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ETHNOGRAPHIC INSIGHTS INTO TERRACE HOUSE RETROFIT PRACTICES: A CASE IN PETALING JAYA, MALAYSIA

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ABSTRACT

Existing residential buildings contribute to significant energy demand and greenhouse gas (GHG) emissions. Malaysia – dominant with the landed residential building were constructed under past building codes with limited attention to energy efficiency. Retrofitting this stock represents both a pressing challenge and a golden opportunity to promote national decarbonization efforts. However, retrofitting practices are often ad hoc and complicated, influenced by homeowners' physical extensions rather than environmental considerations. This research addresses the gap by exploring the retrofit practices of Malaysian terrace houses through an ethnographic, visual case observation approach. Fieldwork was conducted across four sites in Petaling Jaya, where alterations were systematically documented using field notes, sketches, photographs and video taking. These observations were supported by documentary analysis of existing retrofit policies and guidelines. Cases were classified according to scales of intervention – minor, intermediate, major and complete, reflecting both local authority definitions and practices observed in situ. The study uncovered widespread informal interventions, which were primarily motivated by functionality, privacy and cultural preferences rather than energy performance. The findings underscore the limitations of current retrofit policies, which remain advisory rather than mandatory, and highlight the need for frameworks that account for socio-cultural practices and homeowner decision-making. By adopting an ethnographic lens, this study demonstrates how retrofit strategies can be made more socially grounded, practical, and widely adopted, ultimately bridging global low-carbon ambitions with local housing realities.

Keywords: Case Observation, Ethnography, Retrofit, Terrace Intervention, Sustainable Housing.

1.0 INTRODUCTION

The urgency of addressing climate change has placed the built environment at the centre of global decarbonization efforts. Buildings account for nearly 40% of global energy consumption and greenhouse gas (GHG) emissions, prompting international frameworks such as the Paris Agreement and the United Nations Sustainable Development Goals (SDGs) to call for transformative action in housing and urban development (United Nations Environment Programme, 2023). For developing nations, however, this transition comes with unique challenges, as the push for decarbonization must be balanced against the realities of rapid urbanization and economic constraints. As Falcone (2023) notes, these regions face a complex interplay of demographic growth and infrastructure gaps that make universal access to sustainable energy a significant capital impediment. Furthermore, the decarbonization rush can inadvertently divert social justice if the speed of implementation ignores the localized socio-cultural factors that drive how residents modify their homes (Cravioto & Mosqueda, 2021; Hoffmann & Hoffmann, 2025). Residential buildings, which have been integral to human settlements since the earliest communities, thus exert far-reaching social, cultural, environmental, and typological impacts on urban development that require a more nuanced, bottom-up approach to policy than currently exists. It is widely recognized that emissions from this sector must be urgently reduced if climate goals are to be achieved. While promoting green buildings is an important step, Amirkhani et al. (2021) emphasize that retrofitting the vast stock of existing residential buildings holds significantly greater potential for advancing low-carbon transitions. Their comprehensive mapping of research trends confirms that the sheer volume and longevity of the existing built environment make it the most critical level for achieving large-scale environmental impact.

Malaysia, as a developing nation, has pledged commitments under the Paris Agreement and the SDGs. Rapid urbanization has contributed to a growing residential stock, particularly terrace houses and stratified apartments. Among these, terrace houses dominate both in volume and transaction value, representing the largest segment of the nation's housing market (National Property Information Centre (NAPIC), 2024). Yet, most of these homes were constructed under outdated building codes with limited attention to energy efficiency, making them carbon-intensive. Retrofitting this existing stock therefore presents both a pressing challenge and a significant opportunity to advance national decarbonization goals. National policies such as the National Policy on Climate Change (2009), the Green Technology Master Plan (2017–2030), and the Twelfth Malaysia Plan (2021–2025) emphasize sustainable development and green growth. Frameworks such as the Low Carbon Cities Framework (LCCF) and the Green Building Index (GBI) provide guidance to the local authorities and consultants, but their adoption has been limited. Much of the focus remains on new developments, while the extensive stock of terrace houses, Malaysia's most common urban housing typology continues to operate with minimal energy efficiency measures. Moreover, existing green guidelines are advisory rather than mandatory, particularly for landed homes, leaving sustainable retrofit decisions entirely voluntary. This creates both a challenge and an untapped opportunity to enhance terrace house performance through retrofitting, a pathway that could substantially contribute to Malaysia's decarbonization ambitions.

Despite this potential, retrofitting practices in Malaysia remain largely ad hoc, shaped by homeowners' immediate functional needs rather than environmental considerations. Extensions, space infills, and other modifications to a building envelope are common but rarely incorporate energy performance or carbon reduction goals. These interventions typically reflect individual priorities for comfort or additional space, with sustainability depending solely on the homeowner's awareness, knowledge, and sense of responsibility. As Pelenur & Cruickshank (2014) demonstrate, the 'Energy Efficiency Gap' persists because homeowners are primarily motivated by functional benefits like thermal comfort and lifestyle improvements rather than carbon reduction, often treating energy performance as a secondary outcome of necessary home modifications. Moreover, any physical alteration requires local authority approval, yet existing regulations often lack the depth needed to meaningfully guide sustainable retrofits. While guidelines for sustainable material selection exist, regulation and enforcement remain weak in many contexts (Cravioto & Mosqueda, 2021). As a result, retrofit activity is usually driven by functionality rather than carbon reduction, leaving sustainability goals as secondary, if considered at all. These informal practices reveal a crucial gap: current policies and guidelines fail to adequately account for the socio-cultural and behavioural factors that shape how households adapt and modify their homes. Consequently, national low-carbon strategies risk becoming misaligned with the lived realities. To bridge this gap, the movement should begin by observing existing modification trends, as these informal practices provide the 'situated knowledge' necessary for larger shifts. As Furman & Hadjri (2025) contend, utilizing such resident expertise can balance building and social needs, ensuring that low-carbon solutions are not only accepted but are effectively utilized by the people they are meant to serve.

Despite growing attention to building energy retrofits globally, much of the existing literature focuses on technological solutions, energy modelling, and policy frameworks. Limited attention has been given to how retrofit practices are actually enacted by homeowners in everyday contexts, particularly in developing countries where informal housing modifications are common. In Malaysia, terrace houses dominate the residential landscape, yet empirical studies documenting how homeowners modify these houses in reality remain scarce. This creates an important gap between formal retrofit strategies and the lived practices of households. Therefore, this study aims to explore terrace house retrofit practices through an ethnographic observation approach, focusing on how homeowners modify spatial elements and building envelopes in real contexts. By documenting these interventions, the study contributes a socio-cultural perspective to retrofit discourse, complementing existing technical and policy-oriented research.

