ANALYSIS OF SHAH ALAM'S CARBON EMISSIONS BASED ON MALAYSIA'S LOW CARBON CITY FRAMEWORK AND ASSESSMENT

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ABSTRACT

Urbanisation and reliance on fossil fuels make cities significant contributors to greenhouse gas emissions, rendering them highly vulnerable to climate change risks and impacts. Addressing this issue is crucial for Malaysia, particularly as cities like Shah Alam strive to reduce their carbon footprint. The existing gap in assessing emission inventories using an acceptable framework for low carbon planning in Malaysian cities underscores the need for this study. This research analyses Shah Alam's emissions using Malaysia's Low Carbon City Framework and Assessment System (LCCF), introduced in 2011 to guide urban areas towards low carbon development. The study reveals that electricity emissions account for over 90% of the total measured emissions in Shah Alam's low carbon zones (LCZs). Despite the challenges of accommodating a growing population and fostering economic growth, the LCZs in Shah Alam showed emissions reductions of 18.71%, 7.31% and 9.41% from baseline levels for Section 14, Section 1 and Section 5, respectively. The annual average emissions reductions were 11.4% (Section 14), 3.2% (Section 1) and 3.9% (Section 5), with a combined yearly average reduction of 6.2%. These zones represent only about 1.6% of Shah Alam's developed area and not all LCCF elements are covered. Based on the emission trends and planning capacity, Shah Alam commits to a 45% absolute emissions reduction by 2035 from baseline year levels of its respective LCZs, with priorities on building energy strategies. This study supports evidence-based low carbon planning, while helping Shah Alam prioritise future strategies and initiatives particularly in the renewable energy and energy efficiency measures.

Keywords: low carbon city, GHG emissions, LCCF, Shah Alam, sustainability target.

1 INTRODUCTION

City development plays a central role in the global transition towards a green and climate resilient future. The way cities develop is the key to keeping global temperatures below 2°C compared to pre-industrial levels as they are key contributors to and impacted by climate change. Aside from being the engine of economic growth, cities contribute about 60% of global gross domestic product, about 70% of global carbon emissions and over 60% of overall resource consumption [1]. The trend of population growth taking place in cities is likely to continue in the future, as rural residents migrate to urban areas for economic and employment reasons. The United Nations Department for Economic and Social Affairs estimated that 55% of the world's population now lives in urban areas and this number is expected to reach 68% by 2050 [2]. There are many risks and impacts related to climate change that cities are sensitive to, such as groundwater depletion, food shortages, sea-level rise, extreme temperatures and an increase in the frequency of extreme weather events, such as floods, droughts and storms. Additionally, this can negatively impact urban infrastructure as well as the livelihoods and health of citizens and, more broadly, economic growth.

Mitigating climate change can be a major role played by cities. Urban and infrastructure sectors are among the sectors identified in the IPCC Special Report as requiring transition, along with energy, land use and industry [3]. It would take a transformational change in land

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and urban planning practices and a deep reduction in transportation and building emissions to limit global warming to 1.5°C. Report estimated that cities can cut 90% of their emissions by 2050 from buildings, transport, materials efficiency and waste, while also enjoying a prosperous economic return; in 2030, cost savings alone will generate US$2.8 trillion [4]. Low carbon measures in cities could support the equivalent of 87 million jobs in 2030, mostly in buildings sector and 45 million jobs in 2050, mostly in transport sector.

Most of the future population growth will take place in urban areas and developing countries. Malaysia for instance is currently one of the most rapidly urbanised regions around the world. Malaysia's urbanisation rate has increased from around 66% in 2004 to 74% in 2014 and about 77% of total population lived in urban areas and cities in 2020 [5]. Fostering Malaysia's urban development in the most sustainable manners can greatly reduce energy demand and consumption and its greenhouse gas (GHG) emissions as well as contributes to Malaysia's NDC pledge [6]. In supporting this, the Low Carbon Cities Framework (LCCF) was introduced as a national framework and assessment system to guide and assess the development and transformation of cities into low carbon cities [7]. The framework guide city stakeholders such as developers, local councils, town planners, non-governmental organisations (NGO's) and the general public re-evaluate their priorities in the planning and development of new projects, and provides strategies that existing cities, townships and neighbourhoods can use to reduce their carbon emissions [8].

