

Kuala Lumpur Net Zero Carbon Buildings Roadmap: Compliance Pathways, Costs, and Retrofit Prioritisation

1. INTRODUCTION

The transition toward net-zero carbon buildings is a critical component of urban decarbonisation strategies in rapidly developing cities. This paper investigates the Kuala Lumpur Net Zero Carbon Buildings (NZCB) Roadmap 2050, focusing on compliance pathways, lifecycle cost implications, and retrofit prioritisation strategies. The roadmap establishes a structured framework targeting a 70% reduction in building carbon intensity by 2030 and full decarbonisation by 2050. This study proposes an integrated analytical framework combining energy benchmarking, embodied carbon assessment, and financial modelling to evaluate building performance and retrofit feasibility. Results indicate that deep retrofits and renewable integration provide the highest carbon reduction potential, while policy-driven compliance tools enhance implementation efficiency. The study highlights the importance of digital compliance systems, multi-stakeholder governance, and equity considerations in achieving sustainable outcomes. The findings contribute to decision-support mechanisms for policymakers, developers, and investors in accelerating low-carbon transitions.

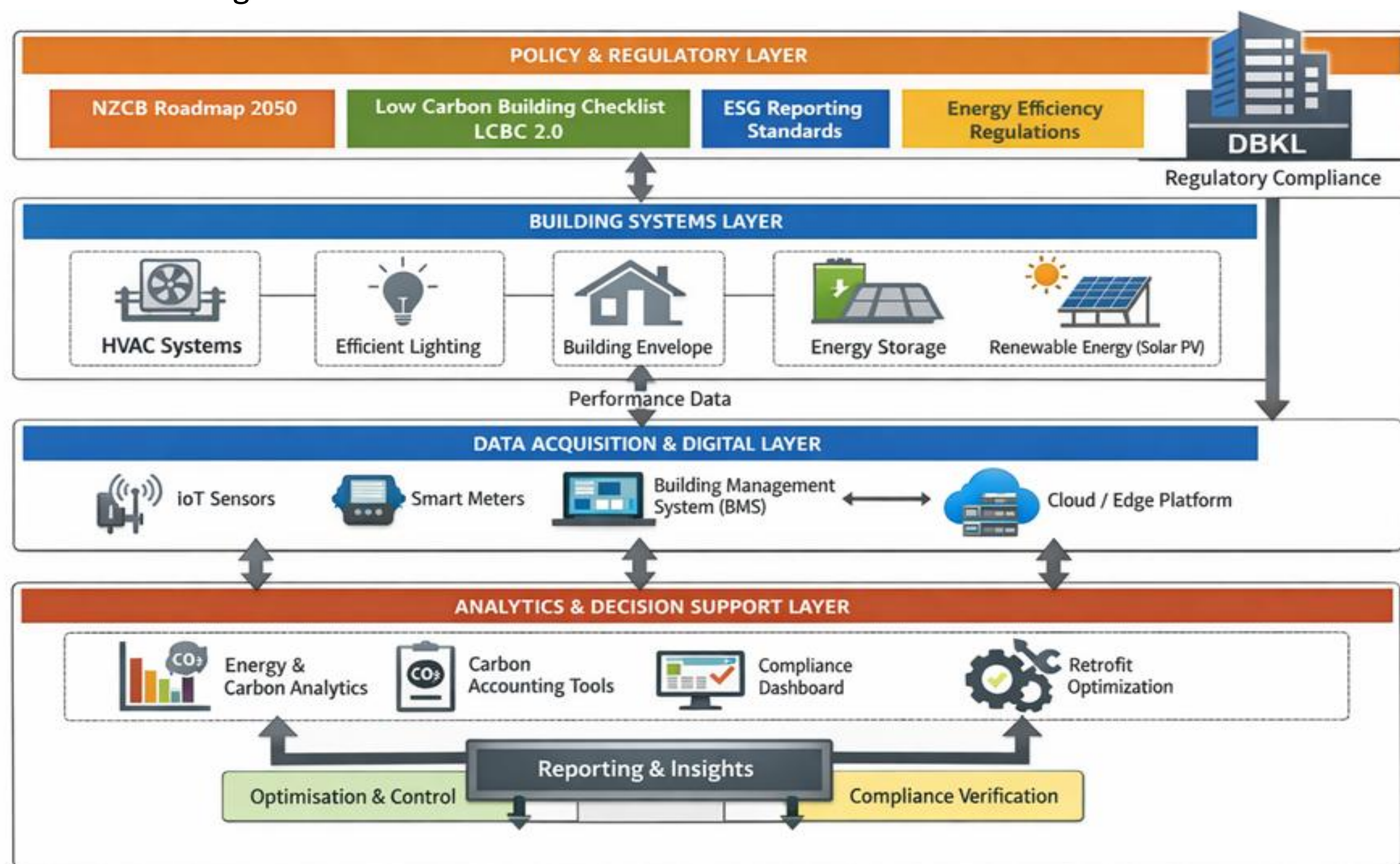


Figure 1. NZCB Compliance and Implementation Framework

2. OBJECTIVES

This study aims to

- To analyse compliance pathways for the Kuala Lumpur Net Zero Carbon Buildings (NZCB) Roadmap
- To assess the economic feasibility and lifecycle costs of net-zero building strategies
- To develop a data-driven retrofit prioritisation model for maximising carbon reduction efficiency

