

Resident Typologies Based on Preferences for Energy-Efficient Building Design: Evidence from Low-Income Urban Settlements in Indonesia

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Abstract

The residential sector is a major contributor to global energy consumption and carbon emissions, making improvements in residential building energy efficiency essential for sustainable development. Occupant-centred approaches, which account for residents' preferences, behaviours, and socio-technical characteristics, have been shown to achieve more effective energy conservation than technology-driven strategies alone. This study aims to identify the underlying dimensions of residents' preferences for energy-efficient building design and to develop resident typologies based on these preferences in a low-income urban settlement. A questionnaire survey was conducted with 223 households in Kapuk Subdistrict, West Jakarta, Indonesia. Exploratory Factor Analysis (EFA) was applied to identify the latent dimensions of residents' preferences, and the resulting factor scores were subsequently used in a two-stage cluster analysis consisting of Hierarchical Cluster Analysis followed by K-means clustering. The analysis identified five preference dimensions: Energy Efficiency Preference, Climate-Responsive Building Design Awareness, Natural Ventilation Preference, Passive Thermal Comfort Preference, and Natural Daylighting Preference and three distinct resident typologies: Low-Engagement Residents, Energy-Conscious Residents, and Passive Comfort Seekers. The findings indicate that these typologies differ primarily in their design priorities, reflecting variations in occupants' comfort needs, environmental perceptions, and housing expectations rather than socioeconomic characteristics alone. The identified preference dimensions were further translated into practical design strategies tailored to each resident typology. This study contributes by proposing a preference-based occupant segmentation framework that links latent preference dimensions with occupant-centred housing design strategies. The findings provide an empirical basis for developing more responsive, acceptable, and effective energy-efficient housing for low-income urban communities.

1. Introduction

The residential sector is a major contributor to global energy consumption and carbon emissions. Residential buildings account for approximately 70% of the total energy demand within the building sector, making the improvement of residential energy efficiency a critical component of building sector decarbonisation strategies. (IEA, 2025; UNEP, 2025). In this context, improving the energy efficiency of residential buildings has become a key strategy for reducing energy consumption in the building sector while mitigating its environmental impacts. (Lee et al., 2025) This is particularly important in urban areas of developing countries, where rapid economic growth and urbanisation continue to drive increasing demand for housing and energy. One of the most widely adopted approaches to improving building energy performance is building retrofitting, which involves upgrading existing buildings through design interventions and technological improvements. Previous studies have shown that retrofit strategies implemented in residential buildings can reduce energy consumption by up to 70% and decrease CO₂ emissions by approximately 40% (AlMaqremi & Abdou, 2026; Maliki et al., 2020). Therefore, improving the energy efficiency of residential buildings not only contributes to reducing energy consumption and carbon emissions but also supports the development of more sustainable cities.

Residents living in densely populated urban settlements collectively contribute substantially to urban energy demand (Güneralp et al., 2017; Norman et al., 2006). Low-income households are often compelled to choose affordable housing located in high-density neighbourhoods due to economic constraints. Studies have consistently shown that densely populated informal settlements are predominantly inhabited by low-income and socioeconomically disadvantaged communities (Mottelson & Venerandi, 2023; Ren et al., 2020; Winarso et al., 2015; Zhu et al., 2023). Furthermore, high building density often results in poor environmental quality and inadequate thermal comfort, with many of these neighbourhoods exhibiting characteristics of urban slums (Winarso et al., 2015). Consequently, many dwellings in these areas fail to meet basic standards of adequate housing, while the adoption of energy-efficient building design strategies remains limited. Nevertheless, improving housing quality through climate-responsive and energy-efficient design has considerable potential to enhance residents' quality of life while reducing household energy consumption. Therefore, understanding occupants' needs and preferences for energy-efficient housing design is essential for developing design interventions that are responsive to the socio-economic context of low-income urban communities.

As a developing country, Indonesia faces increasingly significant challenges in addressing these issues amid rapid urbanisation and the growing demand for urban housing. Jakarta, the capital city of Indonesia, is the country's most populous city, with a population exceeding 10.8 million in 2025 (BPS, 2025a). Rapid population growth, urbanisation, and rural-to-urban migration have substantially increased the demand for adequate and affordable housing. However, the limited supply of housing, coupled with land scarcity, has intensified pressure on urban housing provision, resulting in the widespread presence of high-density, low-income settlements across many Indonesian cities (BPS, 2025b; UNEP, 2025; UN-Habitat, 2024).

In the context of energy-efficient housing design, an occupant-centred approach that considers residents' preferences, behaviours, and socio-technical characteristics has been shown to be more effective in reducing energy consumption than strategies that rely solely on technological solutions (Pourtangestani et al., 2024; Wineman & Hamilton, 2014). Integrating occupants' preferences and characteristics into the design process is therefore essential, as conventional design approaches often fail to bridge the gap between predicted and actual building energy performance (Elmualim, 2012). Previous studies have demonstrated that providing occupants with greater personal control over building systems, such as lighting, heating, ventilation and air-conditioning (HVAC), and external shading devices, can improve the alignment between occupants' needs and building energy performance (Nagy et al., 2016; Yuan et al., 2020). Furthermore, occupants' socio-economic and cultural characteristics have been found to influence the magnitude of the energy performance gap through differences in building use patterns, energy-related behaviours, and household characteristics (Gram-Hanssen, 2010; Van Den Brom et al., 2018). This issue is particularly important because occupants' activity patterns and comfort requirements are inherently dynamic and diverse. Consequently, energy efficiency strategies should be designed to accommodate occupants' needs without compromising their comfort and quality of life (Hellwig et al., 2019; Mitra et al., 2021).

Several studies have examined occupants' preferences for various energy-efficient building design features, particularly passive design strategies that enhance thermal comfort while reducing energy consumption. Previous research has identified window performance and external shading as key design elements influencing both occupants' comfort perceptions and household electricity consumption (Lou et al., 2024; Makhoul et al., 2025). Natural ventilation and operable windows are also consistently preferred because they improve thermal comfort while providing occupants with greater control over their indoor environment (Fabi et al., 2012; Foldbjerg et al., 2014; Lou et al., 2024). Beyond occupants' preferences, numerous studies have demonstrated the effectiveness of passive design features in improving building energy performance. For example, external shading can reduce cooling loads by approximately 30–35% and lower indoor air temperatures by 1–5°C in buildings located in tropical climates (Mohammed et al., 2022; Sulaiman et al., 2024; Turner et al., 2022). Collectively, these findings indicate that occupants generally exhibit strong preferences for passive design strategies because they simultaneously improve thermal comfort and reduce household energy consumption.

Among low- and middle-income households, preferences for building features are often driven by directly perceived benefits, such as material quality, structural integrity, durability, and affordability. Consequently, housing decisions cannot be explained solely by household income levels (Alegbe, 2024). The same study further indicates that energy-efficient features with visible physical attributes, such as roofs, walls, and external shading devices, tend to be valued more highly than technologies that are less apparent to occupants. Similarly, other studies have found that residents prefer energy efficiency measures that provide tangible economic benefits, such as photovoltaic (PV) systems and energy subsidy programmes, because they help reduce household energy costs (Seyedrezaei et al., 2025). In contrast, more advanced energy-efficient building technologies are often less attractive because they are perceived as expensive, complex, and associated with higher maintenance costs (Ogunsanya, 2026). Overall, these findings suggest that preferences for energy-efficient building design are shaped not only by the potential for energy savings but also by considerations of comfort, economic benefits, ease of use, and occupants' perceptions of the value and usefulness of individual building features.

