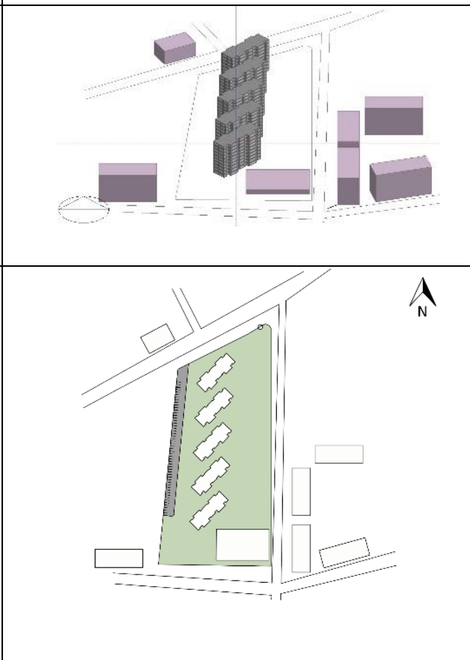
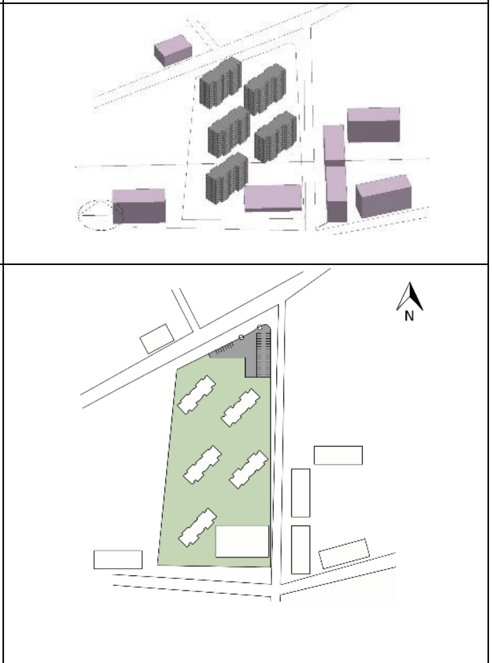
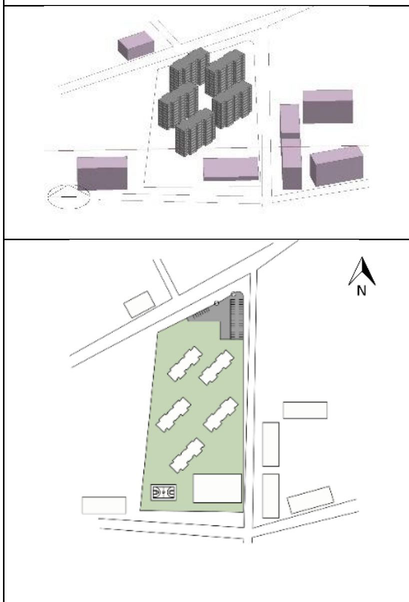
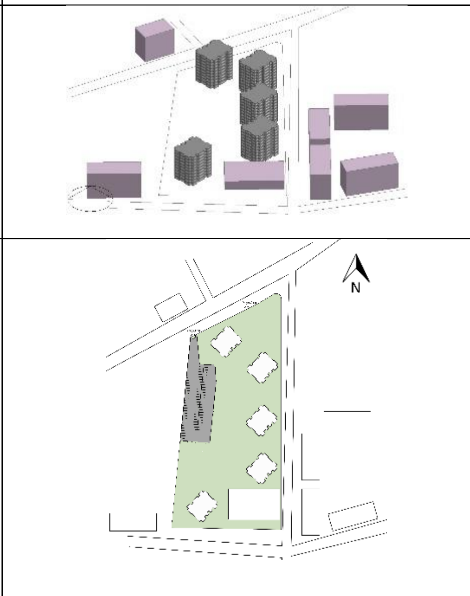
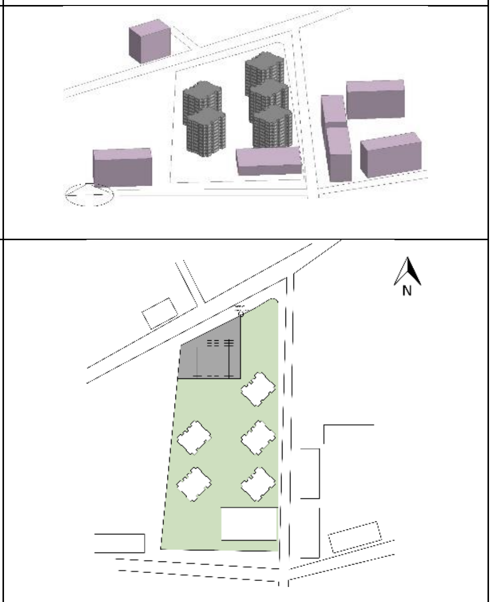
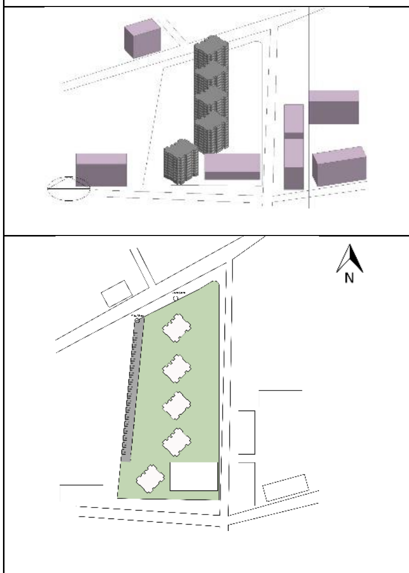
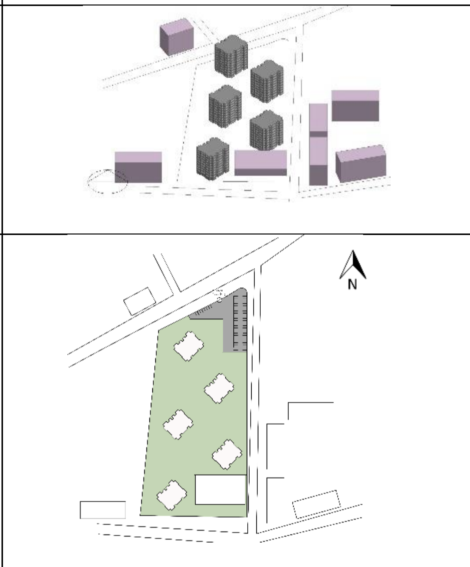
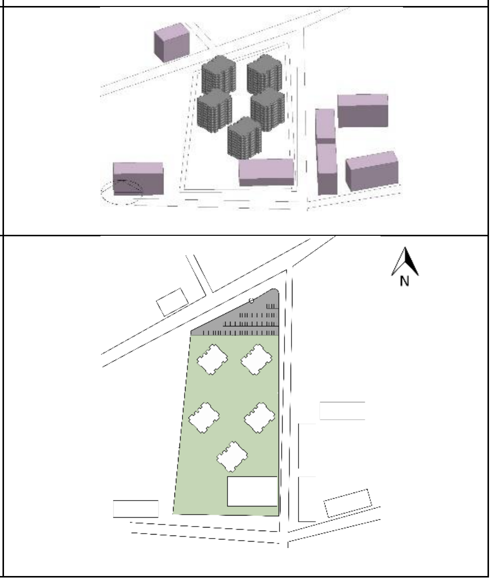
A-Grid Plan Settlement	A-Linear-a Settlement	A-Linear-b Settlement
		
		
A-Radial Settlement	**B-Reference Case**	**B-Grid Plan Settlement**
		
		
B-Linear-a Settlement	**B-Linear-b Settlement**	**B-Radial Settlement**
		
		

Table 9. Alternative Settlement Design Scenarios Oriented 45° West

A-Grid Plan Settlement	**A-Linear-a Settlement**	**A-Linear-b Settlement**
		
A-Radial Settlement	**B-Reference Case**	**B-Grid Plan Settlement**
		
B-Linear-a Settlement	**B-Linear-b Settlement**	**B-Radial Settlement**
		

RESULTS

The energy consumption, daylighting performance and illuminance level results obtained from the simulation are shown below.

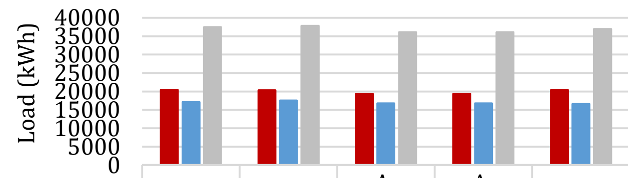
Evaluation of Thermal Gains

Internal heat gains in buildings directly affect energy consumption, reducing the heating load in winter and increasing the cooling load in summer. In this study, thermal gains from building occupants, lighting systems, and equipment were defined in accordance with ASHRAE and TUIK standards and included in the simulation using DesignBuilder software. For reference building A, the internal loads from lighting are 15.90 kWh/m^2/year, 11.79 kWh/m^2/year from occupancy, and 40,505 kWh/m^2/year from miscellaneous sources. In contrast, the internal load for lighting in reference building B is 17.82 kWh/m^{2}a, 17.81kWh/m^{2}a from occupancy, and 42.89 kWh/m^{2}a from miscellaneous. Based on the results obtained, the two layouts have similar building areas and transparency ratios, so the results are close. When evaluated together with building size and usage scenarios, the values are consistent and within acceptable limits (Ferrari et al., 2023).

Evaluation of Settlement Plan Types

The existing block is of the A plan type with two apartments per floor, and the simulation results and their numbering according to these results are shown in Table 10.

Table 10. Heating, Cooling and Total Load of Alternatives According to Plan Type A and Numbering of Alternatives According to Loads (a) and Their Numbering (b)



	Reference	A-Grid	A-Linear-a	A-Linear-b	A-Radial
Heating	20445	20317	19363	19325	20366
Cooling	17070	17515	16741	16743	16621
Total Load	37514	37832	36104	36068	36988

Alternatives

Heating Cooling Total Load

(a)

	Reference Case	A-Grid	A-Lineer-a	A-Lineer-b	A-Radiyal
Heating	5	3	2	1	4
Cooling	4	5	2	3	1
Total Load	4	5	2	1	3

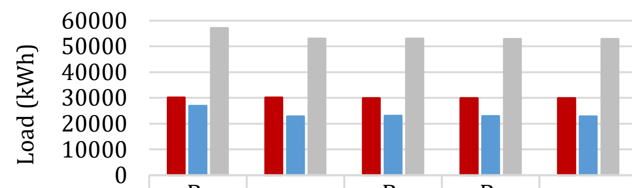
(b)

The results obtained from the simulation program are numbered in ascending order of heating, cooling and total loads. Number 1 indicates the minimum load, and number 5 indicates the maximum load. It has been determined that the alternative with the lowest cooling load is Radial, and the alternative with the lowest total and heating load is Linear-b.

When the blocks are aligned in a radial plane, natural ventilation is easily achieved in a controlled manner by the north wind, thereby reducing cooling demand. In the linear plane in the same direction, with increasing distance between blocks, solar exposure is optimised, and heating demand is reduced. Therefore, among the A-plan types, the linear-b configuration with the highest solar gain potential between blocks exhibits the lowest total load. This is primarily due to a reduction in the heating load, which is the predominant load.