2.0 LITERATURE REVIEW

2.1 Retrofitting and Scale of Interventions

A variety of terms are used to describe actions taken to improve building conditions, each with different implications for scope and scale. Among these, the term *retrofit* has gained increasing prominence in the built environment, where it refers to technical processes aimed at improving the performance of existing structures. Ma'bdeh et al. (2023) define retrofit as the modification of equipment, systems, or buildings to upgrade operations, enhance efficiency, improve energy performance, or achieve all of these outcomes simultaneously. More generally, retrofit can also be described as the act of providing a component or feature that was not originally included when the product was created. Applied to buildings, this implies adding or upgrading elements that were absent from the original construction. Broadly, retrofit research has often focused on energy-related aspects, reflecting global concerns about reducing environmental impacts. In practice, retrofit and refurbishment are closely related, since both involve replacing or upgrading building components. However, *refurbishment* is usually considered a more general term that refers to the renewal of older building conditions, while *retrofit* is more specifically associated with improving energy performance. In fact, the term '*retrofit'* has largely replaced *refurbishment* in many contexts where the emphasis is on enhancing the efficiency of existing buildings.

Awareness of retrofit benefits, national impacts, and the availability of retrofit schemes often depends on individual cases, including the feasibility of the retrofit and whether the intervention is shallow or deep. Basic retrofits are typically defined as alterations that enhance the energy efficiency of a building system or reduce overall consumption (Alabid et al., 2022). For example, installing wall insulation may be highly effective in cases where the building envelope accounts for significant heat loss (Regnier et al., 2018). Deep retrofits, on the other hand, take a more holistic approach by integrating multiple energy improvements. These may include reducing envelope heat losses, upgrading system efficiency, and achieving significant energy savings (Alabid et al., 2022). When the goal is to reach net-zero annual energy consumption, deep interventions are essential. Such efforts often combine extensive fabric retrofits with renewable energy installations and the upgrading of building services using low-carbon technologies. Galvin (2023) suggests prioritising retrofits for residential buildings based on their readiness and structural conditions – starting with those due for cyclical maintenance and presenting no major structural difficulties, followed by those not currently requiring major repairs, and lastly, those with significant structural challenges.

In Malaysia, the scale of residential retrofits is generally divided into four categories: Minor, Intermediate, Major, and Complete Intervention—as outlined by the Petaling Jaya City Council (PJCC) and illustrated in **Fig. 1**. These categories largely align with common practices, except for the *Complete* category, which involves more than 50% of retrofit work and may include partial demolition. This level of intervention is comparable to what the literature refers to as a deep retrofit. From the intermediate category onwards, interventions often involve the removal of existing components such as walls, windows, or roofs.

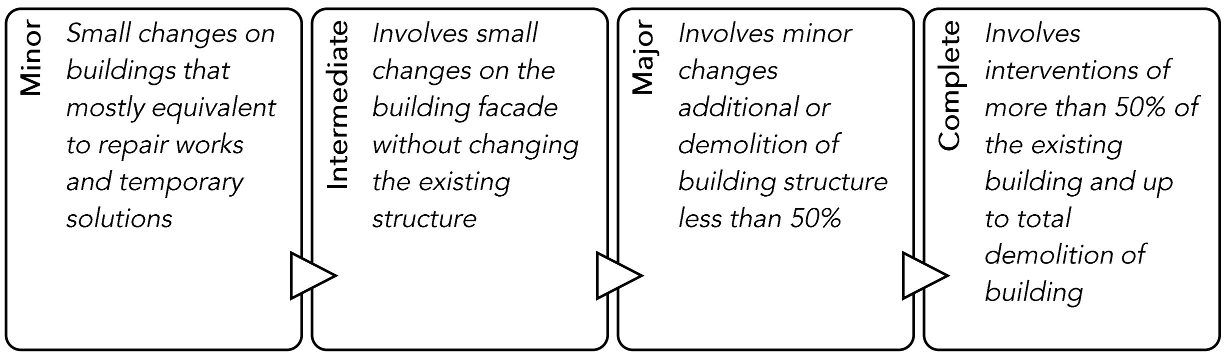


Fig. 1: Levels of interventions

As a developing nation committed to achieving net-zero by 2050, Malaysia faces the dual challenge of addressing the inefficiencies of its vast housing stock particularly terrace houses, which dominate the landed residential (National Property Information Centre (NAPIC), 2024), while ensuring that retrofit strategies remain practical, affordable, and widely adopted. Yet retrofitting is complicated not only by costs and regulatory constraints but also by widespread homeowner-led informal interventions (Charles, 2025). Many residents modify their homes to meet immediate functional or cultural needs, such as extending kitchens, enclosing balconies, or covering courtyards, often without considering energy performance. This demonstrates that retrofits cannot succeed as purely technical solutions; they must be grounded in the lived realities of households, accounting for behavioural, cultural, and socio-economic dynamics.

Although national sustainability frameworks such as the Low Carbon Cities Framework and the Green Building Index exist, their implementation has primarily focused on new developments. Retrofit policies for existing landed houses remain largely advisory. Consequently, many terrace house modifications occur independently of sustainability considerations. Understanding these informal practices is essential for designing retrofit strategies that align with local behavioural patterns. Ethnographic observation provides a valuable methodological approach for capturing these everyday housing practices and revealing the social dynamics that shape retrofit behaviour.

Overcoming these challenges calls for a more integrated approach to retrofit governance. Recent studies highlight that retrofit should not be understood solely as a technical upgrade but as a socio-technical process shaped by everyday practices, governance systems, and household decision-making (Medrano-Gomez et al., 2025). From this perspective, building interventions emerge from interactions between physical structures, cultural practices, and institutional frameworks. Ethnographic observation provides a valuable methodological lens to capture these dynamics, enabling researchers to understand retrofit practices not only as engineering modifications but also as socially embedded behaviours within specific housing contexts. For Malaysia, this means moving beyond prescriptive technical standards toward frameworks that acknowledge informal interventions as part of the housing landscape, while actively involving homeowners in co-developing retrofit strategies. Embedding socio-cultural insights, particularly those revealed through ethnographic studies, into both policy and practice ensures that decarbonisation measures are not only technically sound but also socially relevant and economically viable. By bridging global low-carbon ambitions with the everyday realities of Malaysian households, retrofitting can serve as a transformative pathway for sustainable and equitable urban development.

2.2 Retrofit in Residential Building Context

Globally, residential buildings are among the largest contributors to energy demand and greenhouse gas (GHG) emissions (United Nations Environment Programme, 2025). These emissions are not only linked to their operational energy use but also to the embodied energy consumed during the extraction, procurement, and transportation of raw materials, as well as the construction process itself. Scaling up energy retrofits in existing housing stock is therefore critical to reducing carbon emissions and meeting climate targets. Within this context, research on building energy retrofits particularly in the residential sector, which plays a pivotal role in achieving national goals has largely focused on two key areas: (1) regulatory and policymaking approaches, which emphasize the importance of governance in supporting residential retrofit actions, and (2) the challenge of complex retrofit data, which highlights the need for more systematic and optimal approaches to identifying effective retrofit solutions.