Growing evidence in the field of energy-efficient buildings indicates that energy-related behaviours and housing preferences cannot be generalised across occupants, as they are inherently heterogeneous. Numerous studies have shown that occupants' energy-related decisions are influenced by socio-economic characteristics, housing conditions, personal experiences, and individual comfort needs (C. Chen et al., 2022; Noda et al., 2025; Palani et al., 2023; Pourtangestani et al., 2024). These findings have stimulated the development of occupant segmentation approaches, which aim to identify groups of occupants with similar characteristics and preferences in order to better understand the diversity of building users' needs (C. Chen et al., 2022; Risetto & Schweiker, 2024). Consistent with this trend, the concept of user-centred housing design has gained increasing attention in sustainable building research and practice by placing occupants' preferences and needs at the core of energy efficiency strategies (Furman & Hadjri, 2026; Hong et al., 2023; Li et al., 2021). This approach has been shown to reduce the gap between predicted and actual building energy consumption while improving occupants' acceptance

of energy-efficient design strategies (Bahadori-Jahromi et al., 2022; Lorenz et al., 2023; Nazeer et al., 2025).

However, most previous studies have focused on the general occupant population and have primarily examined energy consumption behaviour in relation to household appliance use or building operational practices (C. Chen et al., 2022; Noda et al., 2025; Palani et al., 2023). Meanwhile, research on occupants' preferences has largely been limited to evaluating individual design features, such as natural ventilation, daylighting, external shading systems, or specific energy-efficient technologies, in isolation (Fabi et al., 2012; Lou et al., 2024; Makhoul et al., 2025). Such approaches provide only a partial understanding of how occupants' preferences for energy-efficient building design influence energy-related behaviours across different socio-economic groups. Furthermore, although studies on occupant segmentation and profiling have become increasingly common (X. Chen & Hu, 2023; Risetto & Schweiker, 2024), research that identifies the latent structure of occupants' preferences and develops resident typologies based on these underlying preference dimensions remains scarce, particularly among low-income urban communities in developing countries. As a result, existing energy-efficient housing design strategies tend to be generic and are often unable to adequately accommodate the diversity of occupants' needs, preferences, and socio-economic circumstances.

To address these research gaps, this study aims to identify the underlying dimensions of occupants' preferences for energy-efficient building design and to develop resident typologies based on these preference characteristics in low-income urban settlements in Indonesia. The study further examines differences in socio-economic characteristics across the identified resident typologies to better understand variations in occupants' needs and design preferences. Unlike previous studies, which have generally examined design preferences, energy-related behaviours, or socio-economic characteristics separately, this research proposes a preference-based occupant segmentation framework that integrates latent preference dimensions, resident typologies, and socio-economic characteristics within a single analytical framework. This framework not only identifies groups of occupants with similar preference patterns but also translates the distinctive characteristics of each typology into adaptive, occupant-centred design strategies for energy-efficient housing that are tailored to the needs of low-income urban communities in Indonesia.

2. Methodology

2.1 Case study

More than 63% of households in the Special Capital Region of Jakarta (DKI Jakarta) continue to live in inadequate housing (Ferdiansyah, 2022). This highlights that housing quality remains a major challenge in the provision of urban housing, particularly for low-income communities. At the same time, high population density and the complexity of upgrading informal settlements have made urban revitalisation a key development priority in Jakarta. In line with these challenges, housing revitalisation in Kapuk Urban Village was designated as one of the government's priority programmes in 2025 (Sari et al., 2025).

This study was conducted in Kapuk Urban Village, Cengkareng District, West Jakarta, Indonesia. The study area was selected because it represents a high-density, low-income urban settlement, making it an appropriate setting for investigating occupants' preferences for energy-efficient building design. According to data from Statistics Indonesia (Badan Pusat Statistik), the area covers approximately 562.68 ha and has a population density of approximately 164 inhabitants per hectare, reflecting substantial pressure on land availability and housing provision. These characteristics make Kapuk Urban Village a representative case for examining occupants' preferences for energy-efficient building design in low-income urban settlements in Indonesia. The characteristics of the study area and the housing conditions are presented in Fig. 1.

2.2 Survey

Data were collected through a field survey using a structured questionnaire administered via face-to-face door-to-door interviews conducted by trained surveyors. A total of 250 questionnaires were collected, of which 223 were deemed valid and included in the final analysis. Table 1 presents the questionnaire items used in this study. The questionnaire comprised two main sections. The first section collected information on respondents' demographic characteristics, household socio-economic conditions, and the physical attributes of their dwellings.

The second section was designed to identify occupants' preferences for energy-efficient building design. The questionnaire items were developed to capture six key dimensions of building design strategies: (1) natural ventilation and airflow, (2) daylighting, (3) solar shading, (4) building materials and colour, (5) general energy-efficient design strategies, and (6) active energy-efficient technologies. Together, these six dimensions encompass both passive and active design approaches that have been widely adopted to reduce energy consumption in residential buildings.

Table 1
Questionnaire Items

Questionnaire Component	Questionnaire Contents
Building Characteristics	Housing tenure, dwelling floor area, number of storeys, and other physical characteristics of the dwelling.
Household Characteristics	Household composition, monthly household income, household size, and other socio-economic characteristics.
Electricity Consumption	Monthly electricity bill, installed electrical capacity, electricity tariff type, and other electricity consumption information.
Fan Usage	Fan ownership, duration of use, frequency of use, and other related information.
Air Conditioner (AC) Usage	Air conditioner ownership, duration of use, frequency of use, and other related information.
Individual Characteristics	Gender, age, occupation, educational attainment, and other individual characteristics.
Energy-Saving Behaviour (Passive Behaviour)	Occupants' habitual practices and behaviours related to reducing household energy consumption.
Occupants' Preferences	Preferences for natural ventilation and airflow, daylighting, solar shading, building materials and colour, general energy-efficient design strategies, and active energy-efficient technologies.

The indicators for each preference dimension were developed through the synthesis and adaptation of design strategies identified in previous studies on energy-efficient building design (Elaouzy & El Fadar, 2022). The complete list of preference indicators is presented in Table 2. The study involved 223 households located in low- to middle-income urban settlements. Respondents were selected using a simple random sampling technique. All items measuring occupants' preferences for energy-efficient building design were assessed using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree, with higher scores indicating stronger preferences for the adoption of energy-efficient building design strategies.