As illustrated in Table 11, the simulation results obtained for Plan Type B are presented, along with the numbering of the alternatives according to their respective loads. In the radial settlement alternative, a compact layout is employed to minimize heat loss, and the distance between the buildings is strategically positioned to ensure optimal sun exposure for the blocks. Consequently, this alternative is identified as the one with the lowest total load.

Table 11. Heating, Cooling and Total Load of Alternatives According to Plan Type B and Numbering of Alternatives According to Loads (a) and Their Numbering (b)



	B-Reference	B-Grid	B-Linear-a	B-Linear-b	B-Radial
Heating	30201	30159	29971	29924	29972
Cooling	26956	22885	23064	23001	22906
Total Load	57156	53043	53036	52925	52878

Alternatives

Heating Cooling Total Load

(a)

	Reference Case	B-Grid	B-Lineer-a	B-Lineer-b	B-Radiyal
Heating	5	4	2	1	3
Cooling	5	1	4	3	2
Total Load	5	4	3	2	1

(b)

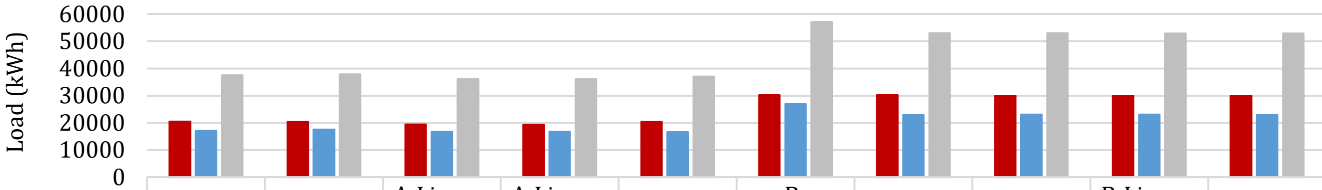
Evaluation of Block Types

Energy-efficient building design depends on the climate conditions of the building. In Konya's continental climate, heating load is dominant during cold winter months, while cooling load is a significant factor during summer months due to high temperatures. Therefore, compact layout designs offer advantages within climate-focused design strategies. Compact design reduces heat loss and gain by minimizing the exterior surface area, thereby decreasing the need for heating in winter and cooling in summer, and improving energy efficiency.

In the study, although the areas of the A and B plan layouts are equivalent, the configuration of the blocks in the A plan (rectangular form) layouts, particularly in the Linear-b alternative, has enabled the reduction of the distance between blocks and the creation of a more compact layout. Additionally, positioning the longer side of the rectangular geometry of the A-plan settlements toward the south created more openings on the south facade of the blocks, thereby increasing solar gain. This reduced the dominant heating load in Konya's cold climate, contributing to a decrease in total energy consumption. As a result, by optimizing solar gain, the Linear-b alternative demonstrated the energy efficiency advantages of the A plan layouts.

According to the findings in Table 12, the lowest cooling load was achieved in the A-Radial alternative, while the lowest heating and total loads were achieved in the A-Linear-b alternative. In both scenarios, A-plan layouts demonstrated lower energy consumption compared to B-plan (square-form) layouts. These results indicate that the compact layout design is not only related to the building form but also to the positioning of the blocks relative to each other and the orientation strategies. Especially under Konya's climate conditions, the compact layout, south orientation, effective use of daylight, and natural ventilation combination play a critical role in energy efficiency.

Table 12. Heating, Cooling and Total Load of Alternatives by Block Types



	Reference	A-Grid	A-Linear-a	A-Linear-b	A-Radial	B-Reference	B-Grid	B-Linear-a	B-Linear-b	B-Radial
Heating	20445	20317	19363	19325	20366	30201	30159	29971	29924	29972
Cooling	17070	17515	16741	16743	16621	26956	22885	23064	23001	22906
Total Load	37514	37832	36104	36068	36988	57156	53043	53036	52925	52878

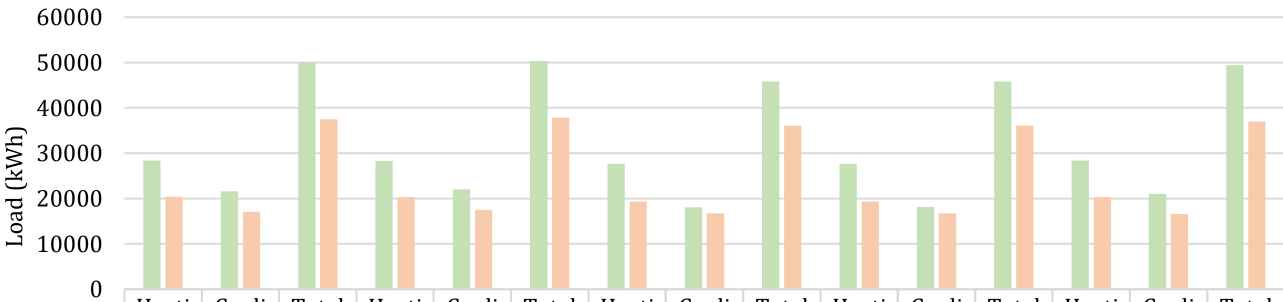
Alternatives
Heating Cooling Total Load

Evaluation of the Impact of Building Envelope Improvement on Energy Consumption

In this study, the envelope values of the TS825 standard for 2008 and 2024 were compared to evaluate the effect of envelope improvement on energy consumption. The U-values for the building's wall, roof, ground, and window layers were adjusted according to the TS825:2008 standard provided in Table 3 and the TS825:2024 standard specified in Table 4. To ensure the U-values of the building layers according to the TS835:2024 standard, the insulation thickness was increased, and low-e glass was used in the window systems. The changes in heating, cooling, and total load due to the envelope improvement are examined in Tables 13, 14, 15, 16, 17, and 18.

Table 13 shows the heating, cooling, and total load changes for settlement alternatives with plan type A according to the envelope values of standards TS825:2008 and TS825:2024. Accordingly, all alternatives resulted in a 28-30% reduction in heating load, an 8-21% reduction in cooling load, and a 21-25% reduction in total load.

Table 13. Effect of Envelope Improvement on Energy Consumption in Plan Type A

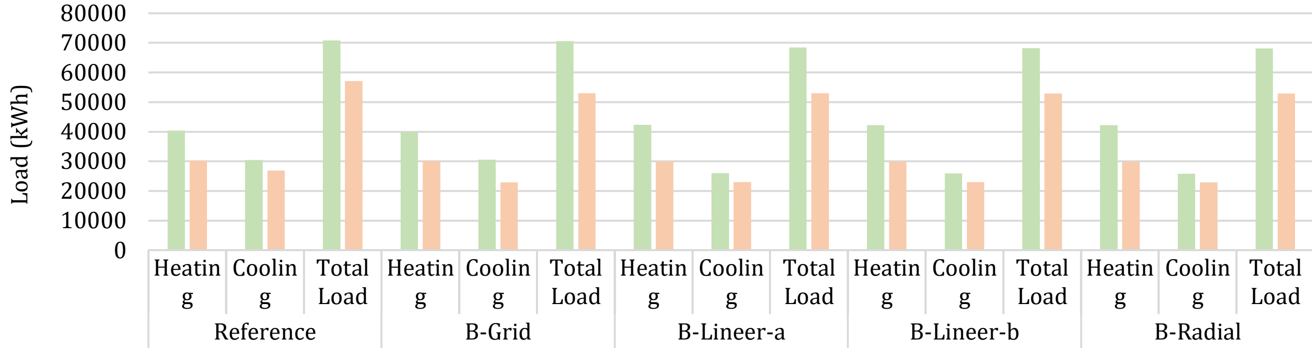


	Reference			A-Grid			A-Lineer-a			A-Lineer-b			A-Radial		
	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load
TS825:2008	28417	21587	50004	28299	22040	50339	27713	18115	45829	27696	18121	45817	28391	21023	49414
TS825:2024	20445	17070	37514	20317	17515	37832	19363	16741	36068	19325	16743	36068	20366	16621	36988

Alternatives
TS825:2008 TS825:2024

Table 14 shows the heating, cooling, and total load changes for settlement alternatives with plan type B according to the envelope values of standards TS825:2008 and TS825:2024. Accordingly, all alternatives resulted in a 11-25% reduction in heating load, an 8-21% reduction in cooling load, and a 19-25% reduction in total load.

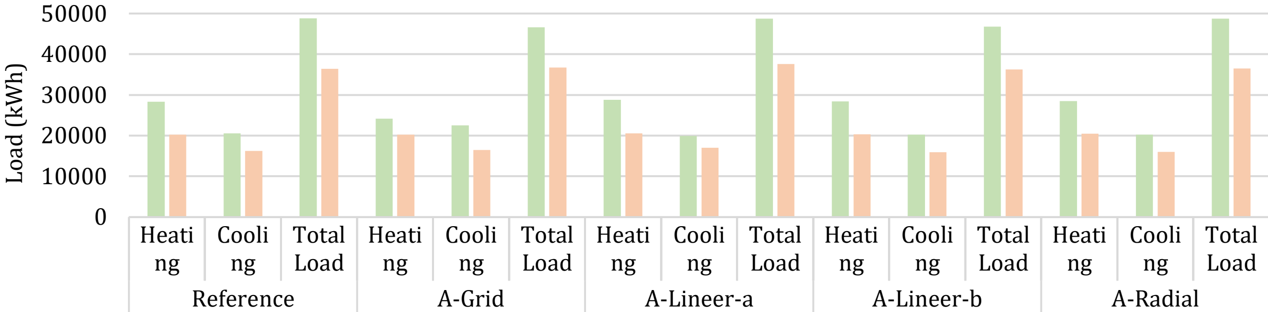
Table 14. Effect of Envelope Improvement on Energy Consumption in Plan Type B



	Reference			B-Grid			B-Lineer-a			B-Lineer-b			B-Radial		
	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load
TS825:2008	40417	30422	70839	39971	30619	70590	42345	26071	68416	42218	25969	68188	42261	25837	68099
TS825:2024	30201	26956	57156	30159	22885	53043	29971	23064	53036	29924	23001	52925	29972	22906	52878

Table 15 shows the heating, cooling, and total load changes of settlement alternatives with a 45° western orientation A plan type according to the TS825:2008 and TS825:2024 standard envelope values. Accordingly, all alternatives achieved reductions of 16% to 29% in heating load, 15% to 27% in cooling load, and 21% to 25% in total energy load.