3. METHODOLOGY

This study adopts a multi-layer analytical framework to evaluate compliance pathways, cost structures, and retrofit prioritisation strategies for the NZCB roadmap. The methodology integrates three core components: energy performance assessment, carbon accounting, and financial modelling.

First, building energy performance is analysed using benchmarking techniques based on Building Energy Index (BEI), measured in kWh/m²/year. Data inputs include building typology, occupancy patterns, and energy consumption profiles. Second, carbon accounting is conducted using lifecycle assessment (LCA) methods, capturing both operational carbon emissions and embodied carbon associated with construction materials.

Third, a multi-criteria decision analysis (MCDA) model is developed to prioritise retrofit interventions. The model incorporates key parameters, including:

- Energy savings potential
- Carbon reduction (kgCO₂/m²)
- Retrofit cost (RM/m²)
- Payback period (years)
- Occupant comfort improvement

A marginal abatement cost (MAC) curve is generated to evaluate cost-effectiveness of various retrofit measures. Scenario simulations are conducted to compare three pathways:

1. Baseline (business-as-usual)
2. Incremental efficiency upgrades
3. Deep retrofit with renewable integration

Additionally, compliance pathways are assessed through policy analysis, focusing on regulatory instruments such as LCBC 2.0, energy efficiency standards, and ESG reporting requirements.

The framework is validated using representative building datasets from commercial, residential, and public sectors in Kuala Lumpur. The results provide insights into optimal strategies for achieving net-