Table 2
Energy-Efficient Building Design Preference Items

No	Questionnaire Statement	Scale				
		1	2	3	4	5
Natural Ventilation and Airflow						
1	I prefer a home with good natural ventilation.					
2	I feel comfortable in a home with good airflow.					
3	I prefer a home that does not feel stuffy.					
4	I prefer a home that remains cool even without air conditioning.					
Daylighting						
5	I prefer a home that is bright during the daytime.					
6	I like natural sunlight entering my home.					
7	I feel comfortable in rooms that require little artificial lighting during the day.					
Solar Shading						
8	I prefer homes with window shading devices (e.g., canopies or external blinds).					
9	A home protected from direct sunlight feels more comfortable to me.					
10	I am interested in homes with solar shading for windows or terraces.					
Building Materials and Colour						
11	I prefer a home that does not feel hot indoors.					
12	I prefer homes with light-coloured exterior finishes.					
13	I believe that building materials influence indoor thermal conditions.					
14	I feel more comfortable in homes with cool floor surfaces.					
General Energy-Efficient Design						
15	I am interested in homes designed to remain cool naturally.					
16	I prefer homes that are comfortable without relying heavily on cooling equipment.					
17	I am willing to consider design features that help reduce indoor heat.					
18	I believe that house design affects everyday comfort.					
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree						

No	Questionnaire Statement	Scale				
		1	2	3	4	5
Natural Ventilation and Airflow						
19	I prefer homes with larger or more numerous windows.					
20	I am interested in homes with a small yard or open outdoor space.					
Active Energy-Efficient Technologies						
21	I am interested in using energy-efficient household appliances.					
22	I prefer homes equipped with energy-efficient lighting.					
23	I am interested in homes that use solar photovoltaic (PV) panels.					
24	I am willing to consider energy-efficient cooling systems.					
25	I prefer homes that use technologies to reduce electricity consumption.					
1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree						

2.3 Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) was employed to identify the latent dimensions underlying occupants' preferences for energy-efficient building design. Because the objective of this study was to identify the underlying latent constructs rather than merely reduce the number of observed variables, the Principal Axis Factoring (PAF) extraction method was adopted (Costello & Osborne, 2005). Prior to factor extraction, the suitability of the data for factor analysis was assessed using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. In addition, the adequacy of each variable was evaluated using the Anti-Image Correlation matrix, with values greater than 0.50 indicating sufficient sampling adequacy and supporting the retention of variables in the factor analysis.

To obtain a simpler and more interpretable factor structure, Varimax rotation with Kaiser normalization was applied. The number of retained factors was determined using the Kaiser criterion (eigenvalues > 1.0). Factor interpretation was based on a minimum loading threshold of 0.50, as values above this threshold indicate a sufficiently strong association between the observed variables and their underlying latent constructs. Accordingly, only variables with factor loadings of 0.50 or greater were retained for factor interpretation and naming (Hair et al., 2014). The factor scores derived from the final EFA solution were subsequently used as input variables for the cluster analysis to classify respondents according to similarities in their preferences for energy-efficient building design. Using factor scores, rather than the original questionnaire items, also helped minimise multicollinearity among the input variables while providing a more parsimonious representation of the underlying preference dimensions.

2.4 Cluster Analysis

Cluster analysis was performed to classify respondents according to similarities in their preferences for energy-efficient building design. The analysis was based on the factor scores obtained from the Exploratory Factor Analysis (EFA), which provide a parsimonious representation of the underlying preference dimensions while reducing potential multicollinearity among the original questionnaire variables. A two-stage clustering procedure was adopted. In the first stage, Hierarchical Cluster Analysis (HCA) was conducted using Ward's linkage method and Squared Euclidean Distance to explore the underlying data structure and identify the most appropriate number of clusters..

The optimal number of clusters was determined through the combined interpretation of the dendrogram and the agglomeration schedule, with substantial increases in the agglomeration coefficient indicating the appropriate point at which distinct clusters emerged. The selected number of clusters was subsequently used as the initial input for K-means Cluster Analysis, which refined the cluster membership to produce groups that were internally homogeneous and externally heterogeneous. This two-stage clustering approach is widely recommended because it combines the strength of Hierarchical Cluster Analysis in identifying an appropriate cluster solution with the ability of K-means to optimise cluster membership and improve the stability of the final classification (Hair et al., 2014).

2.5 Statistical Analysis

Statistical analyses were conducted to examine whether socio-economic characteristics and building attributes differed significantly across the identified resident clusters. This analysis aimed to explore the relationship between occupant preference typologies and respondents' characteristics, thereby providing a more comprehensive interpretation of each cluster. Two statistical tests were employed. The Chi-square test was used to examine differences in the distribution of categorical variables across the clusters, including educational attainment, occupation, household income category, and housing tenure. The Kruskal–Wallis test was applied to compare continuous or ordinal variables that did not satisfy the assumption of normality across three or more independent groups, including household size, dwelling floor area, monthly electricity expenditure, and the ownership or use of household appliances (e.g., air conditioners and electric fans). Statistical significance was determined at $p < 0.05$, with p-values below this threshold indicating significant differences among the identified clusters.

2.6 Prioritisation of Energy-Efficient Building Design Strategies

The results of the Exploratory Factor Analysis (EFA) were subsequently used to prioritise energy-efficient building design strategies. This prioritisation aimed to identify the relative importance of each design strategy across the identified resident clusters based on their preference patterns. Consequently, the proposed design strategies could be tailored to the specific preferences of each resident group, thereby providing more targeted and occupant-centred design recommendations.

$$\bar{X}_{jk} = \frac{\sum_{i=1}^{n_j} X_{ijk}}{n_j} \text{ where:}$$

$\bar{X}_{jk}$ = mean score of design strategy j for cluster k;

X_{ijk} = score of indicator i belonging to design strategy j for cluster k;

n_j = number of indicators representing design strategy j.

Higher mean scores indicate a higher priority assigned to a particular design strategy by residents within a given cluster, whereas lower mean scores suggest that the strategy is considered relatively less important than other design strategies.

3. Result

3.1 Respondent Profile

Table 3

summarises the demographic, socio-economic, and housing characteristics of the respondents. The majority of respondents were female (87.4%), while males accounted for 12.6% of the sample. The average respondent age was 46 years, and the mean household size was four members. In terms of socio-economic characteristics, most households reported a monthly income of less than Rp3 million (60.1%), followed by 38.1% with monthly incomes between Rp3 million and Rp6 million, while only 1.8% reported monthly incomes ranging from Rp6 million to Rp10 million. These findings indicate that the sample predominantly represents low- to lower-middle-income households. Educational attainment was generally low, with most respondents having completed senior high school (38.6%), followed by junior high school (31.8%), primary school (27.8%), and only 1.8% holding a bachelor's degree.

Tabel 3. Respondent Profile		
Category	Subcategory	n
Sample	Total sample (n)	223
Respondent Characteristics	Gender (%)	
	Male	12.60
	Female	87.40
	Age (years), mean	46.00
Socioeconomic Characteristics	Household size (persons), mean	4.00
	Household income (%)	
	< USD 185/month	60.10
	USD 185–368/month	38.10
	USD 368–613/month	1.80
	Educational attainment (%)	
	Primary school	27.80
	Junior high school	31.80
	Senior high school	38.60
	Bachelor's degree	1.80
	Occupation of the breadwinner (%)	
	Unemployed / Homemaker / Retired	17.00
	Formal employee	26.90
	Self-employed / Trader	15.70
	Construction / Manual labor	17.90
*USD values were converted from Indonesian Rupiah (IDR) using an exchange rate of USD 1 = IDR 16,300		

Tabel 3. Respondent Profile		
	Transportation and service sector	14.80
	Others	7.60
Housing Characteristics	Housing tenure (%)	
	Owner-occupied	66.40
	Rental	33.60
	Average dwelling area (m²)	33.42
	Number of storeys, mean	1.00
Ownership of Cooling Equipment	Electric fan (%)	98.70
	Air conditioner (%)	15.70
Household Electricity Consumption	Average monthly household electricity expenditure (USD)	21.04*
*USD values were converted from Indonesian Rupiah (IDR) using an exchange rate of USD 1 = IDR 16,300		

Regarding the occupation of the breadwinner, formal employees constituted the largest group (26.9%), followed by manual labourers and construction workers (17.9%), unemployed individuals, homemakers, and retirees (17.0%), self-employed workers and small business owners (15.7%), and those employed in the transportation and service sectors (14.8%). The remaining 7.6% were engaged in other occupations. This occupational profile suggests that most households rely on employment sectors characterised by relatively limited and economically vulnerable income sources. With respect to housing characteristics, two-thirds of respondents (66.4%) lived in owner-occupied dwellings, while 33.6% resided in rented housing. The average dwelling floor area was 33.42 m², and most dwellings consisted of a single storey, reflecting the predominance of modest low-rise housing with limited living space in densely populated urban settlements.