In 2019, Malaysia's government launched The Low Carbon Cities 2030 Challenge (LCC2030C) to accelerate the transition to low-carbon cities, with ambitious targets of achieving 200 low carbon zones (LCZs) and 1,000 low carbon partners by 2030 [9]. This challenge adopted the LCCF quantitative framework that assessed annual GHG emission reduction of participating cities in various elements: energy, water, mobility and waste, as well as the sequestration potential (greenery), and has achieved a total reduction of 3 million tonnes carbon dioxide equivalent [10]. The government also launched the RM35 million Low Carbon Cities Catalyst Grant (GeRAK) to enable local governments implementing high-impact low-carbon city initiatives [11], with priority given to municipalities in the LCZ category. GeRAK's launch coincides with the National Low Carbon Cities Master Plan (NLCCM), a highly ambitious plan that outlines three key drivers, three key enablers, nine key directions and 24 key actions to propel Malaysia's low-carbon development to the next level [12].

The introduction of Malaysia's LCCF provides a structured approach for urban areas to transition to low carbon development. However, empirical studies analysing the practical implementation and GHG emissions of the LCCF in Malaysian cities are limited [13], [14]. This study addresses this gap by examining the LCCF landscape of Shah Alam, a rapidly developed city with a growing urban population. The study provides valuable insights into the current state of carbon emissions in Shah Alam's LCZs and highlights significant areas for improvement. The findings support the need for continued and expanded efforts to reduce emissions across the entire city, leveraging the insights gained from the study.

2 METHODOLOGY

This study employs a structured methodology to analyse the carbon emissions of Shah Alam's LCZs, consisting of several key steps: data collection, data validation and cleaning, carbon emission calculation and comparative analysis.

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2.1 LCZs identification and data collection

Potential LCZs were identified and building owners were approach to get buy-in into LCCF challenge with various stakeholder engagement and consultation sessions. Then, the primary data collection phase involved obtaining detailed information from building owners within the LCZs. Data were gathered on electricity consumption, waste management practices, water usage and mobility patterns. Monthly electricity usage data were collected to understand energy consumption patterns. Additionally, information on waste generation, segregation and disposal methods was obtained to assess the waste management practices. Water usage records, documenting monthly water consumption, were also collected to evaluate water-related emissions. Furthermore, data on transportation modes and commuting patterns were gathered from mobility.

2.2 Data cleaning and validation

After data collection, the next step was to ensure the accuracy and consistency of the gathered information through a rigorous data validation and cleaning process. Cross-verification involved checking the collected data against utility bills, waste management logs and transportation records to confirm its reliability. Data cleaning involved identifying and correcting errors, handling missing values and ensuring consistency across different sources. This process was crucial to ensure that the subsequent analysis would be based on high-quality, accurate data.

2.3 Emission calculation

With validated data, the study proceeded to calculate the carbon emissions for each LCZ. The emission calculation for water, waste and mobility followed the guidelines provided by the LCCF and applied appropriate emission factors for electricity, waste, water and mobility based on both local and international standards [15]. For electricity, emission factors specific to the local power generation mix were used, adopted from a study conducted by the Malaysia Green Technology Corporation (MGTC) [16]. At the time of calculation, emission factors for 2017 onwards were still not available. Similarly, waste-related emissions were calculated using data from the waste disposal bill (tonne of waste). Water-related emissions were calculated from the water bill (volume usage). Mobility emissions were derived from traffic count of all vehicles' movement within the designated boundary. The total emissions for each LCZ were then aggregated to provide a comprehensive view of the carbon footprint.

2.4 Comparative analysis

The emissions data were analysed to identify trends and patterns across different elements and zones of Shah Alam. Current emissions were compared against baseline levels to assess the reductions achieved in each LCZs. This baseline comparison highlighted the progress made and areas needing further improvement. Additionally, emissions were compared across different zones (Section 14, Section 1 and Section 5) to identify high and low emission areas, providing insights into section-specific challenges and successes. Lastly, a temporal analysis examined annual average emissions reductions to understand trends over time and to set the target for Shah Alam.

3 RESULTS

This section presents the key findings from the analysis of carbon emissions in Shah Alam's LCZs. The results highlight the emission profiles, hotspot emissions and emission reduction target for the three LCZs.