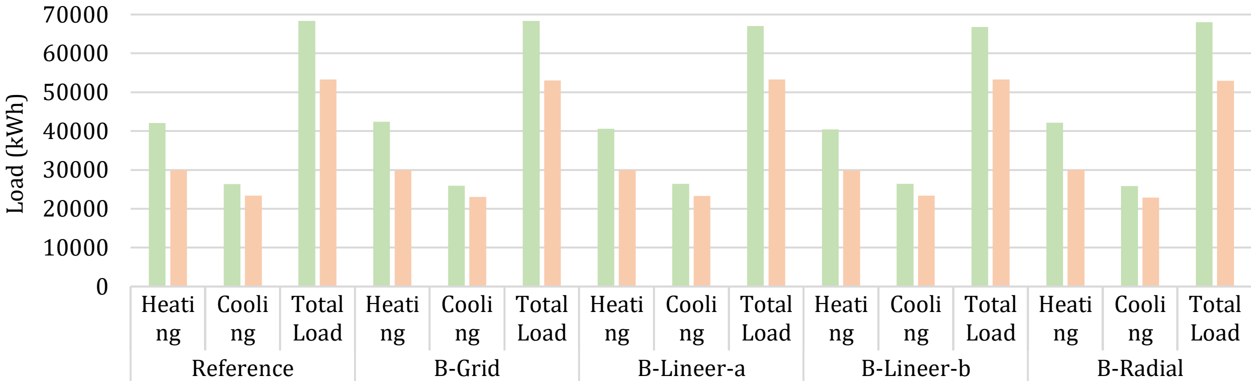
Table 15. Effect of Envelope Improvement on Energy Consumption in Plan Type A and 45° West Orientation



	Reference			A-Grid			A-Lineer-a			A-Lineer-b			A-Radial		
	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load
TS825:2008	28315	20543	48857	24145	22499	46644	28788	19950	48738	28415	20210	46824	28515	20273	48788
TS825:2024	20214	16210	36424	20273	16495	36767	20586	17035	37621	20346	15948	36294	20502	15997	36499

Table 16 shows the heating, cooling, and total load changes of settlement alternatives with a 45° western orientation B plan type according to the TS825:2008 and TS825:2024 standard envelope values. Accordingly, all alternatives achieved reductions of 26% to 29% in heating load, 11% in cooling load, and 20% to 22% in total energy load.

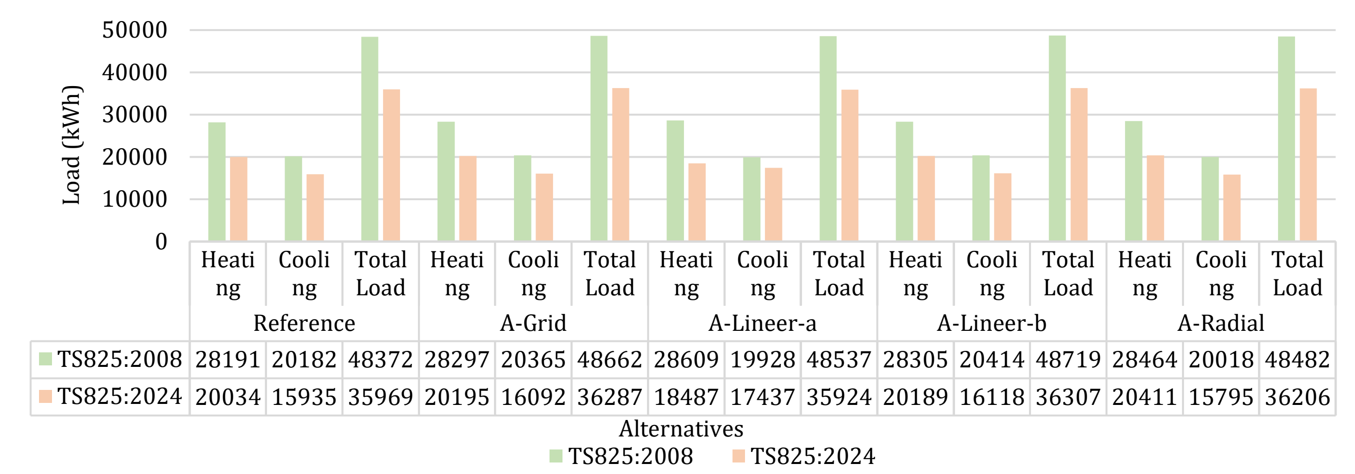
Table 16. Effect of Envelope Improvement on Energy Consumption in Plan Type B and 45° West Orientation



	Reference			B-Grid			B-Lineer-a			B-Lineer-b			B-Radial		
	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load
TS825:2008	42069	26316	68385	42366	25958	68324	40563	26433	66996	40395	26414	66808	42189	25840	68029
TS825:2024	29951	23353	53304	29986	23030	53016	29953	23322	53275	29901	23349	53250	30041	22914	52955

Table 17 shows the heating, cooling, and total load changes of settlement alternatives with a 45° eastern orientation A plan type according to the TS825:2008 and TS825:2024 standard envelope values. Accordingly, all alternatives achieved reductions of 28% to 35% in heating load, 12% to 21% in cooling load, and 25% to 26% in total energy load.

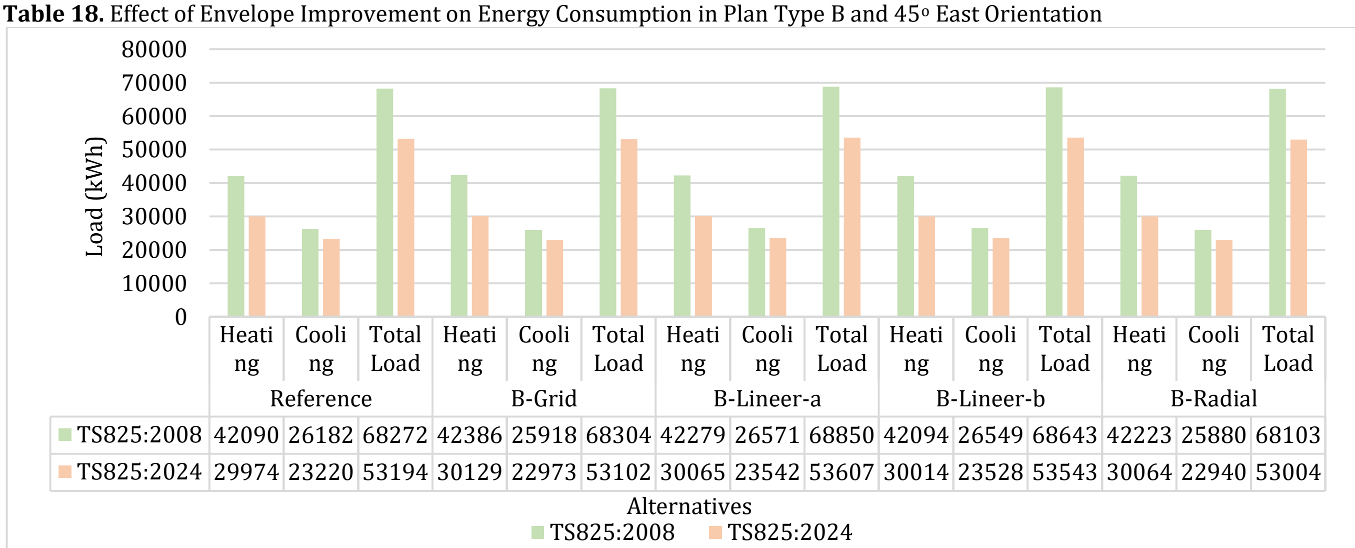
Table 17. Effect of Envelope Improvement on Energy Consumption in Plan Type A and 45° East Orientation



	Reference			A-Grid			A-Lineer-a			A-Lineer-b			A-Radial		
	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load
TS825:2008	28191	20182	48372	28297	20365	48662	28609	19928	48537	28305	20414	48719	28464	20018	48482
TS825:2024	20034	15935	35969	20195	16092	36287	18487	17437	35924	20189	16118	36307	20411	15795	36206

Table 18 shows the heating, cooling, and total load changes of settlement alternatives with a 45° eastern orientation B plan type according to the TS825:2008 and TS825:2024 standard envelope values. Accordingly, all alternatives resulted in approximately 28% reduction in heating load, approximately 11% reduction in cooling load, and approximately 22% reduction in total load.

Table 18. Effect of Envelope Improvement on Energy Consumption in Plan Type B and 45° East Orientation



	Reference			B-Grid			B-Lineer-a			B-Lineer-b			B-Radial		
	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load	Heating	Cooling	Total Load
TS825:2008	42090	26182	68272	42386	25918	68304	42279	26571	68850	42094	26549	68643	42223	25880	68103
TS825:2024	29974	23220	53194	30129	22973	53102	30065	23542	53607	30014	23528	53543	30064	22940	53004

According to the results obtained, envelope improvement has reduced heating, cooling, and total loads. Since the study was conducted in Konya, which has a cold climate, and the building function is residential, the dominant load is heating. For this reason, the envelope improvement has been more effective in reducing heating loads, and the reduction rate in heating loads is higher than the reduction rate in cooling loads. Additionally, since the energy consumption of settlements with an A-type plan is lower, it was determined that the envelope improvement is more effective and the total load is reduced more significantly.

Evaluation of Illuminance Level

In the study, to provide sufficient natural light in the buildings, ensure the homogeneous distribution of daylight, and reduce excessive lighting differences, a lighting and daylight analysis was carried out in accordance with the EN 17037 (2018) standard on the lowest floor of the blocks at 12:00 on March 21, the equinox when the duration of day and night is equal and the lighting conditions can be observed in an average manner.

The color legend showing the distribution of daylight factor (DF) or illuminance (lux) in different areas in the daylight and illuminance analyses performed is shown in Figure 4. According to the standard, at least 50% of an area should have an illumination level of 300 lux, and the distribution of the minimum illumination level should be balanced.

As shown in Table 19, which presents the results of daylight performance and illuminance level simulations for reference and alternative scenarios, the layouts with A and B plan types comply with the requirements of the EN 17037 standard, achieving an illuminance level of 300 lux in at least 50% of the area. When evaluated as a block, the daylight performance and illuminance level of the A-block type were found to be higher. This is because block type A has a rectangular plan, allowing daylight to reach deeper than block B, which has a square plan, and because its long side faces south, increasing its exposure to daylight. When examining the settlement in the A block type, it was observed that the A-linear-b settlement has the highest daylight performance and illumination level because the blocks are oriented diagonally toward the south, so they do not block each other's daylight. The simulation results measuring daylight, illuminance level and energy consumption in buildings are consistent with each other, thereby validating the findings. In terms of energy consumption, daylight potential, and illuminance level of the A-block type is the most advantageous alternative.