Ownership of cooling appliances revealed that almost all households owned at least one electric fan (98.7%), whereas only 15.7% owned an air conditioner (AC). This finding suggests that electric fans remain the primary cooling option because of their substantially lower purchase and operating costs compared with air conditioners. In addition, the average monthly household electricity expenditure was Rp343,003, indicating a relatively moderate level of electricity consumption that is consistent with the respondents' socio-economic conditions.

4.1 Identification of Resident Preference Dimensions for Energy-Efficient Building Design

The results of the Exploratory Factor Analysis (EFA) indicate that the 25 variables representing residents' preferences for energy-efficient building design can be reduced to five underlying factors, collectively explaining 59.87% of the total variance. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.885, while Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), confirming that the dataset was suitable for factor analysis. Furthermore, all Anti-Image Correlation values exceeded the recommended threshold of 0.50, indicating that all variables met the criteria for retention in the factor analysis.

Factor interpretation was based on a factor loading threshold of ≥ 0.50 , as recommended by Hair et al. (2019), since loadings above this value indicate a sufficiently strong association between observed variables and the underlying latent factors. Table 4 presents the rotated factor matrix, where the highest factor loading for each variable served as the basis for grouping variables and assigning descriptive names to the extracted factors.

Table 4
Rotated Factor Loadings for Energy-Efficient Building Design Preference Items

Variables	Factor				
	1	2	3	4	5
I prefer to use energy-efficient household appliances.	0.754	0.099	0.371	0.053	0.136
I prefer homes that incorporate energy-saving technologies.	0.699	0.228	0.091	0.191	0.168
I prefer homes equipped with energy-efficient lighting.	0.682	0.090	0.198	0.197	0.213
I feel more comfortable in homes with cool floor surfaces.	0.589	0.110	0.449	0.247	0.129
I am willing to consider more energy-efficient cooling systems.	0.544	0.398	-0.031	0.153	0.199
I am willing to consider housing features that help reduce indoor heat.	0.491	0.345	0.185	0.345	0.036
I prefer homes that remain comfortable without relying heavily on cooling devices.	0.488	0.341	0.070	0.261	0.166
I prefer homes with a yard or small outdoor space.	0.442	0.333	0.233	0.015	0.055
I prefer homes designed to remain cool naturally.	0.437	0.323	0.219	0.249	0.119
I prefer homes with light-coloured exterior finishes.	0.345	0.063	0.118	0.046	0.166
I believe that building materials influence indoor thermal conditions.	0.030	0.719	0.193	0.060	0.192
Homes protected from direct solar exposure feel more comfortable to me.	0.187	0.595	0.001	0.100	-0.119
I am interested in homes equipped with solar photovoltaic (PV) systems.	0.127	0.580	0.081	0.053	0.068
I believe that building design influences everyday comfort.	0.350	0.555	0.099	-0.013	0.101
I prefer homes with external shading devices for windows or terraces.	0.089	0.523	0.097	0.281	0.148
I prefer homes with shaded windows (e.g., canopies or external blinds).	0.217	0.406	0.314	0.283	0.394
I prefer homes with larger window openings.	0.266	0.368	0.359	0.168	0.215
I prefer homes with abundant natural ventilation.	0.210	0.169	0.700	0.199	0.060
I feel comfortable in homes with good natural airflow.	0.229	0.082	0.653	0.228	0.089
I feel comfortable in rooms that require little artificial lighting during the daytime.	0.296	0.189	0.356	0.187	0.291

Variables	Factor				
	1	2	3	4	5
I prefer homes that are well ventilated and not stuffy.	0.099	0.109	0.344	0.713	0.116
I prefer homes that do not feel excessively hot indoors.	0.419	0.137	0.108	0.638	0.039
I prefer homes that remain cool even without air conditioning.	0.193	0.191	0.319	0.524	0.251
I prefer homes that are bright during the daytime.	0.173	0.093	0.163	0.115	0.788
I like homes where natural sunlight can enter the indoor space.	0.294	0.095	0.021	0.074	0.627

Based on the extracted factors, five dimensions of residents' preferences for energy-efficient building design were identified. The first factor was labelled "Energy Efficiency Preference", comprising preferences for energy-efficient appliances and technologies. This factor reflects residents' concern for reducing household energy consumption through the adoption of efficient technologies and equipment. The second factor, "Climate-Responsive Building Design Awareness", represents residents' awareness of the importance of building materials, solar protection strategies, photovoltaic systems, and climate-responsive design in enhancing both thermal comfort and energy efficiency. The third factor, "Natural Ventilation Preference", reflects the importance residents place on adequate natural ventilation and effective airflow within the dwelling. The fourth factor, "Passive Thermal Comfort Preference", captures residents' preference for homes that remain cool, well-ventilated, and free from excessive heat without relying on air-conditioning. The fifth factor, "Natural Daylighting Preference", represents residents' preference for homes that receive sufficient daylight and maintain adequate indoor brightness during daytime.

Overall, the EFA results suggest that preferences for energy-efficient building design among low-income households extend beyond the adoption of energy-saving technologies. Instead, residents place considerable importance on passive building design strategies, particularly those that promote natural ventilation, passive thermal comfort, and adequate daylighting. These findings indicate that both technological interventions and passive design features should be considered when developing occupant-centred energy-efficient housing strategies for low-income urban communities.

4.2 Resident Typologies Based on Preferences for Energy-Efficient Building Design

To identify resident preference typologies, cluster analysis was conducted in two stages. First, Hierarchical Cluster Analysis (HCA) using Ward's method was performed to determine the optimal number of clusters based on the natural structure of the data. The resulting number of clusters was subsequently used as the input for K-means Cluster Analysis to refine the classification and produce more stable and homogeneous clusters. The analysis identified three distinct clusters representing

different patterns of residents' preferences for energy-efficient building design. The characteristics of each cluster were interpreted based on the mean factor scores of the five dimensions extracted through Exploratory Factor Analysis (Table 5). Positive factor scores indicate that a particular preference dimension is more strongly represented than the overall sample average, whereas negative scores indicate relatively lower preference levels.

Table 5
Cluster profiles based on mean factor scores

Factor	Cluster 1	Cluster 2	Cluster 3
	n = 37	n = 97	n = 89
F1 (Energy Efficiency Preference)	-0.889	0.213	0.138
F2 (Climate-Responsive Building Design Awareness)	-0.141	0.233	-0.195
F3 (Natural Ventilation Preference)	-1.138	0.208	0.247
F4 (Passive Thermal Comfort Preference)	-0.084	-0.336	0.402
F5 (Natural Daylighting Preference)	-0.062	0.330	-0.334

Cluster 1 exhibited relatively low preference levels across most dimensions of energy-efficient building design, particularly Energy Efficiency Preference (-0.889) and Natural Ventilation Preference (-1.138). In contrast, Cluster 2 demonstrated consistently positive preferences across multiple design strategies, with relatively high scores for Energy Efficiency Preference (0.213), Natural Ventilation Preference (0.208), and Natural Daylighting Preference (0.330). Meanwhile, Cluster 3 showed stronger preferences for Passive Thermal Comfort (0.402) and Natural Ventilation (0.247), while exhibiting comparatively lower preferences for Climate-Responsive Building Design Awareness (-0.195) and Natural Daylighting (-0.334).