3.1 Profile of Shah Alam's LCZs

Shah Alam's LCZs comprise Shah Alam City Centre Section 14, UiTM Section 1 and Section 5 as shown in Table 1. The LCC2030C covers Shah Alam inventory into two to four of these elements: energy (electricity consumption), transport (traffic counts), water (water consumption) and waste (waste generation), depending on the data availability of the LCZ. The LCCF inventory is not a sectorial-based that classifies emissions into the respective three emission scopes: Scope 1, Scope 2 and Scope 3 and different GHGs as defined by the GHG Protocol. NLCCM specifies Malaysia cities to align their GHG inventories with that of The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). As MGTC moves to a GPC aligned reporting framework in the future, Shah Alam emissions is analysed and reported based on the LCCF until the new reporting framework is adopted. The LCCF can provide preliminary insight into Shah Alam's emissions profile to understand key emissions elements, prioritising reduction strategies, as well as establishing initial reduction levels to track the LCC progress.

Table 1: Shah Alam's LCZs profile.

Zone name	Zone area (ha)	Baseline year	Baseline population	No of elements
City Centre Section 14	159.89	2015	8,957	Four (energy, water, waste and mobility)
UiTM Section 1	141.6	2015	31,589	Three (energy, water and waste)
Section 5	45.68	2017	3,692	Two (energy and water)

3.2 Baseline emission and intensity

The baseline for measuring progress toward Shah Alam's emissions reduction goal was set using data in 2015, except for Section 5 in 2017. Fig. 1 illustrates the breakdown of the baseline emissions for all the three LCZs. The baseline emissions were 60,475 tonnes carbon dioxide equivalent (tCO_2e), for Section 14, 48,806 tCO_2e for UiTM Section 1 and 11,408 tCO_2e for Section 5, respectively. Energy (electricity) dominated all emission sources, contributed more than 90% of all CO_2e emissions combined especially for Section 14 (54774 tCO_2e) and UiTM Section 1 (46139 tCO_2e).

Narrowing down to the electricity emissions intensity (Fig. 2), Section 14 was the highest (6.1 tCO_2/cap) as per LCC zone population. This is followed by Section 5 (3.1 tCO_2/cap) and UiTM Section 1 (1.5 tCO_2/cap). On the contrary, the emission intensity per LCC zone area for all the three LCZs are comparably similar. It is worth nothing that, these indexes may change with more inclusion of buildings and streetlighting data in the LCZs. The current coverage of buildings is around 80%: 22 buildings in Section 14 and three buildings in Section 5. For UiTM Section 1, the electricity usage is for the whole zone and only Section 1 includes streetlighting data.

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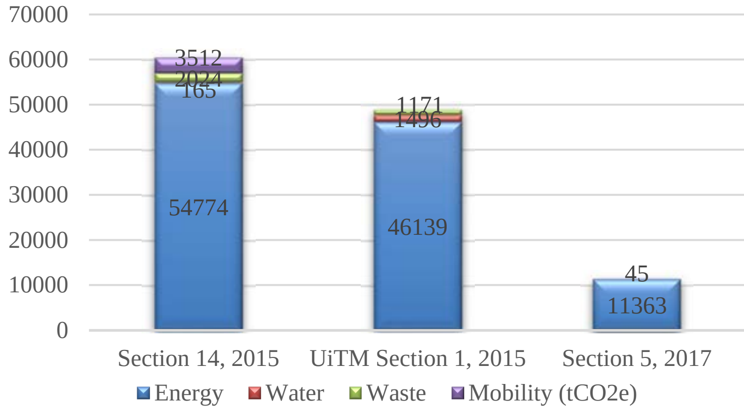


Figure 1: Baseline emissions of Shah Alam LCZs.

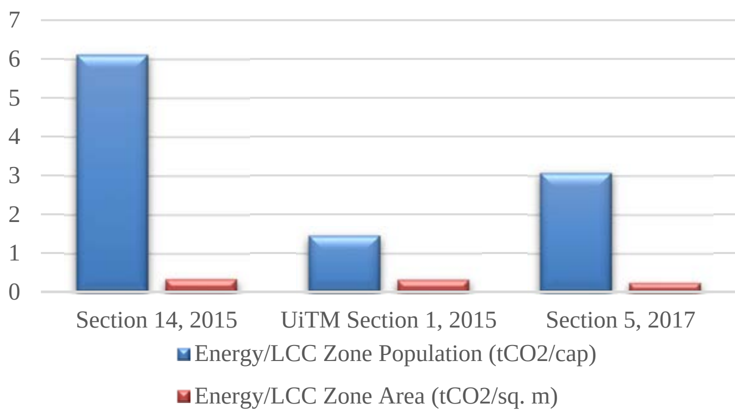


Figure 2: Baseline energy emissions intensity for Shah Alam LCZs.