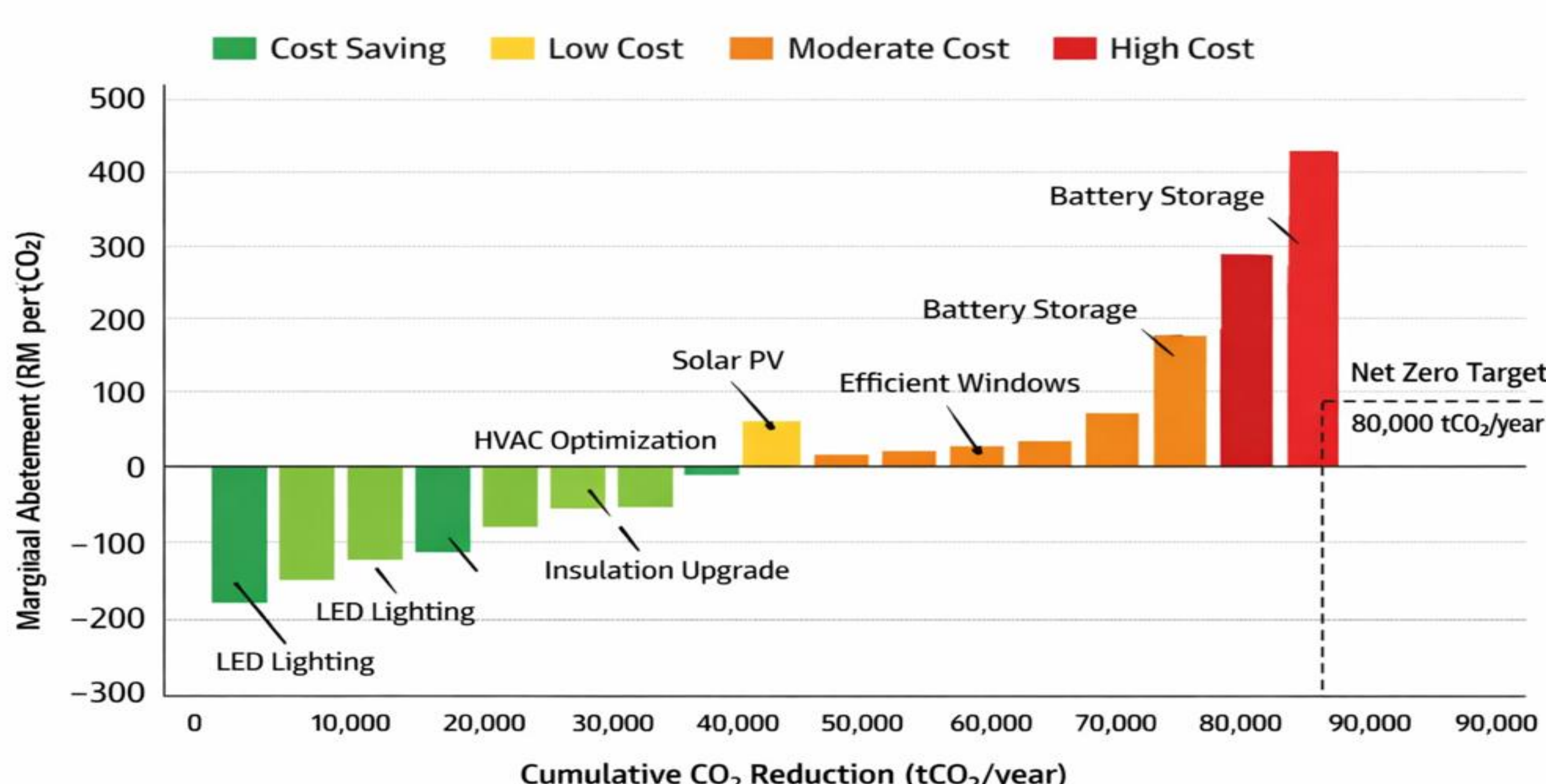


Figure 2. Marginal Abatement Cost (MAC) Curve for Building Retrofit Strategies.

4. Results and Observations

The analysis reveals that compliance mechanisms significantly influence the effectiveness of the NZCB roadmap. The LCBC 2.0 digital platform enables streamlined approval processes and ensures that new developments meet stringent energy efficiency standards

Table 1. Retrofit Strategy Performance Comparison

Retrofit Strategy	Energy Reduction (%)	Carbon Reduction (%)	Cost (RM/m ²)	Payback Period (Years)	Key Technologies Involved
Baseline (Business-as-Usual)	5%	3%	50	10	Basic maintenance, minimal efficiency upgrades
Incremental Retrofit	20–30%	15–25%	150–250	6–8	LED lighting, HVAC optimisation, insulation
Advanced Retrofit	35–50%	30–45%	300–400	7–10	High-efficiency HVAC, smart BMS, glazing
Deep Retrofit + Solar PV	55–70%	50–65%	450–600	8–12	PV systems, energy storage, full system upgrade
Net Zero Optimised Retrofit	70–90%	80–100%	600–900	10–15	Integrated PV, storage, AI energy management