Figure 2. Profiles of the three resident clusters based on the five energy-efficient building design preference dimensions

Based on the cluster analysis, respondents were classified into three resident typologies according to their preferences for energy-efficient building design (Fig. 2). Cluster 1 was identified as "Low-Engagement Residents", characterized by relatively low preference levels across most design dimensions. Cluster 2 was labelled "Energy-Conscious Residents", reflecting stronger preferences for energy-efficient technologies and a wide range of energy-saving design strategies. Cluster 3 was identified as "Passive Comfort Seekers", representing residents who prioritize natural ventilation and passive thermal comfort over technology-oriented energy-saving measures and mechanical cooling systems.

4.3 Comparison of Socioeconomic and Housing Characteristics Across Resident Typologies

Table 6 presents the socioeconomic and housing characteristics of the three resident typologies, together with the results of the statistical tests examining the associations between resident typology and the observed characteristics. Chi-square tests and Kruskal–Wallis tests indicated that all examined variables had p-values greater than 0.05 (Table 6). These findings suggest that no statistically significant differences were observed among the three clusters in terms of household income, educational attainment, occupation of the breadwinner, housing tenure, dwelling size, number of air conditioners, number of electric fans, or monthly household electricity expenditure.

Table 6
Socioeconomic and housing characteristics across resident typologies

Variable	Cluster 1	Cluster 2	Cluster 3	p-value
Number of respondents (n)	37	97	89	
Household size (persons)	3.65	4.41	4.13	0.269
Household income (%)				
< IDR 3 million (< USD 185)	67.6	63.9	52.8	0.299
IDR 3–6 million (USD 185–368)	32.4	35.1	43.8	
IDR 6–10 million (USD 368–613)	0.0	1.0	3.4	
Educational attainment (%)				
Elementary school	29.7	29.9	24.7	0.455
Junior high school	18.9	36.1	32.6	
Senior high school	48.6	32.0	41.6	
Bachelor's degree	2.7	2.1	1.1	
Occupation of breadwinner (%)				
Unemployed / Homemaker / Retired	16.2	20.6	13.5	0.387
Formal employee	21.6	24.7	31.5	
Self-employed / Small business	10.8	17.5	15.7	
Construction / Manual labor	29.7	18.6	12.4	
Transportation and services	16.2	10.3	19.1	
Others	5.4	8.2	7.9	
Housing tenure (%)				
Owner-occupied	73.0	62.9	65.2	0.648
Rented	27.0	35.1	34.8	
Dwelling area (m²)	32.6	35.1	31.8	0.269
Number of floors	1.0	1.0	1.0	0.315
Number of electric fans	1.0	1.0	1.0	0.329
Number of air conditioners	0.1	0.1	0.2	0.318
Average monthly household electricity expenditure (USD)	19.71	22.41	20.11	0.719

Although no statistically significant differences were identified, several descriptive trends distinguish the three resident typologies. Cluster 1 was characterized by the smallest average household size (3.65 persons) and the highest proportion of households earning less than USD 185 per month (67.6%). This cluster also had a relatively large proportion of construction and manual labor workers (29.7%), the smallest average dwelling size (32.6 m²), and the lowest average monthly household electricity expenditure (USD 19.71). Cluster 2 had the largest average household size (4.41 persons) and the largest average dwelling area (35.1 m²). It also exhibited a relatively higher proportion of middle-income households (USD 185–368 per month) and respondents with junior high school education. Furthermore, this cluster recorded the highest average monthly household electricity expenditure (USD 22.41), suggesting relatively greater household energy use compared with the other clusters. Cluster 3 had the highest proportion of households earning USD 185–368 per month (43.8%) and the largest share of formal employees (31.5%). This group also reported slightly higher ownership of air conditioners (0.2 units per household), although its average monthly household electricity expenditure (USD 20.11) remained comparable to that of the other clusters.

Overall, these findings indicate that differences in residents' preferences for energy-efficient building design among low-income households are not significantly associated with the socioeconomic or housing characteristics examined in this study. Instead, the observed heterogeneity in preferences appears to reflect differences in residents' perceptions, comfort needs, and attitudes toward the residential environment rather than variations in their socioeconomic conditions or dwelling characteristics. This suggests that households with broadly similar socioeconomic backgrounds may still exhibit distinct priorities regarding energy-efficient building design, highlighting the importance of occupant-centred approaches when developing housing energy-efficiency strategies

4.4 Design Implications Based on Resident Typologies

Based on the factor analysis, five key dimensions representing residents' preferences for energy-efficient building design were identified. Each factor was interpreted by considering the variables with the highest factor loadings. Table 7 presents the interpretation of each factor together with its corresponding design implications. Variables with higher factor loadings were considered to have a stronger contribution to the underlying latent construct and were therefore used as the basis for naming the factors and formulating the associated design recommendations. For example, Factor 1 was primarily characterized by preferences for energy-efficient electrical appliances (loading = 0.754), energy-saving technologies (loading = 0.699), and energy-efficient lighting (loading = 0.682), leading to its interpretation as Energy Efficiency Preference.

Table 7
Design implications based on residents' preference dimensions

Factor	Dominant Variables	Factor Interpretation	Design Implications
F1. Energy Efficiency Preference	Energy-efficient appliances, energy-efficient lighting, energy-saving technologies, energy-efficient cooling systems	Residents value energy efficiency and the use of technologies that reduce electricity consumption.	LED lighting, inverter air conditioners, energy-efficient appliances, smart meters, community solar PV systems, energy monitoring systems
F2. Climate-Responsive Building Design Awareness	Building materials affecting indoor heat, solar protection, photovoltaic systems, building design affecting comfort	Residents recognize that building design influences thermal comfort and energy use.	External window shading, proper building orientation, reflective building materials, light-coloured roofs, integration of solar energy systems
F3. Natural Ventilation Preference	Homes with abundant natural airflow and good air circulation	Residents prioritize natural ventilation to improve indoor comfort.	Cross ventilation, openings on opposite façades, high-level vents, open corridors, building layouts that enhance airflow
F4. Passive Thermal Comfort Preference	Homes that remain cool, well-ventilated, and comfortable without air conditioning	Residents seek thermal comfort through passive design rather than mechanical cooling.	External shading, roof insulation, shade vegetation, high ceilings, roof ventilation, low thermal-mass building materials
F5. Natural Daylighting Preference	Bright indoor spaces and adequate daylight penetration	Residents value high-quality natural daylighting.	Larger windows, light shelves, skylights, open-plan layouts, daylight optimization strategies

Factor 2 was primarily defined by residents' perceptions of the influence of building materials on indoor thermal conditions (loading = 0.719), protection from solar radiation (loading = 0.595), and the utilization of solar energy systems (loading = 0.580), reflecting Climate-Responsive Building Design Awareness. Factor 3 was dominated by preferences for natural ventilation through effective airflow (loadings = 0.700 and 0.653). Factor 4 represented preferences for achieving thermal comfort without relying on mechanical cooling systems (loadings = 0.713, 0.638, and 0.524), whereas Factor 5 reflected residents' preference for maximizing natural daylight within the dwelling (loadings = 0.788 and 0.627).