Galvin (2023) argues that as energy efficiency standards become increasingly stringent, the marginal costs of both efficiency measures and CO_2 abatement rise. At the same time, however, energy consumption decreases, thereby reducing emissions. He contends that instead of pursuing ever-higher minimum standards for individual buildings, policymakers should prioritize retrofitting a greater number of houses to “modestly high” standards—just below the point where the marginal cost curve rises steeply. This approach, he argues, ensures the greatest overall reduction in CO_2 emissions within the financial resources available. Such a perspective reinforces the government’s responsibility to develop comprehensive retrofit policies that encourage widespread uptake, particularly among older residential buildings. As Tomrukcu & Ashrafian (2024) caution, the effectiveness of current envelope design standards is uncertain when faced with future climate conditions, as existing regulations lack dynamic provisions for adapting to evolving climate effects.

Beyond policy, the retrofit sector must also advance by generating more holistic and systemic retrofit information. Ali et al. (2020) stress that data-driven approaches can enhance the quality of existing building data, enabling the extraction of key features from complex datasets. They argue that scalable retrofit strategies for sustainable urban development will rely heavily on comprehensive building stock databases, which can support benchmarking and performance analysis for retrofit planning. Wise et al. (2025) add that retrofit discussions should move beyond narrow techno-economic considerations to include co-benefits such as improved comfort, well-being, and social value. Raising homeowners' "retrofit literacy" and creating opportunities for households to directly experience retrofit outcomes are equally vital to increasing adoption. Yet, as Ali et al. (2020) point out, the creation of robust building stock databases is inherently complex and time-intensive, requiring both geometric and non-geometric data. Current data availability remains fragmented, inconsistent, and highly variable, which complicates the development of scalable retrofit solutions. Charles (2025) similarly emphasizes that the hindrance to residential retrofit extend beyond technical issues, being strongly influenced by financial, governance, and socio-cultural factors. In particular, fragmented ownership and inconsistent government funding significantly weaken the capacity to scale up retrofit initiatives.

In summary, while policy frameworks and technological solutions are crucial drivers of retrofit, their effectiveness ultimately depends on a robust understanding of the existing housing stock. Without reliable, comprehensive, and context-specific data, large-scale retrofit initiatives risk being misaligned with real conditions, resulting in limited adoption or underperformance. Residential buildings particularly older housing stock are diverse in form, function, and socio-cultural use, making a "one-size-fits-all" approach impractical. Before scaling up retrofitting efforts or developing national databases, there is a pressing need to systematically explore the complex realities of existing residential buildings. This includes not only technical and geometric characteristics but also the lived practices, cultural values, and behavioral patterns that shape household decisions. A nuanced, data-informed foundation is therefore essential to ensure that retrofit strategies are both technically effective and socially grounded, laying the groundwork for meaningful progress toward low-carbon housing.

3.0 METHODOLOGY

The study employed a qualitative case observation framework centered on existing terrace housing in Petaling Jaya (PJ), Malaysia. PJ was selected as a representative case study due to its historical significance as one of the country's first planned residential townships in Malaysia (Ju et al., 2011). Spanning housing generations from the 1960s to the 1990s, PJ provides a longitudinal cross-section of the nation's built environment. Following Yin's (2018) criteria for representative case studies, this selection allows for a robust observation of how retrofit practices and informal modifications have evolved across different housing generations. To ensure data consistency, the study utilized purposive sampling to capture diverse socio-economic contexts and intervention types. The focus was restricted to intermediate lots to maintain data consistency. Intermediate units represent the most standardized urban housing typology and present the most significant passive design challenges due to restricted front/rear façade and shared party walls.

Data collection was conducted through an ethnographic approach to capture the lived reality of retrofit practices, which often diverge from official discourse (Fischer, 2023). This method is particularly suited to navigating the complexities of energy retrofits, including ambiguous building codes and multi-stakeholder engagement (Murto et al., 2019). The study adopts a series of non-participant observations, recording physical extensions and spatial modifications through systematic field notes, architectural sketches, and visual documentation (photographs and video). These observations were guided by the standardized parameters outlined in **Table 1** to minimize bias and ensure scientific comparability across different housing generations.

Table 1: Parameters Setup for Observational Study

Parameters	Details
Duration of Observation	Short-term monitoring (several days up to a week) of the trend of retrospective and prospective renovations
Longitudinal Analysis	Define house clusters by development age to see if older buildings exhibit higher retrofit accumulation
Timing of Observation	Standardized time interval (5 to 10 minutes each house), taking up to a week to complete an observation of each specified area to capture the rhythm of the neighborhood
Frequency	Categorize houses by adoption rate of façade modifications, levels of modifications (Minor, Intermediate, Major and Complete) for a frequency count, and most frequently modified building components
Consistency	Maintain a specific type of terrace house (intermediate lot) to observe consistent and predictable modification patterns

The analysis followed a multi-stage process shown in **Fig. 2** below, beginning with a scoping phase to define the research boundaries and refine the inquiry within the selected neighborhoods. This initial stage established the parameters for identifying modified building components, assessing systematic intervention strategies, and mapping geometric patterns specific to intermediate terrace houses in PJ. By focusing on this specific typology across four distinct sites, the research established a controlled environment to examine the prevalence and rate of retrofit activity relative to existing urban density.

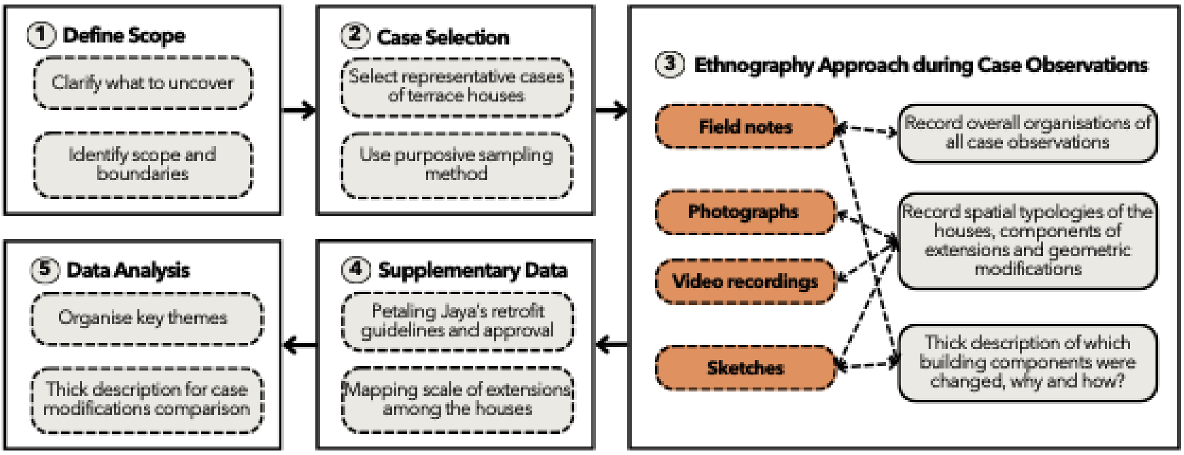


Fig. 2: Process of research methodology adopted in this paper

The empirical core of this study utilizes an ethnographic "visual" approach to examine Malaysian retrofitting practices. Site selection was guided by theoretical frameworks regarding intervention scales and a review of existing retrofit policies, allowing for the classification of cases based on the magnitude of physical change.