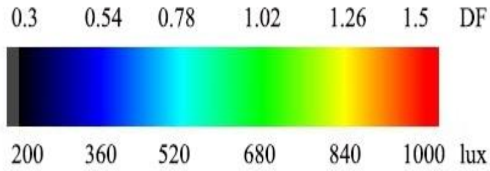
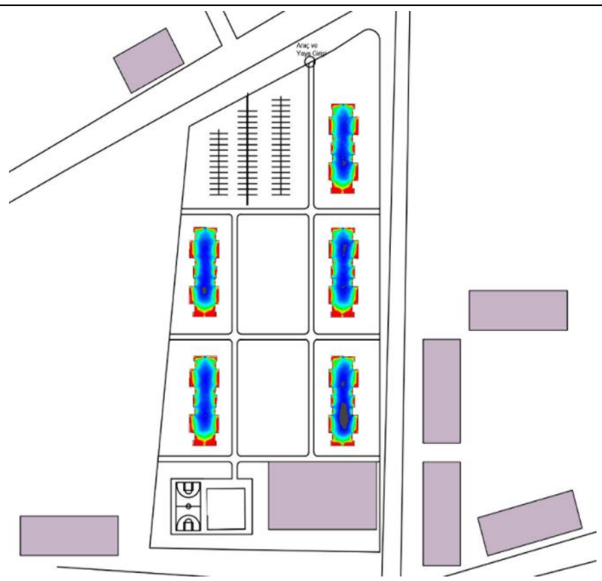
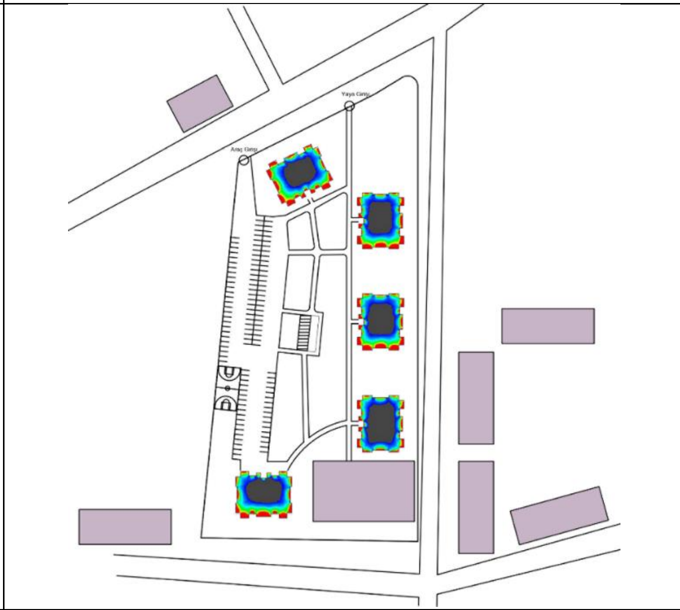
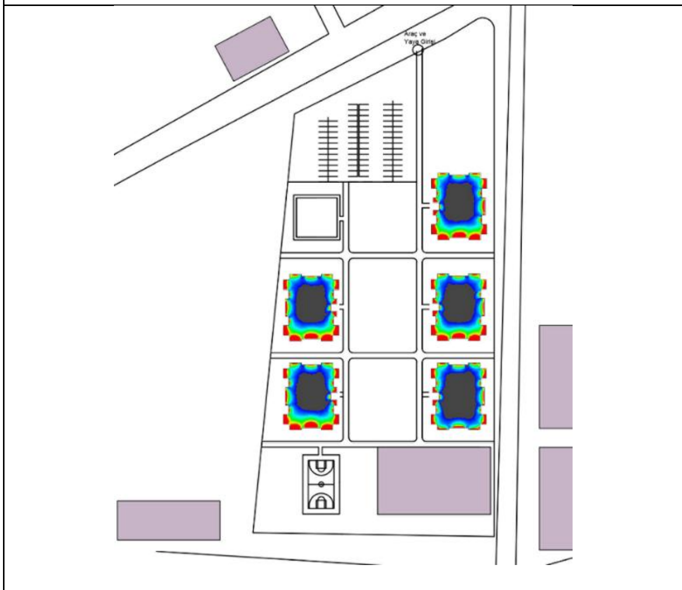
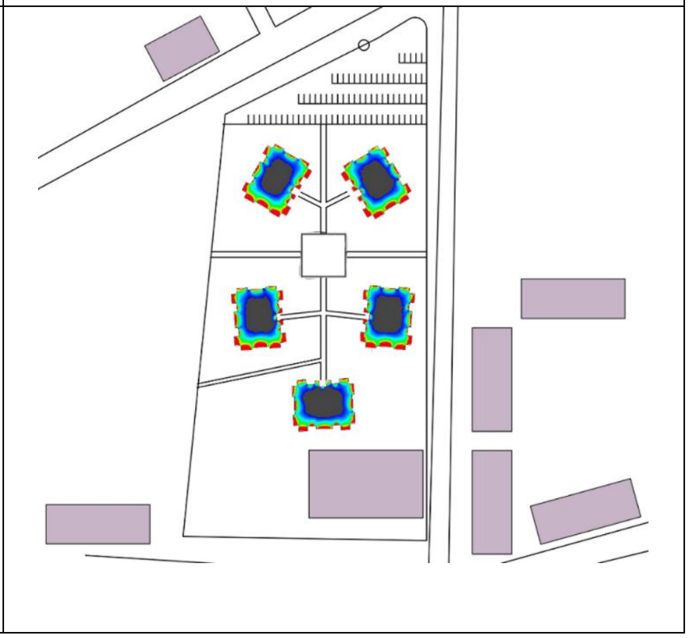


Figure 4. Color Legend for Daylight Factor (DF) and Illuminance (lux)

Table 19. Daylight Performance and Illuminance Level of The Situation Alternatives

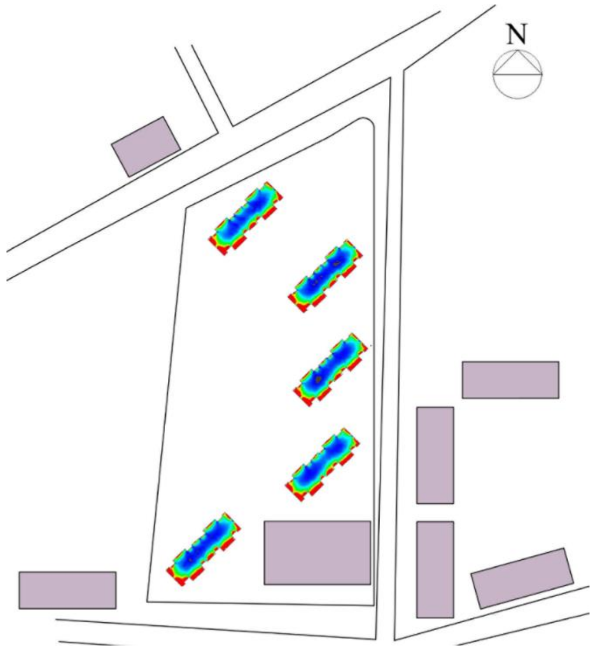
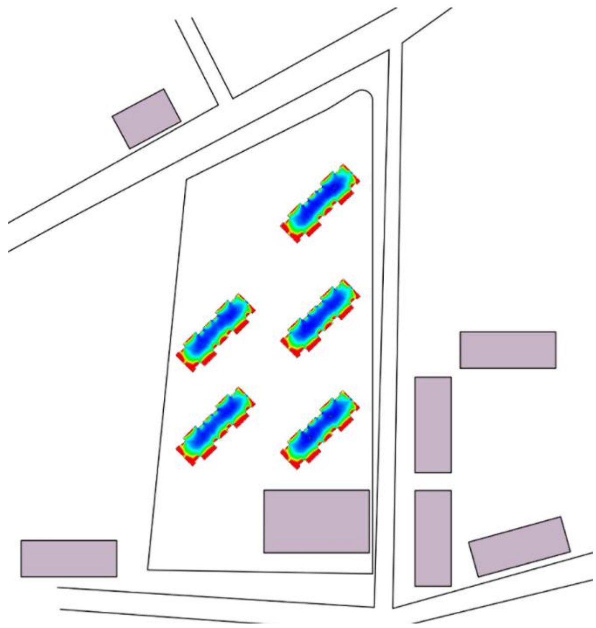
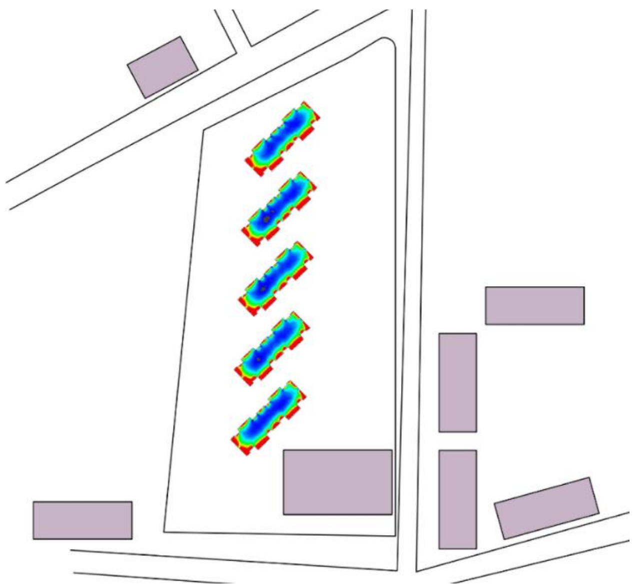
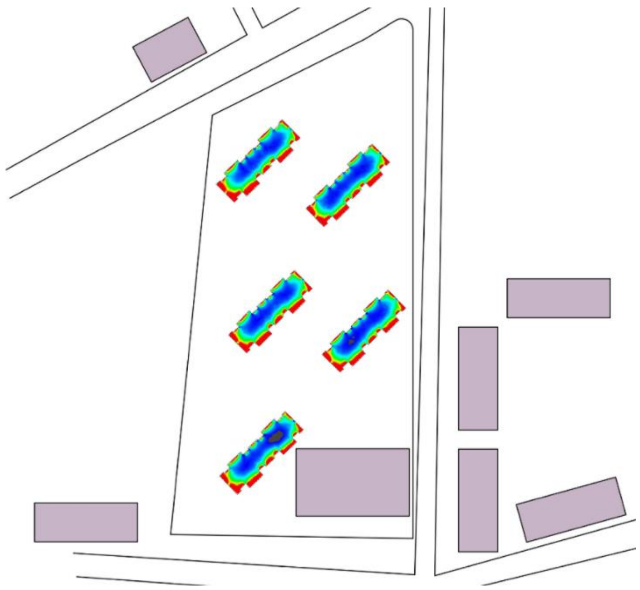
Reference Case	**A-Grid Plan Settlement**
	