Based on these interpretations, each factor was translated into a set of practical design implications. This approach links the preference dimensions identified through statistical analysis with architectural design strategies applicable to low-income housing. Consequently, the factor analysis not only identifies the underlying dimensions of residents' preferences but also provides a practical basis for developing design recommendations that better respond to occupants' needs and expectations.

Overall, the five preference dimensions demonstrate that residents' priorities extend beyond technology-based energy conservation. Instead, they place considerable importance on passive design strategies that improve thermal comfort and indoor environmental quality. These findings highlight the need to integrate technological solutions with passive architectural design principles when developing energy-efficient housing for low-income communities.

The cluster analysis further indicates that energy-efficient building design strategies should be tailored to the preference characteristics of each resident typology. Table 8 presents the priority levels of design strategies for each cluster based on the mean preference scores reported by respondents. The design strategies shown in the table were derived from the factors identified through the Exploratory Factor Analysis (EFA), with each strategy representing one or more indicators belonging to the same latent construct. Mean scores were calculated by averaging the responses to the indicators associated with each design strategy within each cluster. To facilitate interpretation, these scores were classified into four priority levels according to the five-point Likert scale: very high (4.50–5.00), high (4.00–4.49), moderate (3.50–3.99), and low (< 3.50). This classification provides an intuitive representation of the relative importance of each design strategy across the three resident typologies.

Table 8
Design Strategy Priorities for Each Resident Typology

Factor	Design Strategy	Cluster 1	Cluster 2	Cluster 3
		<i>Low-Engagement Residents</i>	<i>Energy-Conscious Residents</i>	<i>Passive Comfort Seekers</i>
F1 (Energy Efficiency Preference)	Energy-efficient appliances and LED lighting	4.10	4.80	4.73
F4 (Passive Thermal Comfort Preference)	Passive thermal comfort	4.25	4.54	4.84
F3 (Natural Ventilation Preference)	Natural ventilation	3.73	4.74	4.80
F2 (Climate-Responsive Building Design Awareness)	Solar shading	3.61	4.16	4.00
	Thermally responsive building materials	3.68	4.53	4.00
	Renewable energy (solar photovoltaic systems)	3.65	4.53	3.72
F5 (Natural Daylighting Preference)	Natural daylighting	4.21	4.78	4.28

The analysis revealed distinct differences in the priority of design strategies across the three resident typologies. Low-Engagement Residents assigned the highest priority to passive thermal comfort (4.25) and natural daylighting (4.21), while the remaining strategies received moderate to high preference scores. These findings suggest that this group places greater importance on achieving fundamental indoor comfort through simple passive design measures rather than adopting advanced energy-saving technologies. Accordingly, housing designed for this group should initially emphasize cost-effective passive strategies, such as improving natural ventilation, maximizing daylighting, and enhancing passive thermal comfort, before introducing more sophisticated energy-efficient technologies.

In contrast, Energy-Conscious Residents demonstrated consistently high preferences across nearly all design strategies. Energy-efficient appliances and LED lighting (4.80), natural daylighting (4.78), natural ventilation (4.74), and passive thermal comfort (4.54) all achieved very high preference scores. These results indicate that this group strongly values comprehensive energy-efficient housing solutions that combine reductions in energy consumption with improvements in indoor environmental quality. Consequently, housing designed for this typology should integrate passive architectural strategies with energy-efficient technologies, including high-efficiency appliances, LED lighting, and the optimized use of natural ventilation and daylight to maximize overall building energy performance.

Meanwhile, Passive Comfort Seekers placed the greatest emphasis on passive thermal comfort (4.84) and natural ventilation (4.80), representing the highest scores among all three clusters. In contrast, technology-oriented strategies such as renewable energy systems (solar photovoltaic panels) received comparatively lower preference ratings (3.72). This pattern suggests that residents in this group prioritize architectural design solutions that naturally improve indoor comfort before considering active technological interventions. Therefore, design strategies for this typology should focus on enhancing passive building performance through effective cross-ventilation, solar heat control, thermally responsive building materials, and spatial layouts that facilitate natural airflow.

Overall, these findings demonstrate that each resident typology exhibits a distinct hierarchy of design priorities, indicating that a uniform approach to energy-efficient housing design is unlikely to meet the diverse preferences of low-income households. Instead, design strategies should be tailored to the preference profiles of different resident groups. Such a preference-based approach enables the development of housing that is not only more energy efficient but also better aligned with occupants' needs, comfort expectations, and daily living practices, thereby increasing the likelihood of user acceptance and the successful implementation of energy-efficient design strategies in practice.

5. Discussion

5.1 Preference Heterogeneity and the Importance of an Occupant-Centred Design Approach

This study demonstrates that low-income households exhibit multidimensional and heterogeneous preferences for energy-efficient housing design. The factor analysis identified five key preference dimensions: energy efficiency, climate-responsive building design, natural ventilation, passive thermal comfort, and natural daylighting. These findings indicate that energy-efficient housing is not perceived as a single, uniform concept but rather as a combination of complementary design strategies related to reducing energy consumption, improving building responsiveness to local climatic conditions, and enhancing occupants' comfort.

This heterogeneity became more evident through the cluster analysis, which identified three resident typologies with distinct preference profiles. Although respondents shared broadly similar socioeconomic backgrounds, each group assigned different levels of importance to various energy-efficient design strategies. These findings suggest that housing design for low-income communities should avoid a one-size-fits-all approach that assumes homogeneous user needs and priorities (Arancibia, 2024; Malik & Bardhan, 2023). Instead, an occupant-centred (user-centred) design approach is required, recognizing the diversity of preferences among different resident groups (Ahn & Park, 2016; Far et al., 2022; Makhoul et al., 2025; Pourtangestani et al., 2024; Pratiwi, 2023).

The present findings are consistent with those of Fathi dan O'Brien (2024), who emphasized that occupants differ in their needs, preferences, behaviours, and comfort priorities. Designing buildings based on assumptions about an "average occupant" may therefore produce solutions that fail to accommodate user diversity (Fathi & O'Brien, 2024). Their study further demonstrated that incorporating occupant profiles during the design stage can influence architectural decision-making and contribute to more inclusive built environments. Such diversity encompasses differences in socioeconomic background, lifestyle, experience, comfort expectations, and daily practices, all of which influence both design decisions and building performance. Consequently, identifying occupant profiles during the early stages of design allows architectural decisions to be guided not only by technical standards but also by the actual needs and expectations of future users .

This argument further reinforces the importance of understanding user preferences in housing provision. Moghimi et al., 2016 et al. (2016) argued that mass housing projects are frequently developed without adequately considering the values and characteristics of prospective occupants (Moghimi et al., 2016). Likewise Kowaltowski & Granja (2011) associated many shortcomings in social housing projects with a mismatch between the values prioritized by consumers and those emphasized by designers during decision-making (Kowaltowski & Granja, 2011). Such discrepancies may result in housing solutions that do not fully address occupants' needs. Therefore, understanding residents' preferences is essential for developing housing solutions that are more responsive, inclusive, and capable of improving residential quality (Ling et al., 2023; Moghimi et al., 2016). Housing that fails to align with user preferences is also less likely to improve residential satisfaction or provide sustainable solutions to housing challenges (X. Chen & Hu, 2023; Jansen, 2014; Mohit et al., 2010).