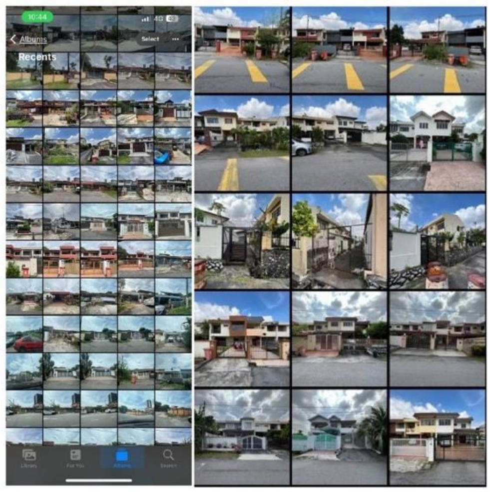
Table 2: Details of the observation on all cases

Case	Case A	Case B	Case C	Case D
Location	Section 17	Damansara Jaya	Kelana Jaya	Kota Damansara
Area	Section 17, PJ	SS22, SS22A	SS5	Section 6, PJU5
Built Year	1964	1975	1984	1990
Detail	Between Jalan Harapan and Jalan 17/1, PJ	Surrounded by three highways LDP (east), SPRINT (north) & NKVE (west)	Between Jalan Bahagia and Jalan Majlis, PJ	Between Persiaran Surian and Jalan Cecawi 6, PJ
Total Units	821 units	846 units	402 units	575 units
Housing Archetype Distribution				

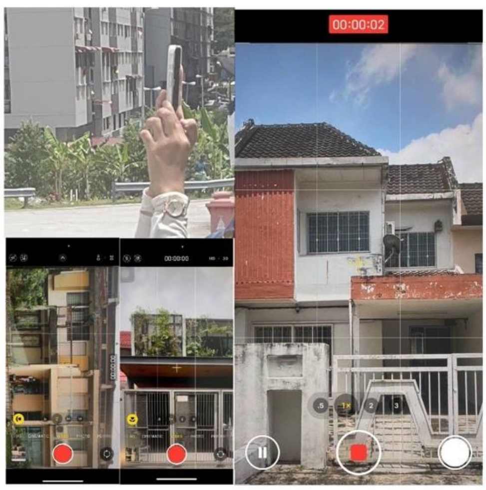
This groundwork enabled a general understanding of the socio-technical processes shaping the built environment. To interpret these complex modifications, grounded theory principles were applied to sharpen theoretical sensitivity, facilitating the conceptualization of emerging categories and codes (Fitzgerald & Mills, 2022). Systematic data documentation played a central role in ensuring reflexivity and analytical rigor. The researcher maintained a comprehensive field diary, integrating written observations with architectural plans, sketches, and high-resolution photographs to create a robust audit trail. As detailed in **Table 2**, these records captured the total units observed and mapped various façade configurations across the study area. This material formed the basis for a frequency analysis, where mid-terrace units were manually identified and classified according to their degree of intervention, providing a clear taxonomy of extension patterns in the Malaysian context.

Supplementary data collection involved an extensive archival review of planning approvals, housing development guidelines and renovation drawings sourced from the local authorities. To ensure a systematic analysis, the study utilized a mapping intervention framework to categorize the subject houses into four distinct degrees of extension. Recognizing the researcher's architectural background and sustainability focused, a reflexive approach was adopted to navigate the dual role of observer and interpreter. Data were synthesized through organizational ethnography, categorizing field notes and visual data into themes. As summarized in **Fig. 3**, this dataset captures the original built forms and spatial typologies of the terrace houses. Finally, cross-case narratives were developed to identify commonalities and interventions across the samples.

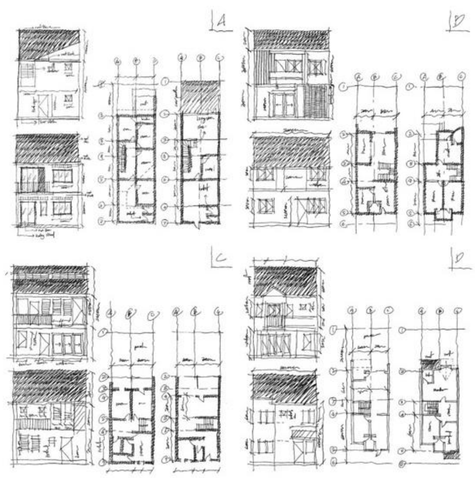
a) Some of field notes taken during observations



b) Photographs captured during case observations



c) Video Recordings of the houses for cross-checking



d) Sketches produced of the intermediate terrace houses

Fig. 3: Summary of ethnography approach conducted in this research

4.0 RESULTS

The data for qualitative case observations are organized according to several key themes which identified through thematic analysis including: (1) built form elements and characteristics, (2) patterns of terrace house intervention, and (3) building envelope effects. The ethnographic approach reveals the scale of extensions resulted from ad hoc modifications carried out by the homeowners in PJ and how the terrace houses' spatial geometric such as balconies, courtyards and backyards were modified and impacted the overall building envelope. The description of the particulars is streamlined, compared across cases and represented through sketch and photograph illustrations for in-depth ethnographic insights of terrace house retrofit analysis in PJ.

4.1 Built Form Elements and Characteristics

The built form elements and characteristics of two-story terrace houses have not change much since the past years until now, possible variations can only be noted at the distinct building façade of the residential buildings due to derived developmental form by different developers. Despite that, the essence and vibes of the terrace house can be said similar only differ in sizes and openings of the land provided, the length of the house, and different provision of courtyard or light wells. Referring to the observations conducted among all 2644 number of terrace houses, the design typologies exuded almost similar characteristics. There are few design attributes that can be observed within the context of terrace house that are; 1) narrow and elongated with focus on two story types; 2) clearly addresses fronts and backs of the house with fronts addressing public streets, spaces or accessways, and backs are contained to the usual rear, usually back-to-back of the houses connected by back-lane in a parameter block arrangement; 3) connected by two adjacent shared party walls, except for end-lot and corner-lot units; 4) car parking is included for each units of the house; and 5) normally include small courtyard, terrace or garden at the front or back of the house.