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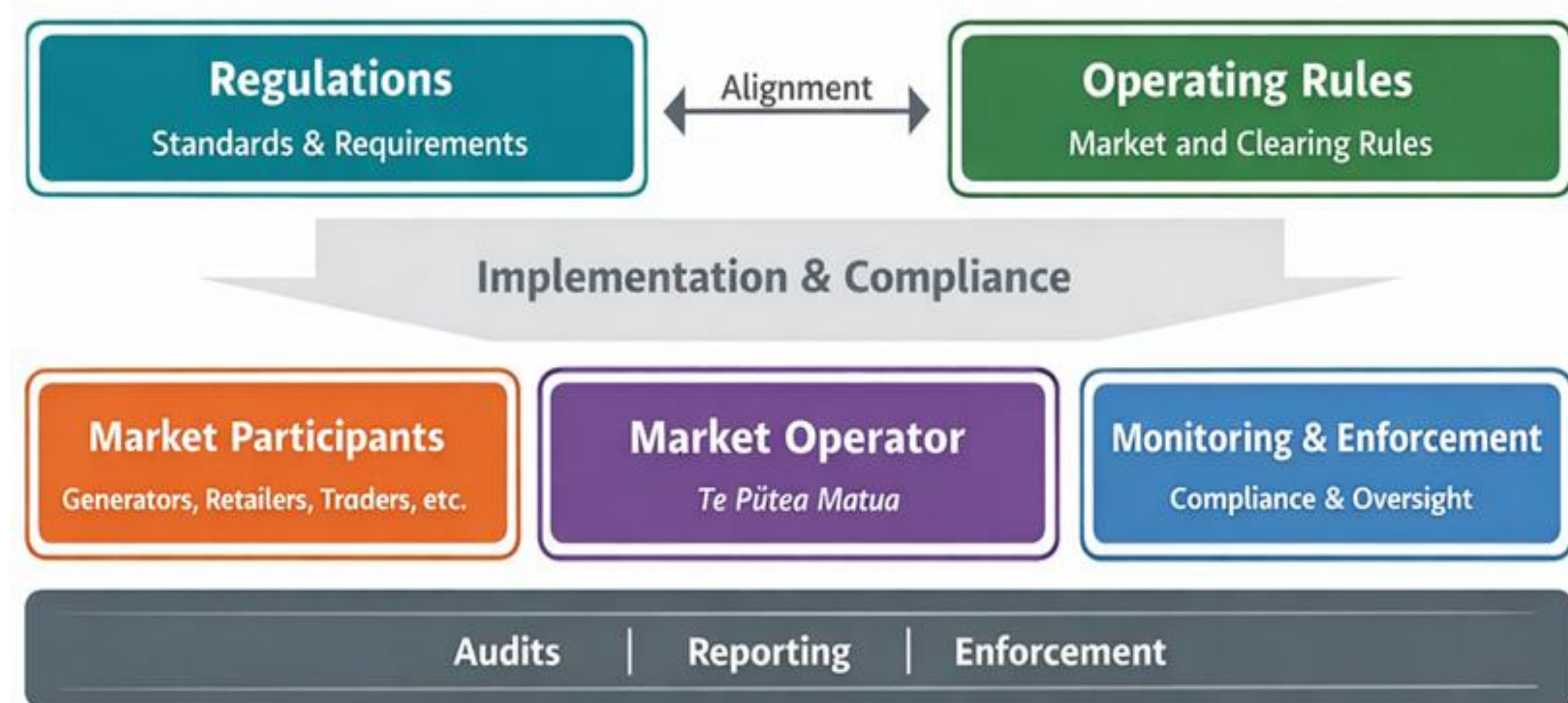


Figure 3. NZCB Compliance and Implementation Framework

6. Conclusions

The Kuala Lumpur NZCB Roadmap 2050 provides a comprehensive framework for decarbonising the urban built environment through structured compliance pathways, cost-effective strategies, and prioritised retrofit interventions. This study demonstrates that integrating energy efficiency measures with renewable energy systems yields significant carbon reductions while maintaining economic feasibility.

Digital compliance tools such as LCBC 2.0 play a crucial role in enhancing transparency, streamlining regulatory processes, and promoting stakeholder engagement. The findings also emphasise the importance of lifecycle carbon assessment and targeted retrofit strategies for high-impact buildings.

Despite challenges related to cost and implementation complexity, the roadmap offers a scalable model for sustainable urban development. Future work should focus on integrating AI-driven predictive analytics and digital twin technologies to further optimise building performance and accelerate Malaysia's transition toward net-zero emissions.