A-Linear-a Settlement	**A-Linear-b Settlement**
	

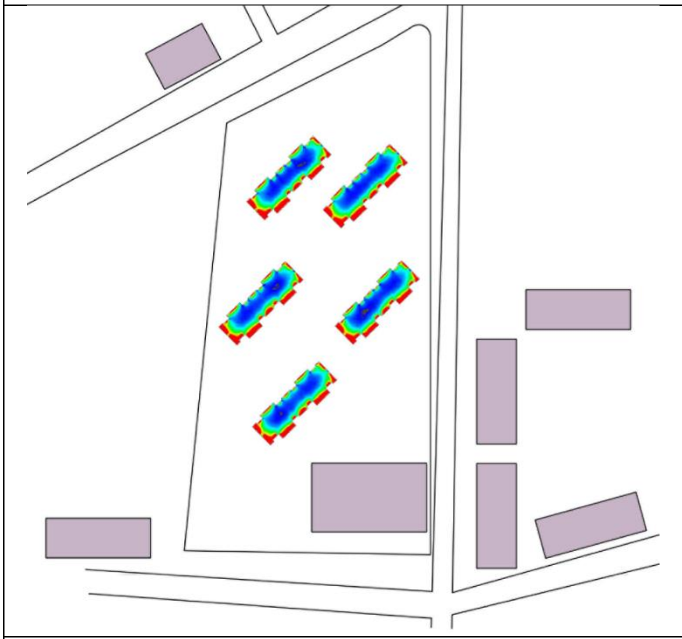
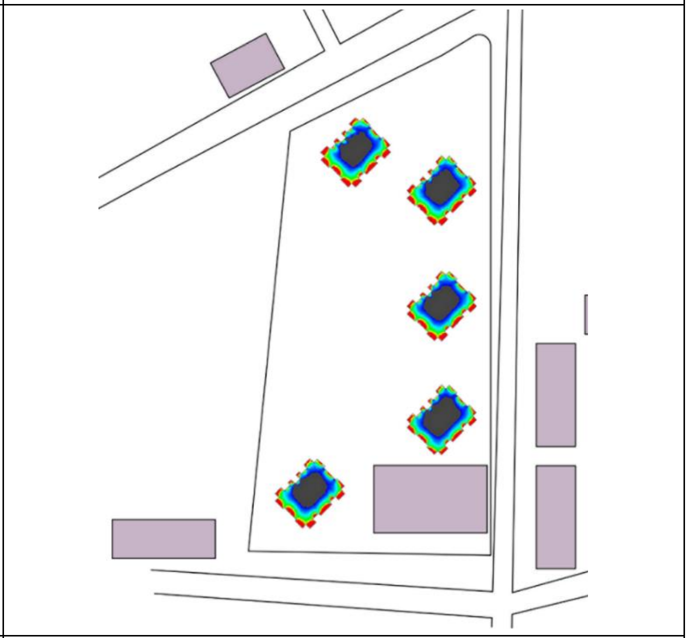
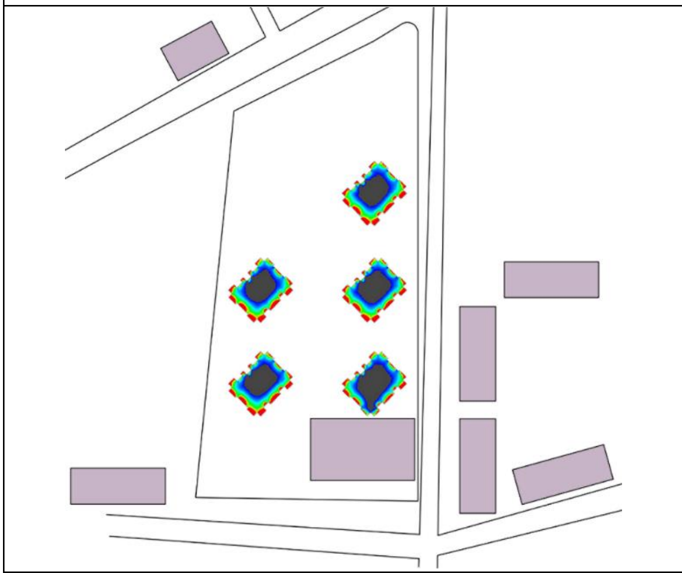
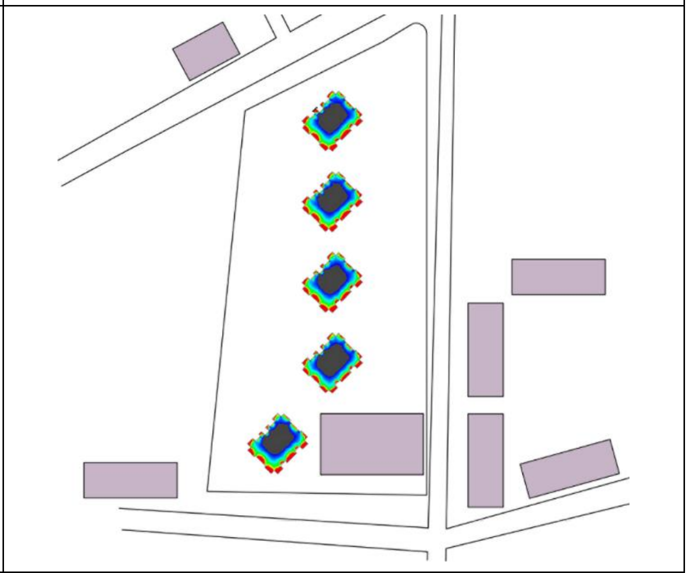
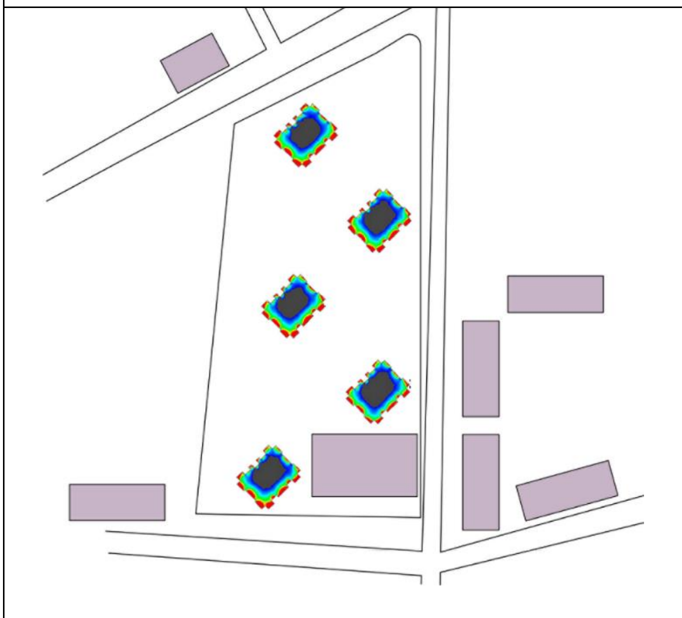
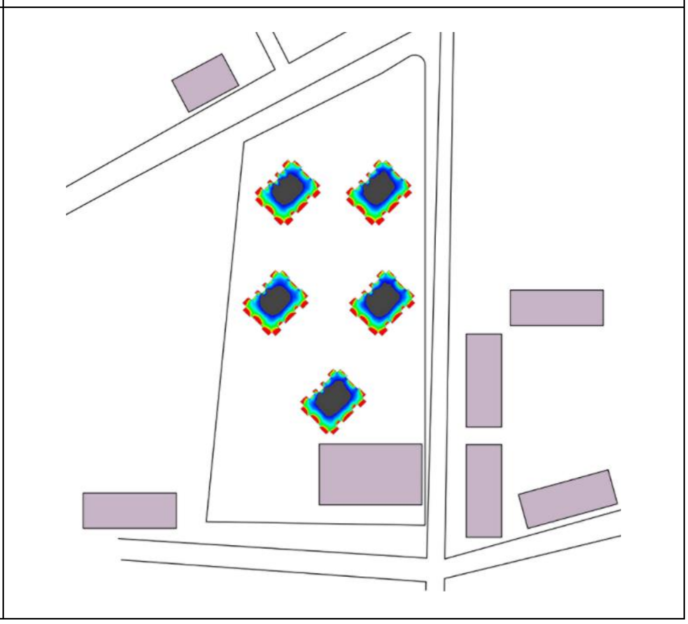
A-Radial Settlement	**B-Reference Case**
	
B-Grid Plan Settlement	**B-Linear-a Settlement**
	
B-Linear-b Settlement	**B-Radial Settlement**
	

Evaluation of Orientation Effect

This section analyzes the impact of the west and east-oriented alternative cases on energy consumption, daylighting performance, and illuminance level. Tables 20 and 21 present the daylighting performance-illuminance level and energy consumption of the 45° West alternatives, while Tables 22 and 23 show the daylighting performance-illuminance level and energy consumption of the 45° East alternatives. According to Table 20, the A-Linear-a Settlement demonstrates the highest daylight performance and illuminance level, achieving a 300 lux illuminance level in at least 50% of the minimum area specified by the EN 17037 standard.

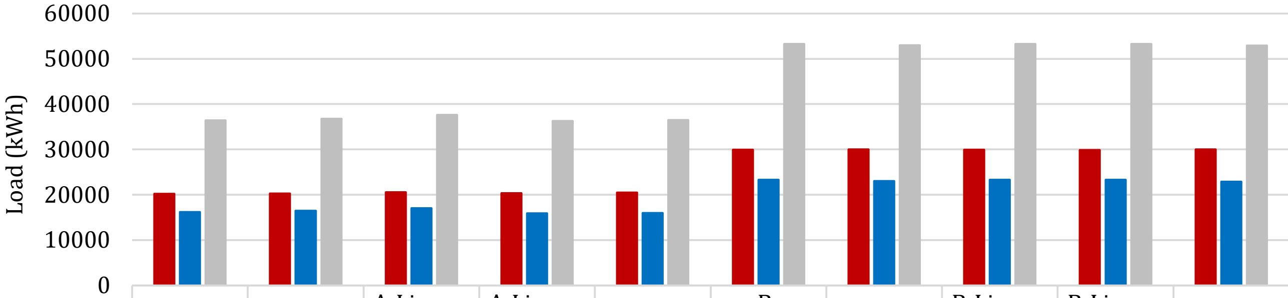
Table 20. Effect of Alternative Cases with 45° West Orientation on Daylight Performance and Illuminance Level

Reference Case	**A-Grid Plan Settlement**
	
A-Linear-a Settlement	**A-Linear-b Settlement**
	

A-Radial Settlement	**B-Reference Case**
	
B-Grid Plan Settlement	**B-Linear-a Settlement**
	
B-Linear-b Settlement	**B-Radial Settlement**
	

According to Table 21, the energy consumption of block type A, which has an orientation of 45º West, is less than that of block type B. The total load is the lowest for the A-Lineer-b Settlement type. Radial planning is the most efficient strategy for Type B, as it results in the lowest total load.