Within the context of this study, the identification of three resident typologies provides an empirical basis for developing more adaptive housing design strategies. These typologies are not intended to produce entirely different housing designs for every individual; rather, they help designers identify which strategies should be prioritized for different groups of residents. Consequently, preference-based segmentation can serve as a bridge between occupant needs and architectural decision-making, enabling energy-efficient housing to become more targeted, inclusive, and responsive to users' expectations.

5.2 Preferences Are Not Fully Explained by Socioeconomic Characteristics

One of the most important findings of this study is that no statistically significant differences were observed among the three resident typologies with respect to socioeconomic characteristics, including household income, educational attainment, occupation, housing tenure, household size, dwelling area, ownership of cooling equipment, and monthly electricity expenditure. These results indicate that variations in preferences for energy-efficient housing design cannot be explained solely by occupants' economic capacity or demographic characteristics. In other words, households with broadly similar socioeconomic conditions may still exhibit substantially different evaluations and priorities regarding energy-efficient design strategies.

These findings extend previous research that has largely explained household energy consumption and energy-related behaviours through variables such as income, education, household size, dwelling characteristics, and ownership of electrical appliances (Fariña et al., 2024). Although these factors remain important for explaining households' ability to access energy-efficient technologies and their actual energy consumption patterns, they do not necessarily explain how occupants perceive the value of different design strategies. Preferences are also likely to be shaped by comfort perceptions, previous residential experiences, knowledge of passive design, environmental awareness, daily routines, and the perceived benefits of specific building features (Day et al., 2025; Harju et al., 2025; Jansen, 2013; Pratiwi et al., 2026). For example, households with similar income levels may prioritize natural ventilation, reduced dependence on mechanical cooling, improved daylighting, or solar protection differently. Such differences may arise from variations in individual experiences, comfort tolerance, and understanding of the relationship between building design and energy use (Abrahamse et al., 2005; Nahmens et al., 2015). Consequently, relying exclusively on socioeconomic characteristics for resident segmentation may oversimplify occupant diversity and lead to housing strategies that fail to address users' actual priorities (Fathi & O'Brien, 2024; Gibler & Tyvimaa, 2014; Huang et al., 2023).

From a theoretical perspective, these findings suggest that preference-based segmentation complements conventional approaches based on socioeconomic characteristics or energy consumption behaviour (Huang et al., 2023; Jansen, 2014). Whereas socioeconomic characteristics primarily describe households' circumstances and constraints, preference typologies provide insight into which design attributes residents consider most important. Integrating these complementary perspectives offers a

more comprehensive understanding of housing users. Accordingly, the principal contribution of this study lies in proposing resident preference typologies as an alternative framework for understanding the diversity of low-income households and supporting the implementation of occupant-centred design in energy-efficient housing.

5.3 The Importance of Energy-Efficient Housing for Affordability and Quality of Life

Among low-income households, preferences for energy-efficient housing extend beyond the technical objective of reducing energy consumption. Utility costs represent a substantial and recurring component of household expenditure and may impose significant financial pressure on household budgets (Fariña et al., 2024). Rising energy prices or increasing demand for space cooling may force households to compromise between paying utility bills and meeting other essential needs. Consequently, housing designs that reduce electricity, water, or overall energy demand have the potential to lower operating costs while improving overall housing affordability (Faraji et al., 2026; Ferrara et al., 2016; Moore et al., 2017).

Within low-income communities, however, energy conservation strategies must be implemented carefully to ensure that they do not compromise healthy and adequate living conditions (Bouzarovski et al., 2025; Zhang et al., 2026). Reductions in energy consumption should not be achieved through forced energy deprivation that exposes residents to excessive indoor heat, insufficient daylight, or poor indoor air quality. Instead, energy demand should be reduced through passive design strategies, including cross ventilation, effective solar shading, optimized daylighting, climate-responsive building materials, and improved building envelope performance (Elaouzy & El Fadar, 2022; Santamouris & Vasilakopoulou, 2026). Such approaches enable meaningful energy savings without placing the primary burden of efficiency on occupants' behaviour.

Overall, the preferences identified in this study should not be interpreted merely as choices regarding physical building attributes but also as aspirations for housing that is more affordable, comfortable, and supportive of everyday living. Providing energy-efficient housing for low-income communities therefore offers multiple benefits, including reduced energy consumption and operating costs, improved thermal comfort, greater economic security, higher residential satisfaction, and enhanced quality of life (Carrus et al., 2021; Hashemi, 2017; Jayalath et al., 2024; Seyedrezaei et al., 2025). Accordingly, user preferences should be regarded as a fundamental consideration in housing design and sustainable housing policy rather than as a secondary consideration introduced only after major design decisions have already been made.

6. Conclusion

This study identified the underlying dimensions of residents' preferences for energy-efficient building design and developed resident typologies based on these preferences among low-income urban households in Indonesia. Exploratory Factor Analysis revealed five key preference dimensions: "Energy

Efficiency Preference", "Climate-Responsive Building Design Awareness", "Natural Ventilation Preference", "Passive Thermal Comfort Preference", and "Natural Daylighting Preference". These findings demonstrate that residents perceive energy-efficient housing as a multidimensional concept that encompasses both technological solutions and passive architectural design strategies.

Cluster analysis further identified three distinct resident typologies: "Low-Engagement Residents", "Energy-Conscious Residents", and "Passive Comfort Seekers". Although no statistically significant differences were found among the clusters with respect to socioeconomic and housing characteristics, each typology exhibited distinct priorities regarding energy-efficient design strategies. This finding suggests that differences in design preferences are influenced not only by socioeconomic conditions but also by occupants' comfort expectations, perceptions, and lived experiences. Consequently, households with broadly similar socioeconomic backgrounds may still require different housing design approaches.

The study also demonstrates that translating preference dimensions into design strategies provides a practical framework for occupant-centred housing design. While Low-Engagement Residents primarily value affordable passive design solutions that enhance basic indoor comfort, Energy-Conscious Residents prefer an integrated approach combining passive design and energy-efficient technologies. In contrast, Passive Comfort Seekers prioritize architectural strategies that naturally improve thermal comfort through enhanced ventilation, solar protection, and climate-responsive building design. These findings indicate that energy-efficient housing should not adopt a uniform design approach but instead tailor design strategies to different resident preference profiles.

The principal contribution of this study lies in introducing a preference-based resident typology as an alternative framework for supporting occupant-centred energy-efficient housing design. Unlike conventional approaches that primarily segment households according to socioeconomic characteristics or energy consumption patterns, the proposed framework captures the diversity of occupants' design priorities and translates them into actionable architectural strategies. This approach provides a stronger empirical basis for designing energy-efficient housing that is more responsive to users' needs while improving the likelihood of user acceptance and long-term effectiveness.

Several limitations should be acknowledged. First, the study was conducted in a single low-income urban settlement in Jakarta, which may limit the generalizability of the findings to other climatic, cultural, and socioeconomic contexts. Second, the identified resident typologies were derived from stated preferences rather than observed energy-related behaviours or measured household energy consumption. Consequently, the findings reflect residents' perceived priorities for energy-efficient housing design rather than their actual implementation of these strategies in everyday practice. Future research should therefore validate these typologies across different geographical settings and examine how preference-based design strategies influence occupants' behaviour, building energy performance, and residential satisfaction after occupancy.

Declarations

Author Contribution

S.N.P. : Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Visualization, Writing – original draft. S.T. : Validation, Review & editing, Proofreading. U.F.F. : Investigation, Data collecting, Validation. T.K.S. : Proofreading. All authors read and approved the final manuscript.