The building energy index (BEI) and carbon emission intensity for selected buildings in the LCC zones are shown in Fig. 3. Lodging has the highest BEI of 912 kWh/m^2/yr and emission intensity of 633 kgCO_2/m^2/yr. BEI and emission intensity are also relatively large in banking and retail category, while the remaining buildings mostly falls below 200 level for both metrics.

3.3 Emission profile of LCZs

Fig. 4 shows the profile of past emissions for the three LCZs and their share of emissions. In 2019, Section 14, UiTM Section 1 and Section 5 produced 49,162.78, 45,239.05 and 10,335.04 tonnes of carbon dioxide equivalent (tCO_2e); a reduction of 18.71%, 7.31% and

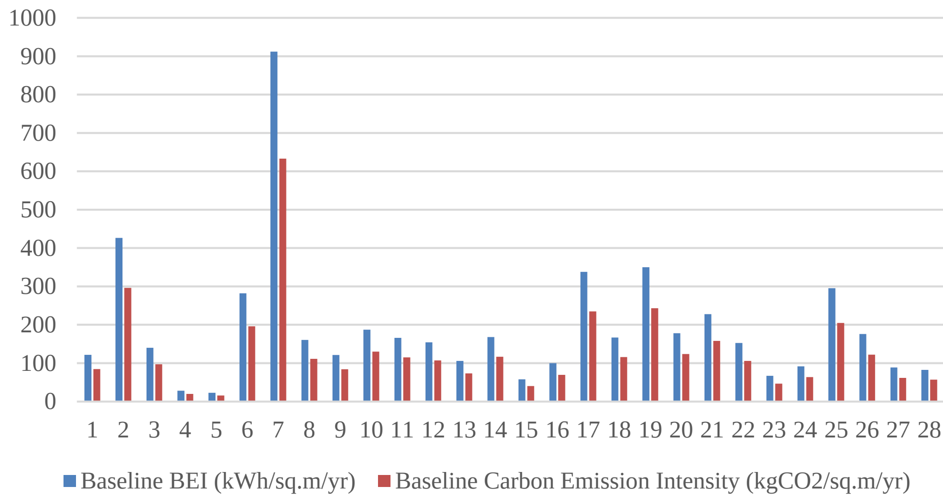


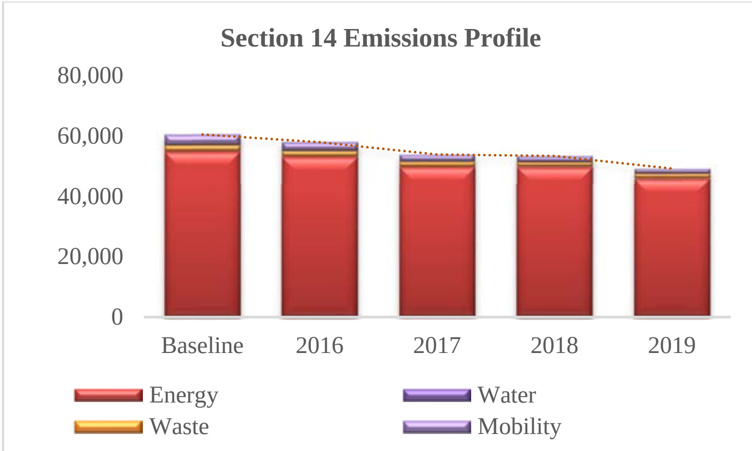
Figure 3: Baseline building emission intensity and carbon emission intensity for various buildings.

9.41% from the baseline levels, respectively. Electricity remained the biggest source of emissions. All zones show a decreasing emissions trend except for UiTM Section 1 where emission increased from 2018 to 2019. The yearly average emissions reductions were 11.4%, 3.2% and 3.9% for Sections 14, 1 and 5 respectively, with a combined yearly average reduction of 6.2% for all the three zones. It is worth noting that the three zones only represent about 1.6% of Shah Alam developed area and not all LCCF elements are covered for some zones. Thus, the yearly average emissions reduction does not reflect the true reduction that may be achieved for future LCC Zones in Shah Alam.

3.4 Setting reduction target

Findings from emissions data allows Shah Alam to set its low carbon target. In setting the target, the target type, target boundary, target levels and timeframe have to be identified. This is summarised in Table 2. There are four target types: base (or baseline) year, base year intensity, fixed level and baseline scenario. Shah Alam adopts a base year absolute target, a target type that reduces emissions by a specified quantity relative to emissions in the base year levels. This target type is among simplest to account for, most certain and transparent as allowable emissions in the target year(s) can be easily calculated at the beginning of target period and progress can be tracked using the inventory alone. The target boundary refers to the existing and future LCZs in Shah Alam. Taking into considerations the yearly average emission reductions achieved in the LCC Zones in comparison to the current LCC Zones coverage and the NLCCMP provision, the target level is set accordingly. Shah Alam commits to a 45% absolute emissions reduction by 2035 from baseline year levels of its LCC Zones. Shah Alam must implement strategies that will reduce its emissions based on this target.