Through the observation of the terrace house development in Petaling Jaya, there are some advantages emphasized from the design that can be highlighted in this study, despite that, it is also observed that there are some drawbacks to all the benefits associated with the terrace houses design including:

1) some cases are facing the issues on the lack of natural ventilation due to poor adoption of strategies among existing fenestration design
2) due to its narrow and elongated form, lack of daylight may result in dark interior which might hinder residents' productiveness and excessive use of artificial lightings but, if retrofitting is deployed accordingly, it will provide good cross ventilation due to its dual aspect form
3) any underrated upgrade works may fail to address the core concern of building occupants while exorbitant extension works may lack the bearing on environmental consideration
4) for old terrace houses, retrofitting without green consideration might lead to excessive energy consumption
5) extra piece of land is ample for house owners to make use of their space, by turning their terrace into small garden; and it is thermally efficient due to a reduced external wall area exposed to direct sunlight.

Therefore, the focus orients towards retrofit measures among intermediate unit houses as they have limited means of retrofitting due to their characteristics. Some of the outcome from direct observations are outlined in **Fig. 4**.

a) narrow and elongated

b) connected by backlane

c) connected by two adjacent party walls

d) front of the terrace houses addressing public street or accessways

e) designated car porch for each house

f) area for small garden or private terrace

g) significant building facade components

Fig. 4: Direct observations of built form elements and characteristics of the intermediate terrace houses (Source: Author)

With thorough observations on the cases, in classifying the rate of retrofitting and defining the interventions, the design attributes and characteristics of the terrace houses were carefully captured and documented. Then, the key building components involved in the residential retrofitting context were determined. It includes the understanding of the common layout of the existing houses and to which extent the retrofit works were carried out. For the two-storey terrace houses, the common spaces that can be evaluated inside the building are illustrated in **Fig. 5** and described in **Table 3**. This stage of investigation employed socio-technical perspective to assess the retrofit performance of terrace houses. More specifically, the task evaluated how various residential archetypes affected the application of green retrofit strategies through typological research.

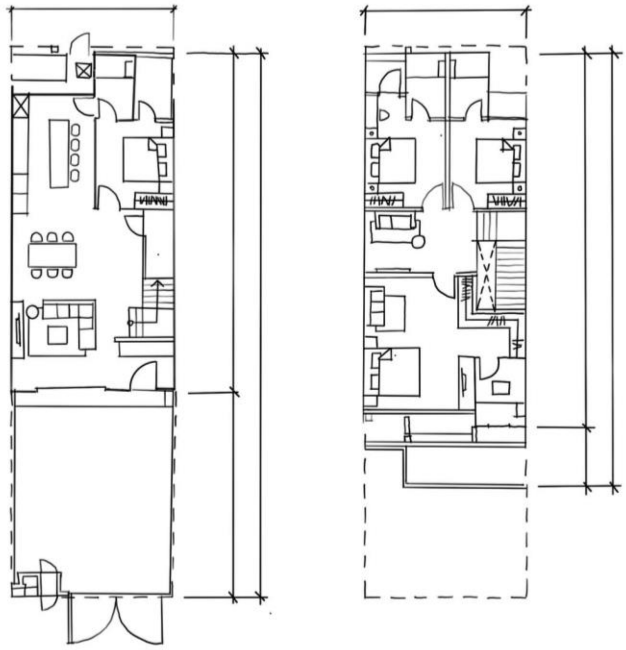


Fig. 5: The common layout for intermediate terrace house in Malaysia
(Source: Author)

Table 3: Common spatial layout arrangements in Intermediate terrace houses

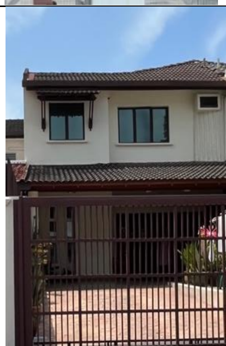
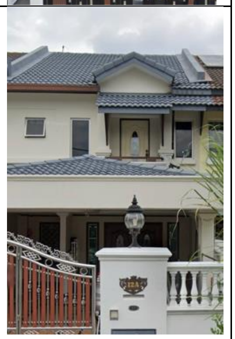
Level	Common Spaces	Common Building Components
Ground Floor	1) Living Area, 2) Dining Area, 3) Kitchen, 4) Guest Room 5) Bathroom 1 6) Backyard, 7) Car Porch	1) Wall 2) Windows 3) Door 4) Stairs 5) Ground Floor Slab 6) Porch 7) Backyard
First Floor	1) Master Bedroom 2) Master Bathroom 3) Family Area 4) Bedroom 2 5) Bedroom 3 6) Bathroom 2 7) Balcony	1) Wall 2) Windows 3) First Floor Slab 4) Roof 5) Balcony

For the past few decades, the layout has not changed much, the common width of the house normally starts from 20 feet with a wider design can go up to 24 feet with depth of minimum about 75 feet. Though the layout of interior spaces is predetermined by the residential housing developer, the common spaces provided in each terrace house remain the same with very few minor differences in term of arrangement. While the basic layout and spatial organization of terrace houses have remained consistent over the decades, direct observations in PJ reveal diverse typologies and façade variations that reflect distinctive design patterns and interventions. There is tremendous design of two-story terrace houses identified within the four locations, accumulating to 30 designations of patterns making up for different façade illustration.

4.2 Patterns of Intermediate Terrace House Interventions

The details of the retrofit levels examined in this study are summarized in **Table 4**, which outlines behavioural interventions across four categories: minor, intermediate, major, and complete. Retrofit activities were generally initiated in response to household needs, such as extending walls by enlarging balconies, removing courtyards, replacing glazing systems, or transforming backyard areas into usable kitchen spaces. Minor retrofits typically involve repair and maintenance works. Under Petaling Jaya City Council (PJ) guidelines, this category also includes the installation of solar panels without altering the roof structure, as demonstrated in Case D – Minor. Intermediate retrofits involve wall extensions that do not affect the house's original structural framework. Major retrofits, by contrast, encompass modifications that require structural changes. Finally, complete retrofits are the most extensive, requiring a building dilapidation report and involving the demolition of more than 50% of the existing structure.

Table 4: Observed cases under different retrofit levels

Intervention	Case A	Case B	Case C	Case D
Minor				
Intermediate				
Major				
Complete				

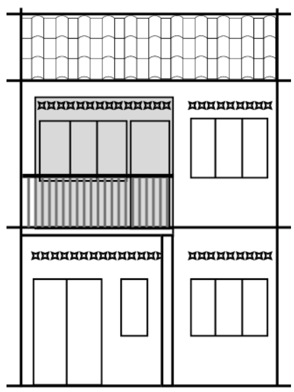
The observation reveals an exceptionally high intervention rate. Out of 2644 surveyed houses, 2403 (over 90%) have undergone visible interventions, particularly noticeable on the building façade as data presented in **Table 5**. These modifications, driven by individual homeowners, result in significant variation in design and contribute to the evolving visual characteristics of the built environment. It can be concluded that the rate of interventions among terrace houses in PJ is very densely acclimatised.