Table 21. Heating, Cooling and Total Load of Alternatives According to 45º to the West



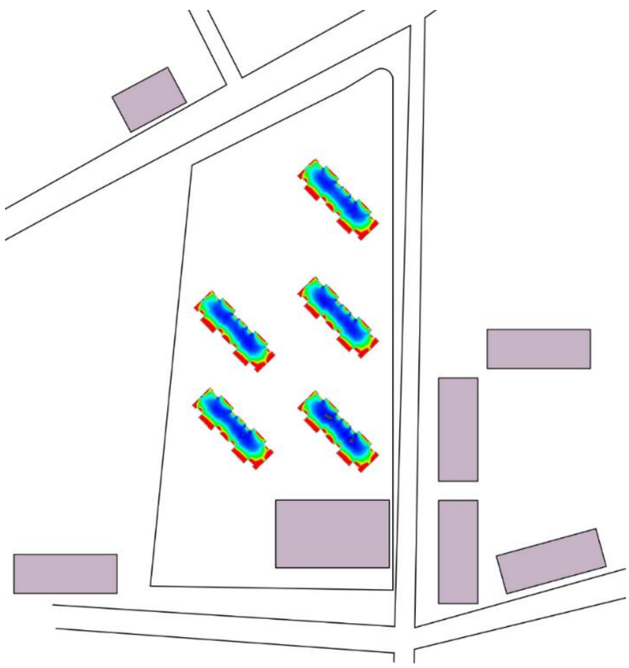
	Reference	A-Grid	A-Linear-a	A-Linear-b	A-Radial	B-Reference	B-Grid	B-Linear-a	B-Linear-b	B-Radial
Heating	20214	20273	20586	20346	20502	29951	29986	29953	29901	30041
Cooling	16210	16495	17035	15948	15997	23353	23030	23322	23349	22914
Total Load	36424	36767	37621	36294	36499	53304	53016	53275	53250	52955

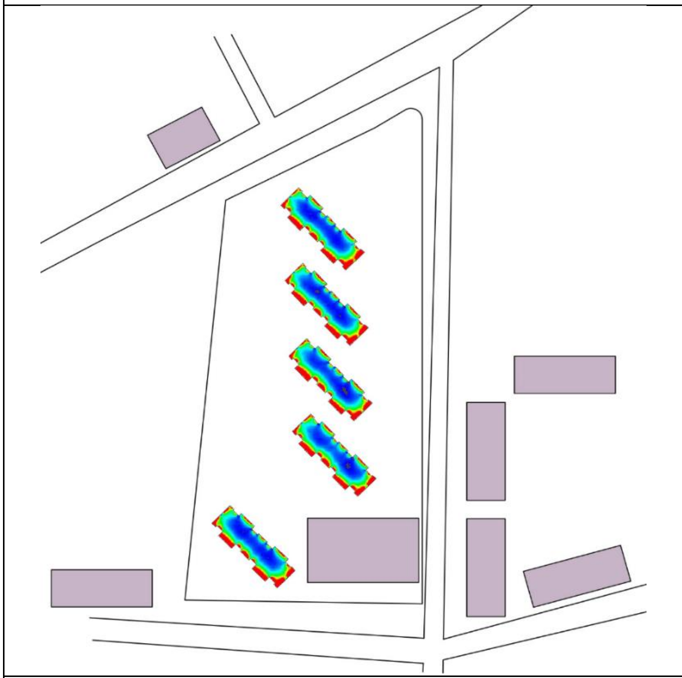
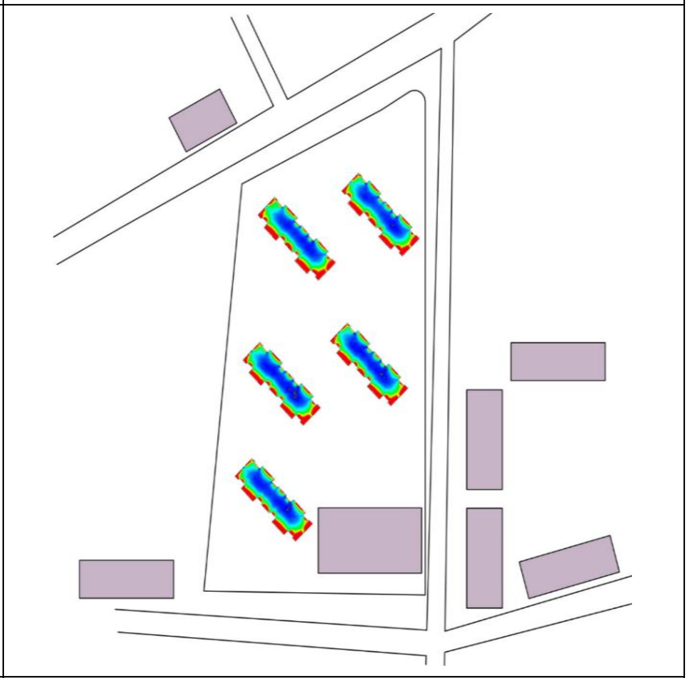
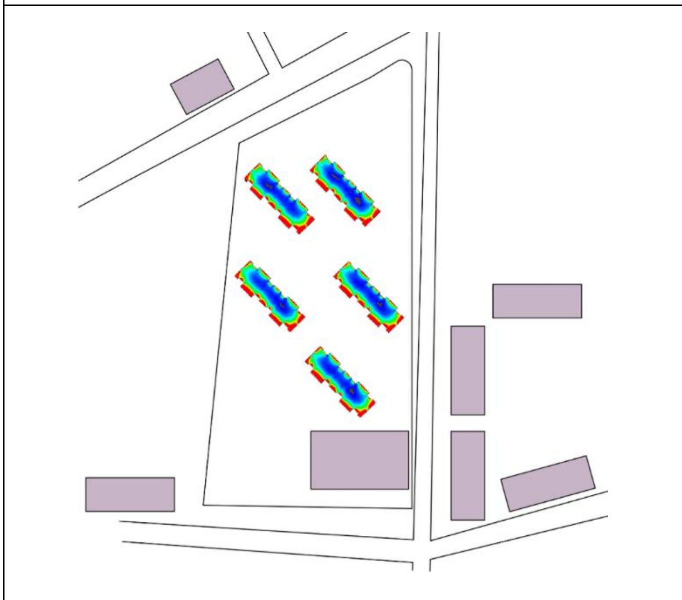
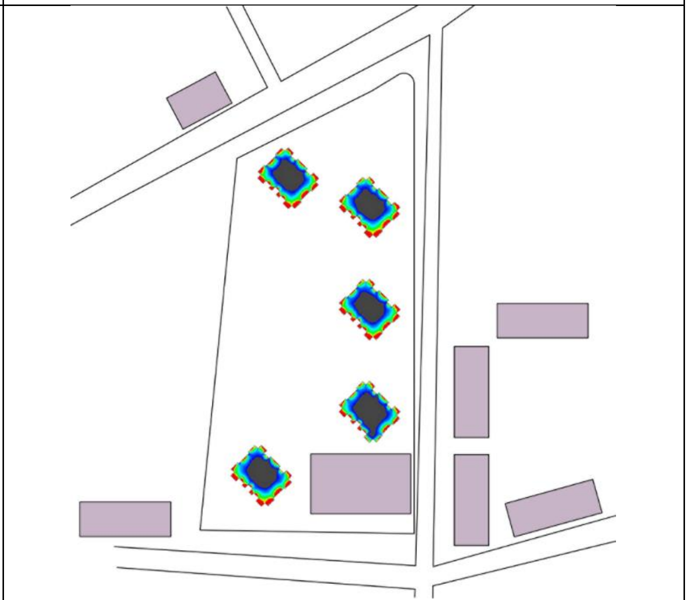
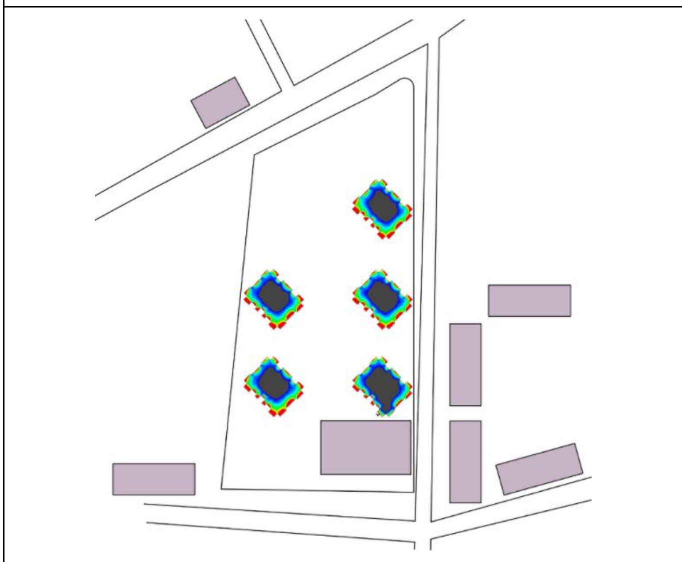
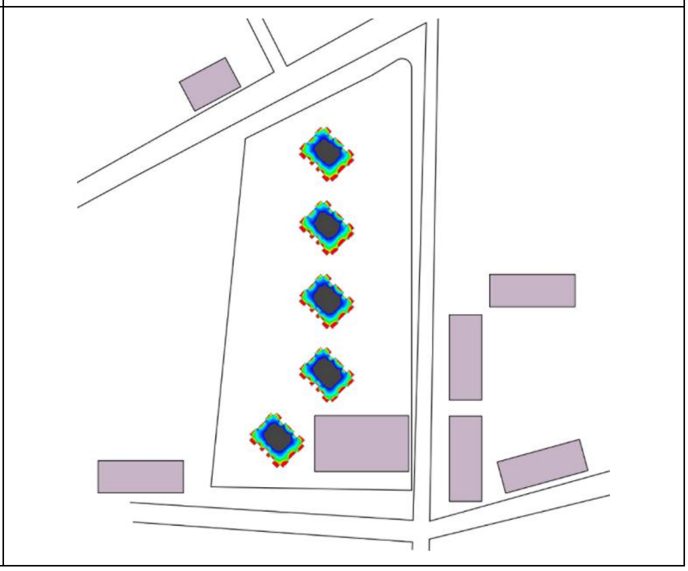
Alternatives

Heating Cooling Total Load

According to Table 22, the A-Grid Plan Settlement demonstrates the optimal daylighting performance and illuminance level. Furthermore, as illustrated in Table 23, the energy consumption of the 45° east-facing A block is comparatively lower than that of the B block. The A-Linner-a settlement exhibits the lowest total load, thereby indicating that block type A exhibits a notable energy performance advantage over block type B in scenarios with east and west orientations. In the case of an east orientation, energy consumption was found to be less than in the west orientation, albeit with a negligible difference. A comparison of cases involving different orientations revealed that the energy consumption was lower in cases without a change in orientation.

Table 22. Effect of Alternative Cases with 45º to the East on Daylight Performance and Illuminance Level