Fig. 5 demonstrates the past emissions, baseline level, business-as-usual (BAU) projections and emissions reduction needed for 2025 (20% relative to baseline), 2030 (35%



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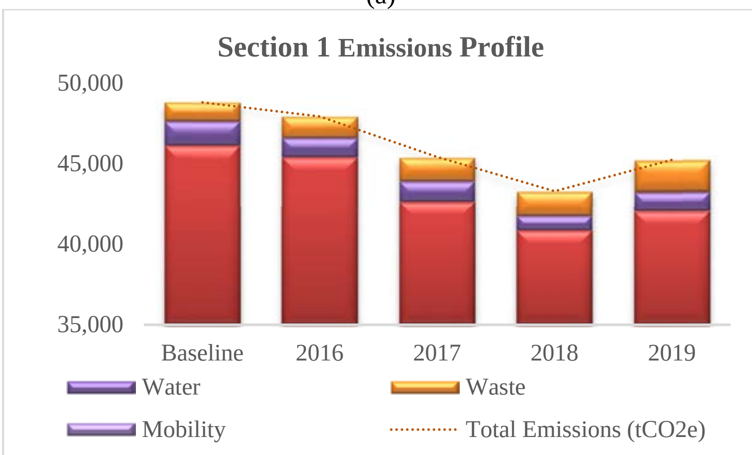

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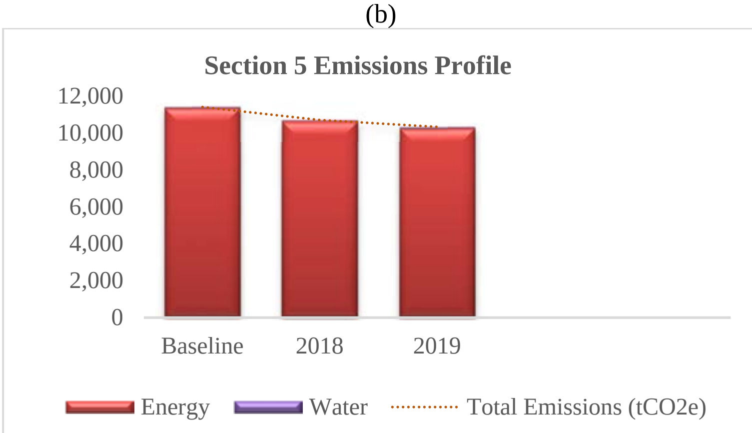
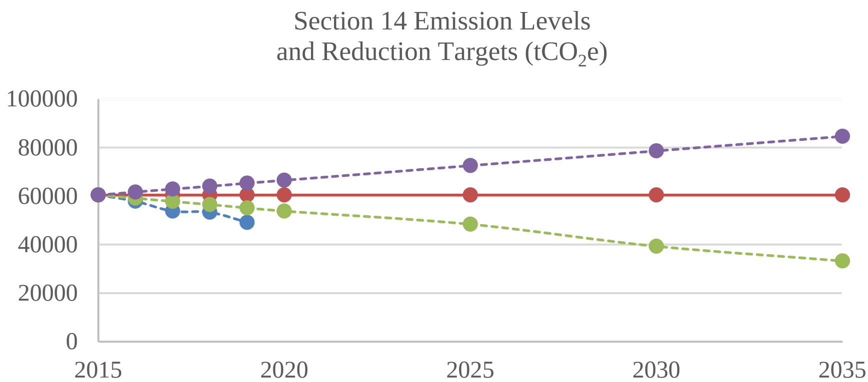


(c)

Figure 4: Emission profiles for Shah Alam LCZs. (a) Section 14; (b) Section 1; and (c) Section 5.