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Figures

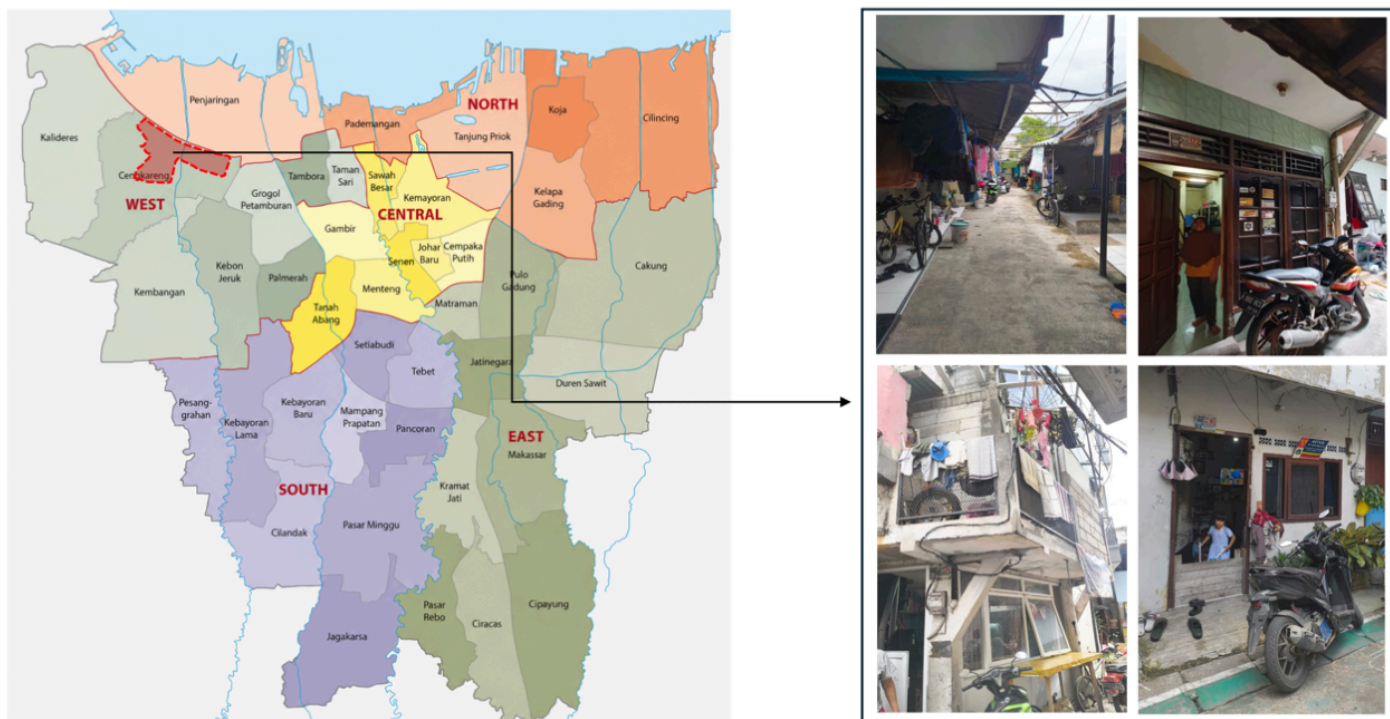


Figure 1

Location of the study area in Kapuk Subdistrict, Jakarta, Indonesia

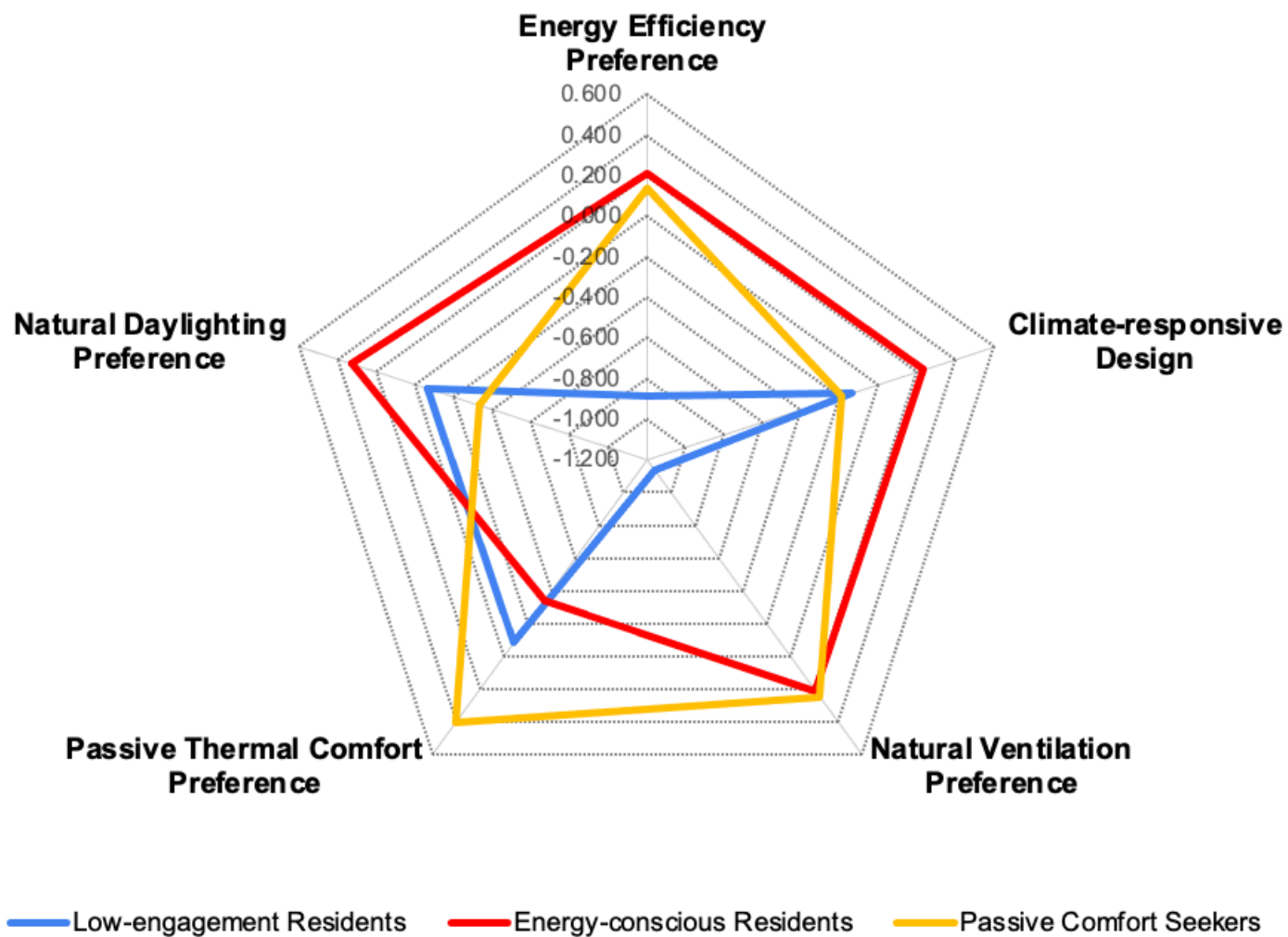


Figure 2

Profiles of the three resident clusters based on the five energy-efficient building design preference dimensions