Reference Case	**A-Grid Plan Settlement**
	

A-Linear-a Settlement	A-Linear-b Settlement
	
A-Radial Settlement	**B-Reference Case**
	
B-Grid Plan Settlement	**B-Linear-a Settlement**
	

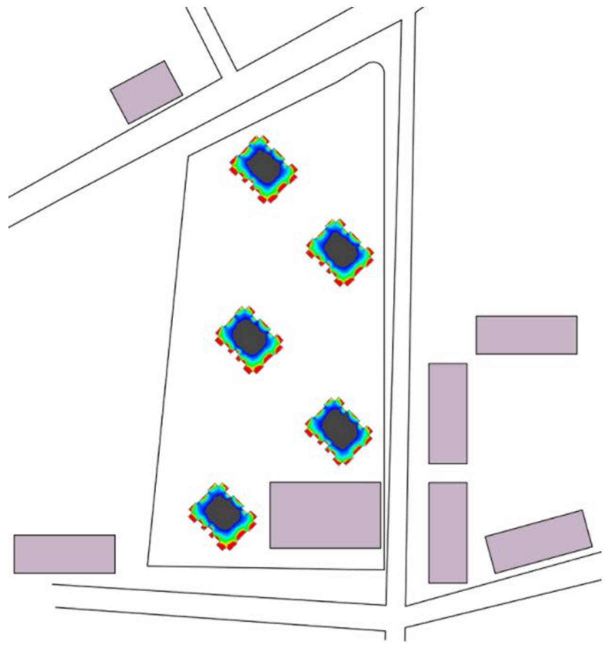
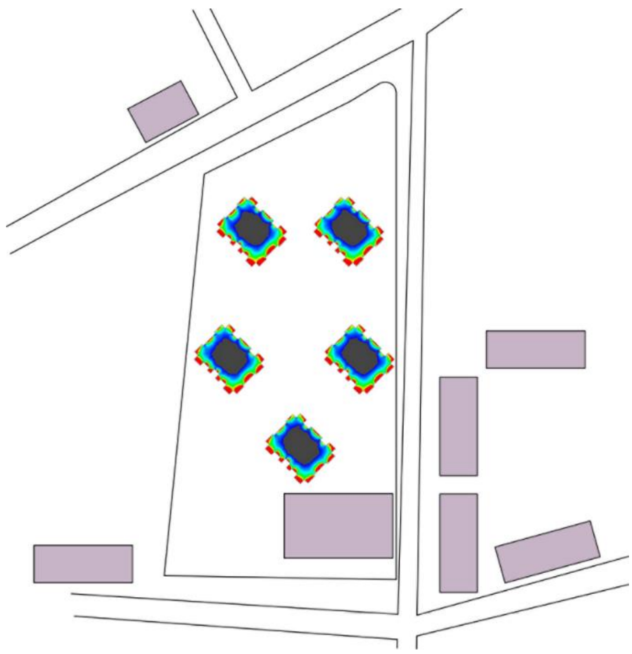
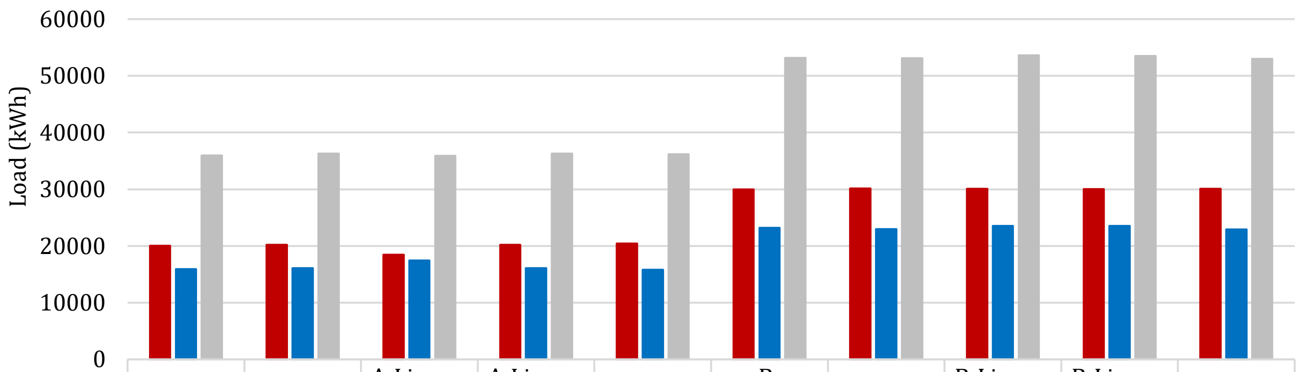
B-Linear-b Settlement	B-Radial Settlement
	

Table 23. Heating, Cooling and Total Load of Alternatives According to 45º to the East



	Reference	A-Grid	A-Linear-a	A-Linear-b	A-Radial	B-Reference	B-Grid	B-Linear-a	B-Linear-b	B-Radial
Heating	20034	20195	18487	20189	20411	29974	30129	30065	30014	30064
Cooling	15935	16092	17437	16118	15795	23220	22973	23542	23528	22940
Total Load	35969	36287	35924	36307	36206	53194	53102	53607	53543	53004

Alternatives

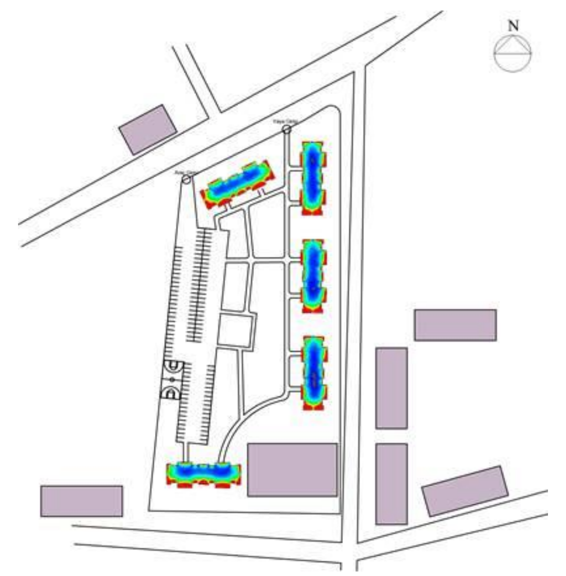
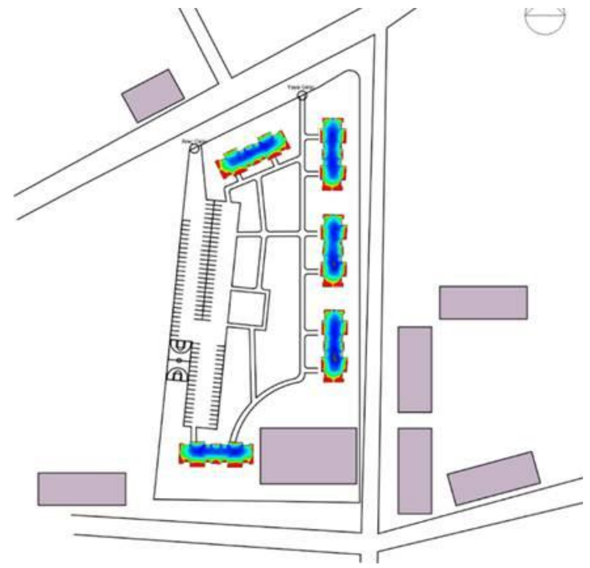
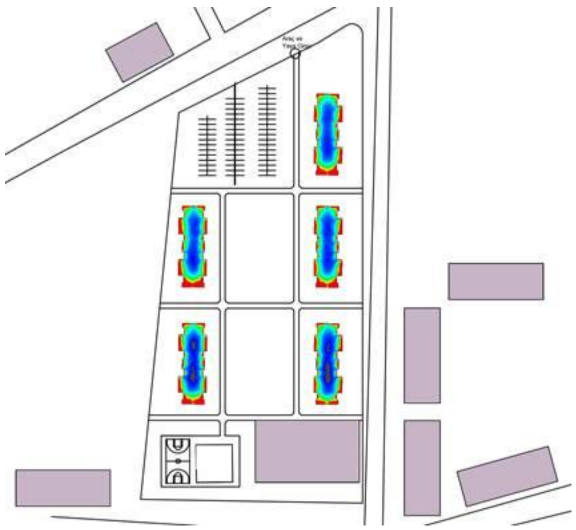
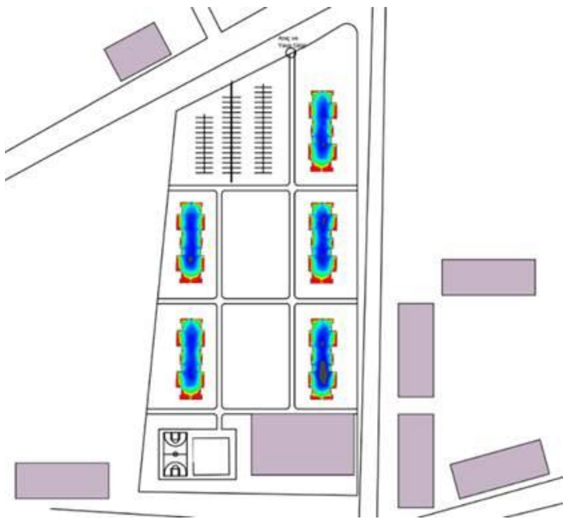
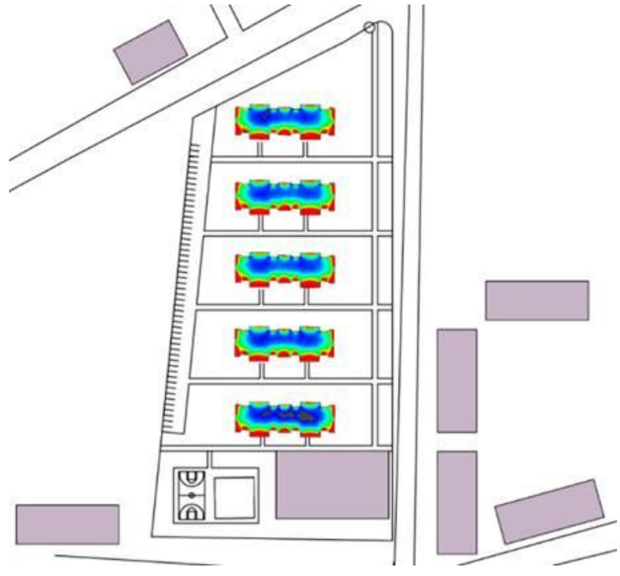
Heating Cooling Total Load

Evaluation of the Impact of Building Envelope Improvement on Illuminance Level

With the updated TS825:2024 standard, the window u-value has been reduced from 2.4 W/m^{2}K to 1.8 W/m^{2}K, and the use of coated glass such as Low-E or Solar Low-E has become mandatory (TS825, 2024: Atalay and Aydın Yağmur, 2025). This section aims to evaluate the effect of changes in window type and envelope U-values under TS825:2024 on daylight performance and illuminance level. Therefore, based on Tables 5 and 6, which show the building envelope U-values according to TS825:2008 and TS825:2024 standards, the daylight performance and illuminance level of all alternatives are presented in Tables 24 and 25. The color legend showing the distribution of daylight factor (DF) or illuminance (lux) in different areas in the daylight and illuminance analyses performed is shown in Figure 4.

Table 24 shows the daylight performance and illuminance level of A-planned settlement alternatives according to the TS825:2008 and TS825:2024 standards. Daylight and illuminance simulations indicate that, in accordance with the TS825:2024 standard, replacing the window with low-e glass results in a slight decrease in indoor illuminance levels and daylight performance. Although low-e glass has improved thermal performance due to its lower visible transmittance value, it has reduced illuminance levels and daylight performance.