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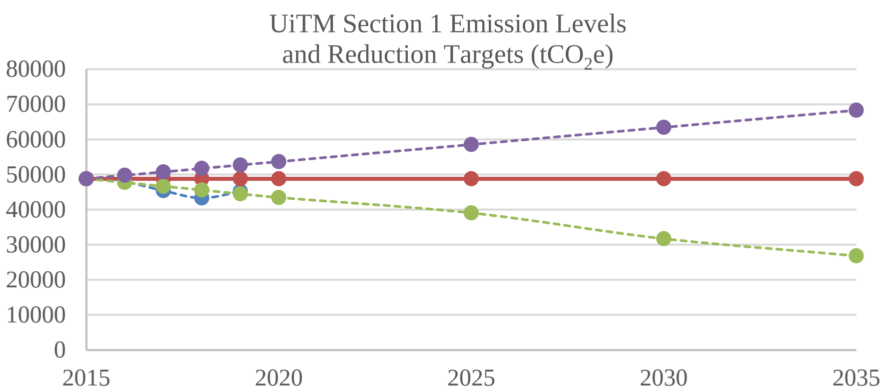

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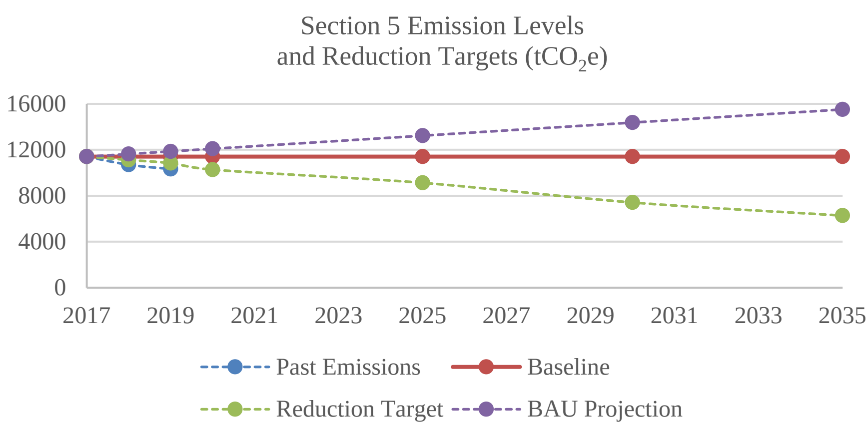

(c)

Figure 5: Emission levels and reduction target for Shah Alam LCZs. (a) Section 14; (b) Section 1; and (c) Section 5.

Table 2: Shah Alam's target setting.

Target type	Target boundary	Target level and date	Required total emission reduction by 2035 (tCO_2e)
Base year (absolute) emissions target	All existing and future LCC zones	45% by 2035 Interim: 35% by 2030 20% by 2025	Section 14: 27,214 UiTM Section 1: 21,963 Section 5: 5,134

relative to baseline) and 2035 (45% relative to baseline) for the three LCZs. The BAU scenario (projected assuming a 2% population growth per year for Shah Alam), is forecasted to provide an understanding of the future emission in the absence of low carbon policy and interventions. The 2025 and 2030 targets will serve as guides for Shah Alam to maintain its trajectory in meeting the 2035 target. Following LCCF changes and requirements in the future, these reduction levels and their respective baselines will have to be revised accordingly, with the addition of new data and adoption of new framework.

4 CONCLUSION

Despite challenges related to population growth and economic development, the LCZs in Shah Alam have demonstrated notable emissions reductions: 18.71% in Section 14, 7.31% in Section 1 and 9.41% in Section 5 from the baseline levels, with combined yearly average reduction of 6.2% for all three LCZs. These reductions, however, pertain to a mere 1.6% of Shah Alam's developed area, indicating that much of the city remains untouched by the LCCF's influence. Furthermore, not all elements of the LCCF are fully implemented across the zones, suggesting a need for expanded and intensified efforts. While not comprehensive, the LCCF's elements-based greenhouse gas inventories are useful for planning purposes, while transitioning to a city-wide GHG inventory that will measure Shah Alam's complete emissions. Initial findings indicate that electricity emissions accounting for over 90% of total measured emissions, with high BEI in associated building types, addressing the need to implement renewables and energy efficiency strategies in this hotspot area.

By utilising these findings and the forthcoming comprehensive city-wide GHG inventories, Shah Alam can formulate and influence policies that will guide its growth and significantly impact its contributions to state and national emissions goals. These insights not only support Shah Alam in evidence-based low carbon action planning but also provide valuable benchmarks for broader urban policies such as sustainable city planning, infrastructure development and energy management, as well as climate change policies including emission reduction targets, renewable energy adoption and energy efficiency standards. The study highlights the importance of scaling up efforts and integrating comprehensive GHG inventories to effectively manage and reduce emissions at both the local and national levels.

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