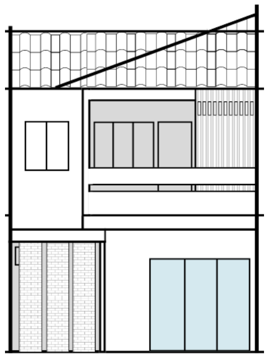
Table 5: Rate of retrofitting according to levels of interventions

Intervention Level	Case A	Case B	Case C	Case D	Overall Statistics
Total Unit	821	846	402	575	**2644 (100%)**
Minor	324	268	110	99	**801 (30.3%)**
Intermediate	274	439	174	148	**1,035 (39.1%)**
Major	127	57	45	110	**339 (12.8%)**
Complete	39	37	27	125	**228 (8.6%)**

Most retrofit works range from minor repairs to intermediate-level upgrades, which are generally insufficient for achieving significant energy savings. The high rate indicates that minor and intermediate intervention is becoming a must-do-task among the homeowners, might be due to change of owners—from older generation to the younger ones—has instigated intervention, condition of the house is getting worse, building materials deteriorating and the need to retrofit the old building system, and the demand to suit a growing family. Carrying out intermediate intervention requires the building approval from the local authority, specifically through the building standard plan, developed by each local authority, which means that all small extensions under minor and intermediate intervention must undergone the approval process and obtain the permissible permit. **Table 6** presents the summary of the intervention patterns of terrace houses for each area.

Table 6: Summary of retrofitting rate according to levels of interventions

<table>
<tr><th colspan="3">Case Description</th></tr>
<tr><th colspan="3">Case A</th></tr>
<tr><td colspan="3">Has the largest area that covers 321.23 acres. It consists of 821 units of two-story terrace houses with 13 different types of façade configurations</td></tr>
<tr><th>Intervention</th><th>Analysis</th><th>Images</th></tr>
<tr><td>The intervention rate for this case is:
Original: 44 cases (5.4%)
Minor: 324 cases (39.5%)
Intermediate: 274 cases (33.4%)
Major: 127 cases (15.5%)
Complete: 39 cases (4.8%)</td><td>Almost 40% of houses have carried out minor retrofit, followed by 33% for intermediate. This involves repair works and replacement of building materials without changing the structural elements of the house</td><td></td></tr>
</table>

Case B		
It covers 294.05 acres, with mostly consist of two-story terrace houses. There are 5 types of 846 units with 4 of them were designed with balcony.		
Intervention	**Analysis**	**Images**
The intervention rate for this case is: Original: 45 cases (5.3%) Minor: 268 cases (31.7%) Intermediate: 439 cases (51.9%) Major: 57 cases (6.7%) Complete: 37 cases (4.4%)	More than half of the houses have conducted intermediate retrofit alone. This involves the extension of external wall at the balcony area	
Case C		
The area covers 261.93 acres that mostly consist of single-story terrace houses. There are 3 types of 402 units of two-story terrace houses: with the least number of 34 and biggest up to 233 units. All design typologies were built with balcony.		
Intervention	**Analysis**	**Images**
The intervention rate for this case is: Original: 46 cases (11.4%) Minor: 110 cases (27.4%) Intermediate: 174 cases (43.3%) Major: 45 cases (11.2%) Complete: 27 cases (6.7%)	In this case, most of the cases were observed have conducted intermediate retrofit which commonly involve the conversion of existing balcony into a usable space	
Case D		
The area covers 235.57 acres, with 8 types of 575 units with the least 16 units and biggest up to 108 units. Only 2 types of houses were built with balcony.		
Intervention	**Analysis**	**Images**
The intervention rate for this case is: Minor: 99 cases (20.5%) Intermediate: 148 cases (30.7%) Major: 110 cases (22.8%) Complete: 125 cases (25.9%)	Minor and intermediate intervention accounted for more than half of the houses. The area oversees higher rate of major and complete intervention compared to previous cases.	

4.3 Building Envelope Effects

Early results of close monitoring revealed building envelope as the key building components as they are the largest surface exposed to direct sunlight. Therefore, to attain strategic building envelope designs that are responsible in the augmentation of existing building performances, identifying each component to steer the application of strategic green retrofit practice for each individual process of intervention is a critical task to curtail the excessive energy consumption. **Fig. 6** illustrates the building envelope components: roof, windows, wall, and balcony which is due to the party walls sandwiching the house-responsible to the heat transfer of the building.

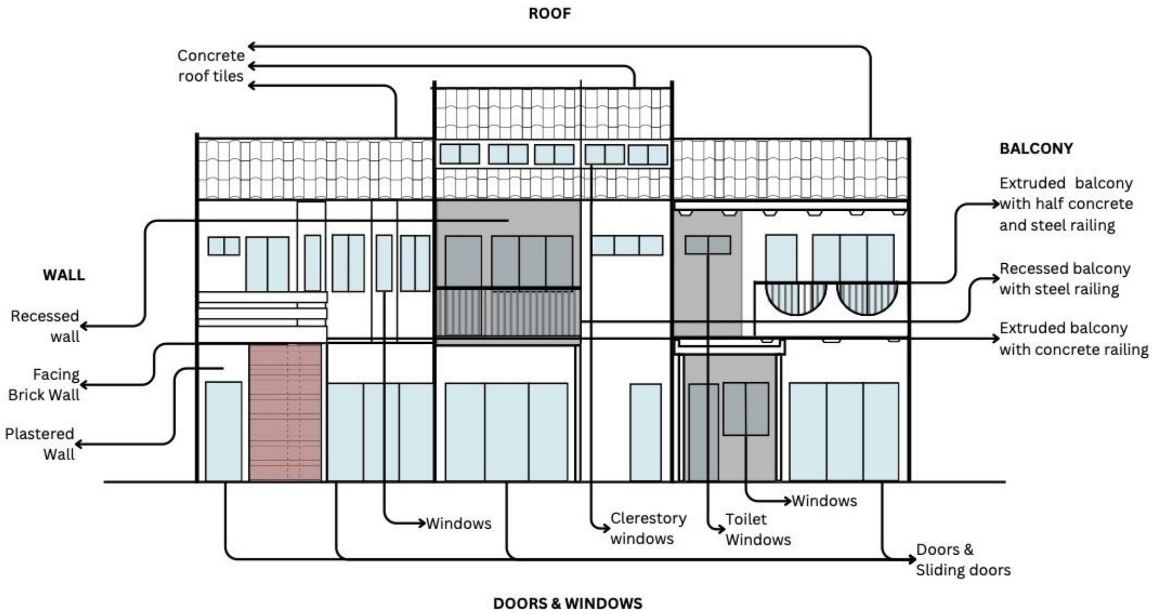


Fig. 6: Building envelope components in terrace house retrofit
(Source: Author)