Table 24. The Effect of Building Envelope Improvement on Daylight Performance and Illuminance Level in Settlement Alternatives with Plan Type A

Daylight and illuminance level according to TS825:2008 standard	Daylight and illuminance level according to TS825:2024 standard
Reference Case	**Reference Case**
	
A-Grid Plan Settlement	**A-Grid Plan Settlement**
	
A- Linear-a Settlement	**A- Linear-a Settlement**
	

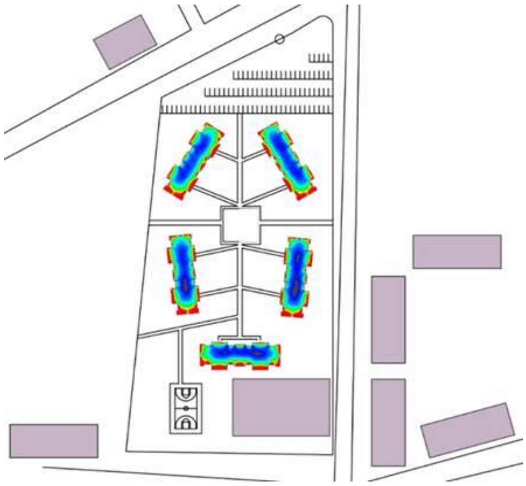
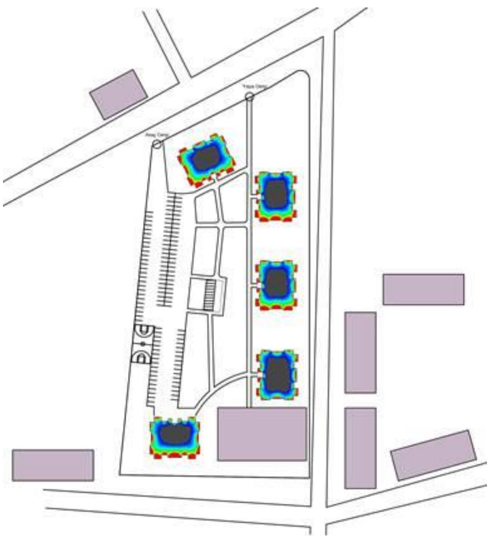
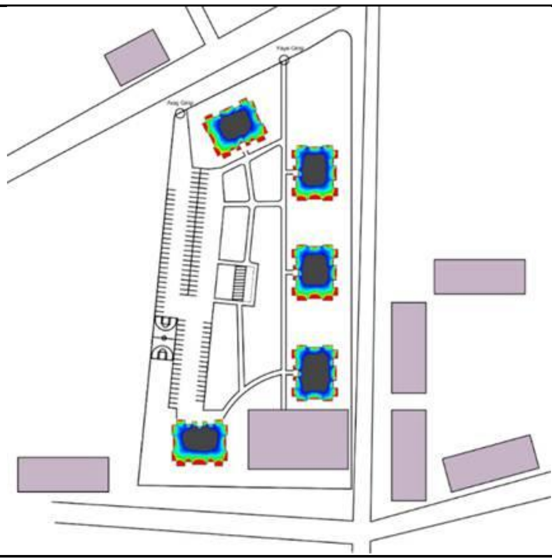
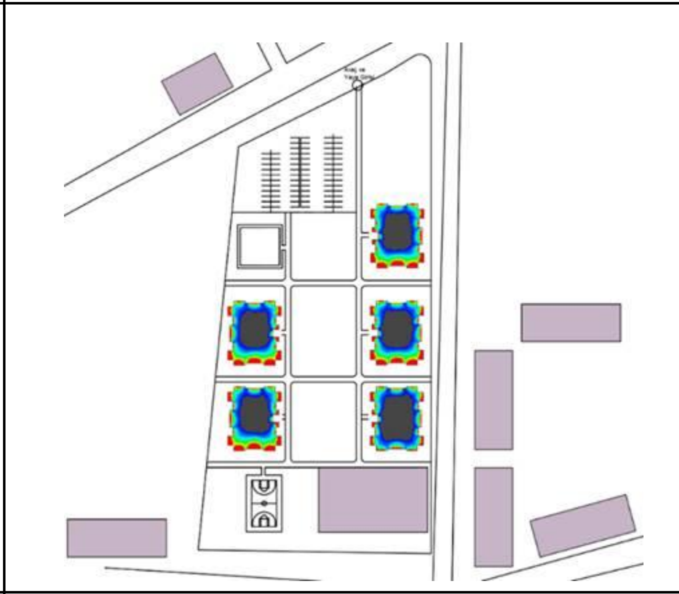
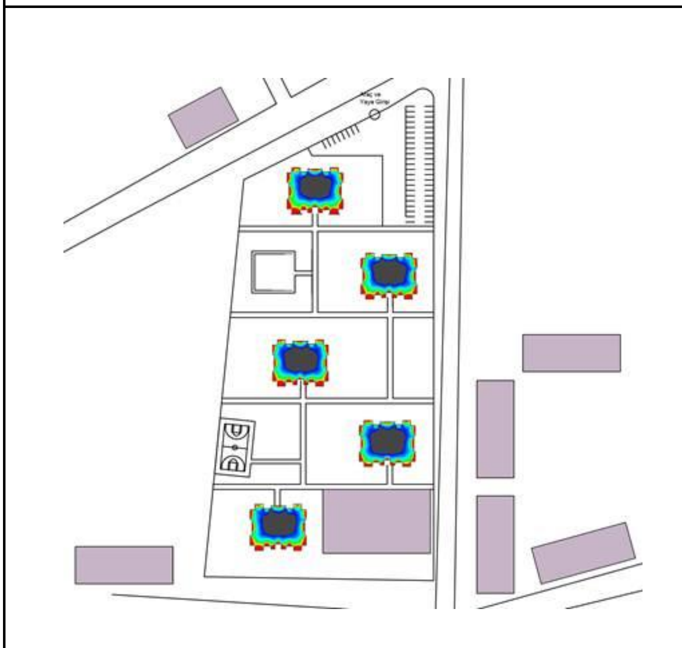
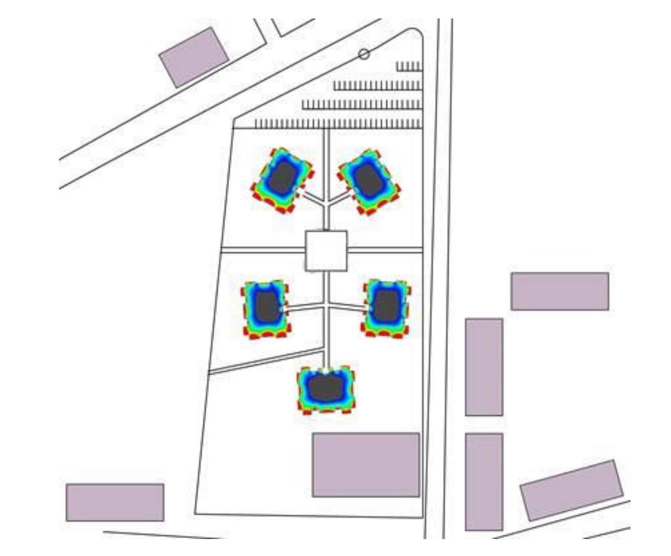
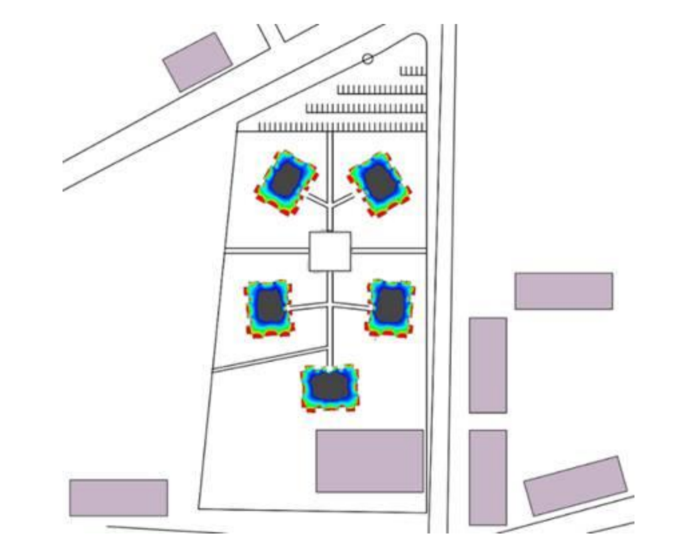
A- Linear-b Settlement	A- Linear-b Settlement
	
A-Radial Settlement	**A-Radial Settlement**
	

Table 25 shows the daylight performance and illuminance level of B-planned settlement alternatives according to TS825:2008 and TS825:2024 standards. Similar to Plan A, Plan B also shows a slight decrease in indoor illuminance levels and daylight performance when the window is replaced with low-e glass according to the TS825:2024 standard.

Table 25. The Effect of Building Envelope Improvement on Daylight Performance and Illuminance Level in Settlement Alternatives with Plan Type B

Daylight and illuminance level according to TS825:2008 standard	Daylight and illuminance level according to TS825:2024 standard
B-Reference Case	**B-Reference Case**
	

B-Grid Plan Settlement	B-Grid Plan Settlement
	
B- Linear-a Settlement	**B- Linear-a Settlement**
	
B- Linear-b Settlement	**B- Linear-b Settlement**
	

B-Radial Settlement	B-Radial Settlement
	

As a result of the analyses conducted, it was determined that the A plan type settlement is more advantageous than the B plan type in terms of daylight performance and illuminance levels. In both plan types, a minor decrease in daylight performance and illuminance levels was observed in accordance with the building envelope and window characteristics updated to comply with the TS825:2024 standard. However, this decrease is negligible. The conclusion drawn from this is that replacing the glass with low-e glass in accordance with the requirements of the TS825:2024 standard has increased thermal performance but did not result in a significant change in daylight performance and illuminance levels.

CONCLUSION

It is crucial for sustainability to reduce energy consumption and improve the daylighting performance and illuminance level of buildings. This study analyzes different residential settlement typologies considering these factors. The energy consumption, daylighting performance and illuminance level of a reference site in the Meram district of Konya and 36 residential scenario areas with similar characteristics are evaluated according to different plan types, block types, and orientations. In addition, shell values were improved in accordance with the TS825:2024 standard, and the improvement rate was examined by comparing them with the TS825:2008 values.

According to the results of the study, the A-linear-b settlement type has the highest daylight, illumination levels and lowest total energy consumption. In this context, it is recommended that blocks be designed in a rectangular shape and that the short side be limited so that it does not exceed the length of the façade through which daylight can reach its maximum level. At the same time, positioning the long side facing south ensures that the blocks benefit from daylight to the highest degree. This increases solar gain and reduces the dominant heating load, resulting in significant reductions in the total load.

In addition, it is important to plan building settlements in a linear plane, with blocks spaced so that they do not block each other's daylight and allow for natural airflow between them. In particular, avoiding settlements at an angle of approximately 45° to the north-south axis is a promising approach for improving both daylight performance and energy efficiency.

Finally, designing the layers forming the building envelope in accordance with the TS825:2024 standard, particularly by updating the envelope thermal conductivity coefficients (U-values), can achieve an average reduction of 25% in total energy loads.

This study adopts an approach based on settlement typology in urban planning, addressing a dimension that has been largely overlooked in previous studies. The literature mostly examines building layouts in terms of building spacing, building heights, and density. It also touches upon the envelope configuration, which clearly affects energy expenditure. Most of these studies are in grid-based planning systems, and they do not take settlement typologies into account. This shows that settlement typologies also affect energy loads. This study is pioneering, and its next stages will extend it to consider other factors (settlement density, albedo, etc.) using optimization programs to get the enhanced solution for typologies. The study was conducted in a province with flat topography, but it is expected that topography may create different results in terms of energy expenditures in settlements. To ensure the robustness of our findings, we will replicate the study with varying slopes and settlements in subsequent stages. The impact of these variations on our results will be systematically investigated.

This study underlines the significance of expressing building layouts that enhance energy efficiency in accordance with local climatic conditions and environmental factors within architectural design processes, thereby providing a foundation for future research. Notably, the study omitted elements that influence the layout of residential areas from a social perspective. It is proposed that incorporating social dimensions into the study's results may be achieved by assessing the study area's utilization from a social perspective, in conjunction with numerous factors such as outdoor user behaviours, integration, accessibility, and centrality.

REFERENCES

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