For landed residential property, roof is the largest surface exposed to the sunlight as it serves as a critical building component in retrofitting, compared to high-rise residential buildings. Due to its longitudinal deep plan, roof provides a wider setting for retrofit technologies to curtail the issue of daylight scarcity especially at the middle of terrace houses. Thorough investigations also revealed that majority of roof in residential buildings were built with lack of insulation that resulted in increased indoor temperature as there is no thermal barrier between roof and ceiling. On the similar instance, wall is another building component that is lacking insulation on both exterior and interior surface despite the approach is yet another good option for noise reduction. Majority of the houses were not designed with light wells which is contrast to the UBBL requirement 40, that necessitates each residential building to have one. Light wells deficit has induced initiatives such as jack roof installation as secondary option for increased daylighting and foster stack ventilation among certain cases following their interventions.

Fenestration refers to the openings in a building's façade that affects a building's practicality and comprised of windows, doors and skylights. These elements are concerned with buildings' aesthetics as it made up the entire building façade, therefore the choice of material size, shape, operation type, colour, finish, glazing system, security and locks for windows, doors and skylights are detail considerations for the selection. Additionally, balcony, a geometric design that is made up of small built-up space, plays a part in reducing the heat gain of the interior spaces. However, starting in the 1990s, Case D exhibits very minimal practice of balcony. It is understandable to say that its practicality has slowly diminished with the feasible use of air-conditioning, inefficient use of the area and the safety concern of the building owners. Thus, it is becoming less practical to fully utilize the space and homeowners ended up opting for full extension of the balcony into enclosed space. Hence, balcony has been highlighted as one of the key building components in terrace house intervention as older terrace houses were built with this feature. Following the high rate of intervention among intermediate level, **Table 7** summarizes the detail modification analysis of the four main building components involved that are walls, windows, roofs and balconies.

Table 7: Building components commonly involved in the retrofit practices

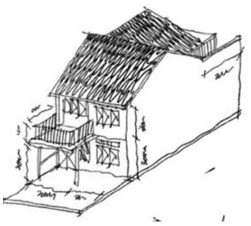
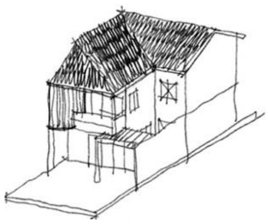
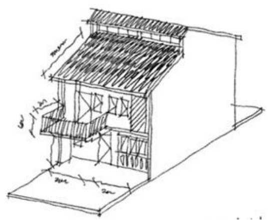
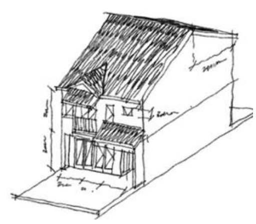
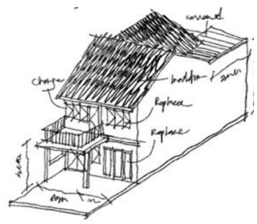
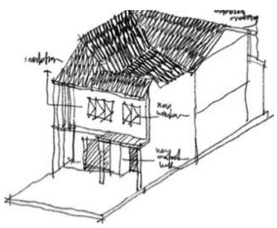
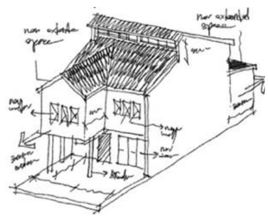
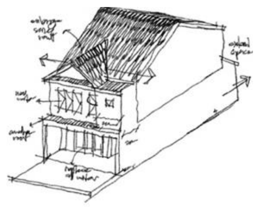
Building Components	Analysis
Wall 	Intermediate level presents the built of new wall from the extension from existing building walls. Fenestration design also affects the new wall configuration as the placement of windows and door can be totally altered. The extension also can either implicate ground floor in which living area will be affected or first floor in which bedroom and bathroom area will be affected. Since the existing wall is not built with insulation, there remains potential for more sustainable option in the new built wall.
Window 	Intermediate retrofit involves replacement of existing louvred windows to clear single glazed windows. Due to new wall existence, placement of windows and door can be totally altered. Opening size, materials and type also may differ from the existing component such as use bigger size of single glazed windows as well as tinted reflective layer on glass. In the meantime, additional shading devices for windows or doors also is being used
Roof 	The extension of wall during this level requires the extension of roof as well. This has prompted either the replacement of the entire existing concrete roof tiles to the owners' preferable roof tiles colour, or the extension of roof from the existing structure. Another possible intervention is the use of lightweight roof structure as awnings to shade the uncovered balcony.
Balcony 	Intermediate retrofit involves works to turn existing balcony into fully covered or semi-enclosed area. It shows that due to new wall existence, the balcony can be totally removed or extended into a bigger area. It can be concluded that the main motive for intervention is to cover the open balcony area as it lacks the purpose to serve building owners in the tropical climate weather. The replacement of materials is also recognized.

These building envelope components have mostly undergone changes and alterations due to retrofit intervention, hence highlighting the focus of building envelope in modifications for the minor and intermediate interventions. Within the guidelines developed by PJCC, the intermediate intervention must select and follow the ten (10) standard plans (in which 5 of them) are relevant to the mid-unit of terrace houses as follows: 1) an additional ground floor wet kitchen area (back), which requires a new roof; 2) an extension of the front wall (living area); 3) the conversion of the existing balcony into new spaces; 4) the replacement of the existing roof tiles; and 5) the installation of a new fenestration system. In this regard, the existing guideline can serve as a validation mechanism to the observational findings on building envelope components as they are consistent with the common components of modifications. It is sufficient to note that building envelope components as critical components to be regarded during terrace houses interventions.

5.0 DISCUSSIONS

This observation approach presents four case-study units representing different development timelines of terrace houses in PJ, spanning the 1960s, 1970s, 1980s, and 1990s. Despite differences in construction periods and built-up areas, the selected cases share notable design similarities. Each case represents a significant period in the development history of terrace houses and exhibits a clear tendency toward intermediate intervention. **Table 8** presents four detailed case profiles (Cases A, B, C, and D), offering an in-depth fact-to-case analysis. Understanding the existing house conditions following their characteristics, intervention patterns and issues that lead to their modifications is critical to provide in-depth insights into the current state of each case, enabling the researcher to better interpret how intervention behavioural patterns are influenced by the original design.

Table 8: Summary of four cases observation analysis

Item	Case A	Case B	Case C	Case D
Glazing Problems	The use of frosted single glazed louvred & deteriorated wooden frame	Single glazed side hung with clear glass & deteriorated wooden frame	The use of frosted single glazed louvred & deteriorated wooden frame	Single glazed side hung clear glass windows with aluminium frame
Physical Problems	Balcony can act as an extra thermal barrier, but the absence of shading devices exposed façade directly which causes overheating	Side courtyard allows daylighting to the middle area without light well however, it can be overlooked if not utilized efficiently when retrofit	Balcony and the only case with provided light wells on the roof that allows for more daylight to the family area at first floor.	AC ledge was designed & useful when the owner opted for air-conditioner. Natural ventilation is possible but limited across all spaces.
Thermal Problems	Poor insulation on existing façade and designed with ventilation blocks for natural air flow	Poor insulation on façade, there is presence of thermal bridge if efficient fenestration design is not employed	Poor insulation on roof & wall, there is light well that allows daylight & provides ventilation to middle area	Lack of insulation on roof and wall. Lack of passive strategy to allow daylight into the middle of the house
Existing Condition				
Modified Condition				
Modifications	When modified, semi-open balcony area is removed to cater for more built-up space, and the open backyard was covered with lightweight roof.	When modified, the existing courtyard area is fully covered, with extension at the back area. The existing balcony is removed, and turned into usable area	Balcony is replaced by a new space and the back kitchen area is extended. The replacement of new opening system is also possible during modifications.	When modified, the front façade area is extended. It provides extra overhang for the porch area. The entire back kitchen area is also extended

This study sets out to explore the existing state of retrofit practices in Malaysian terrace houses through an ethnographic case observation approach. The findings reveal that there are active incremental interventions happening in the Malaysian terrace houses landscape that are deliberate, primarily driven by immediate functional or socio-cultural needs rather than considerations for energy efficiency and carbon reduction. This finding reflects the view asserted by Medrano-Gomez et al. (2025) that retrofit is framed by everyday practices and household decision-making rather than a technical upgrade. Common modifications indicate the prevalence of intermediate intervention such as extending wet kitchen at the backyard, removing balconies into full usable space and enclosing courtyards, which involve extending existing walls without altering the building's primary structural system. They reflect the daily facts of retrofitting trends in dense urban neighbourhoods that significantly shape the thermal performance of the house and long-term sustainability of the housing stock.

These insights underscore a critical gap in the current retrofit discourse: while the policies and guidelines in Malaysia accentuates the low-carbon targets and technical standards, they pay limited attention to the lifestyle and practices of homeowners who are the true perpetrator of transformation at the household level. As noted by Cravioto & Mosqueda (2021), sustainable retrofit approach should be culturally compatible and environmental friendly tailored to local needs. By examining the course of interventions based on the socio-cultural needs, can the most workable green strategies suit to the context of Malaysian terrace houses can be proposed. This study offers an alternative lens through which retrofit can be understood, framing it not purely as a technical procedure, but as a socially embedded practice. Given that intermediate-level modifications have emerged as the dominant trend within the terrace housing landscape, local policies and guidelines should pivot toward green strategies tailored specifically for this level. By addressing these prevalent, incremental changes first, policymakers can establish a foundational sustainable framework before transitioning toward more intensive deep renovation strategies.

On another note, this observational study reveals the most prominent changes observed in the building façade are walls, windows, balconies, and roofs. Although roofs were the least often altered, they remain the largest contributor to thermal transfer due to their direct and prolonged exposure to sunlight. The prevalence of these physical interventions suggests that current envelope design standards may be insufficient; as Tomrukcu & Ashrafian (2024) caution, the effectiveness of existing regulations is increasingly uncertain, as they lack the dynamic provisions required to adapt to evolving climate conditions and future thermal demands. Additionally, this observation also revealed a widespread preference among homeowners for air-conditioners, a trend accelerated by the availability of increasing affordable models. This amasses use of mechanical cooling reflects households' immediate response to thermal discomfort, but also highlights a critical gap, in the absence of effective retrofit measures, homeowners default to energy-intensive solutions that directly increase carbon emissions. Furthermore, the effective implementation of high-performance ventilation system in ageing houses requires complementary measures such as enhanced building envelope airtightness to maximise its operational efficiency. As Liu et al. (2019) demonstrate, without a sufficiently airtight envelope, mechanical energy recovery systems cannot fully reach their full potential, as uncontrolled infiltration bypasses the system's ability to regulate thermal gain. This technical gap suggests that without interventions grounded in socio-cultural realities and made accessible to average homeowner, Malaysia's low-carbon housing aspirations risk being undermined. In the absence of such integrated strategies, residents are likely to resort to a growing dependence on energy-intensive air-conditioning as their primary means of managing comfort within an increasingly inefficient built environment.

In summary, the detailed investigations that were summarised in **Table 8** are pivotal attributes for the next stage of research, in which to select feasible strategies by analysing the state of before-after retrofit using a simulation stage. This research contributes to the diagnostic understanding of existing terrace house interventions, providing a necessary pre-retrofit evaluation that establishes a baseline for future sustainability measures. Beyond mere observation, this initial dataset supports the benchmarking and performance analysis critical for strategic retrofit planning, as emphasized by Ali et al. (2020). By integrating both geometric and non-geometric data, these findings serve as foundational components for a robust building stock database, facilitating more sophisticated analysis of the complex residential landscape in Malaysian. Taken together, these insights highlight the need for retrofit strategies in Malaysia to move beyond prescriptive green technical standards and embrace a more integrated context-sensitive approach to sustainable advances. By beginning with ethnographic exploration of existing interventions, policymakers and practitioners can better appreciate the motivations, constraints and cultural values that drive household decisions. In this way, the study establishes a foundation for developing a socio-culturally informed retrofit framework that aligns Malaysia's low-carbon ambitions with the practices of terrace house owners, ensuring that decarbonisation efforts are both effective and practical.

6.0 CONCLUSION

This research reveals that homeowners are already active participants in modifying their built environment; however, these behaviours are currently driven by immediate functionality rather than long-term carbon reduction. While local authority guidelines capture some of these practices, they fail to integrate the green strategies necessary to transform ad-hoc interventions into sustainable retrofits. Consequently, sustainable retrofitting remains outside the mainstream among residents, leaving a significant opportunity for large-scale carbon reduction untapped.

The ethnographic approach employed here demonstrates that interventions—whether formally approved or not—are largely voluntary and home-driven. In the absence of robust regulatory standards for existing landed houses, these informal practices often unintentionally degrade thermal performance and increase energy demand. This suggests that retrofitting is not a neutral application of technology, but a socially embedded practice situated within the lived reality of the household.

To move toward a resilient urban future, policy must shift from rigid structural oversight to a more dynamic framework that incentivizes thermal upgrades, particularly for high-impact areas like roofs within the existing pattern of incremental, functionality-driven modifications. Ultimately, recognizing these socio-cultural dynamics is essential for steering green retrofitting toward a future that is not only technically effective but also socially accepted and naturally accustomed to within the Malaysian terrace housing landscape.

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