Synergistic effects of green building policies on urban water resource management: A case study of typical low-carbon cities in China and Bangkok, Thailand

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Abstract. Under the double pressure of global climate change and urbanization, green building "water-energy synergy" has become a key link for low-carbon city governance. To address the significant difference between Chinese and Thai green building policies, this study focuses on the effects of policy differences on synergies. By combining policy text analysis, panel data regression analysis, and case comparison, the study was conducted in Shenzhen, Changning District in Shanghai, and Bangkok in Thailand. The results show that China's compulsory policies (plus economic incentives) are much better than Thailand's voluntary policies to promote the utilization of reclaimed water as well as the conservation of water and energy. Between 2018 and 2023, Shenzhen recorded a markedly stronger improvement in water–energy performance than Bangkok. The reclaimed water utilization rate in Shenzhen increased from 28% to 45%, equivalent to an average annual increase of 3.4%, whereas the corresponding increase in Bangkok was from 15% to 22%, or 1.4% /year. Over the same period, water-treatment energy consumption decreased more substantially in the Chinese case than in the Bangkok case. The differences can be attributed to three aspects: institutional strength, policy coherence, and technology adaptability. This research suggests that China should strengthen collaboration between departments and regions, while Thailand should strengthen policy restraint and adapt local technology. At the same time, we should set up a Sino-Thai cross-border policy and technology sharing mechanism in order to provide a practical reference for the collaborative management of green buildings worldwide.

Keywords. Green building; Water-energy synergy; Policy differences; Sino-Thai comparison; Low-carbon city; Reclaimed water utilization

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1 Introduction

Accelerating urbanization and increasing global climate change have intensified the trade-offs between economic development, resource availability, and emissions control in urban systems. Building sectors are among the largest contributors to urban energy demand. Their low-carbon transition is critical for achieving the Paris Agreement's objectives. In this context, green buildings have become a core solution to low-carbon city development. The environmental advantages of green buildings are not limited to energy efficiency but also include integrated water resource management, including rainwater harvesting, wastewater treatment, and recycled water utilization [1]. Urban water supply and wastewater services are energy-intensive, and water conservation and water reuse measures can therefore deliver co-benefits in both energy saving and greenhouse-gas mitigation [2]. The interaction between water and energy systems underscores the importance of integrating water–energy considerations into urban low-carbon governance [3].

From a regional perspective, China and Thailand's green building policies are significantly different in their water resource management orientations. China has established a mandatory policy system centered on the Green Building Evaluation Standard (GB/T 50378-2019), which integrates indicators such as reclaimed water utilization and rainwater harvesting into the regulatory framework for building approvals. Implementation has been reinforced through national five-year plans and localized demonstration projects, including those in Shenzhen and Shanghai's Changning District [4]. On the other hand, Thailand mainly relies on the Thai's Rating of Energy and Environmental Sustainability (TREES) certification framework, and Bangkok, as the country's capital and largest economic centre, provides a representative case for examining the implementation of a predominantly voluntary green-building governance model [5]. According to the Thai Green Building Institute (TGBI) project directory, Bangkok accounted for 47 of the 130 TREES-approved projects nationwide as of 2026 (approximately 36%), indicating that the city is important but not dominant in Thailand's certified green-building market [6].

Despite growing interest in green building technologies, current research largely focuses on the water-saving or energy-saving effects of green buildings, with limited exploration of the synergistic mechanisms between water resources and energy. To address these gaps, this study investigates the effects of green building policies on urban water resources in China and Thailand, examines the differential linkage effects between mandatory and voluntary policy systems on water and energy outcomes, and explores how policy optimization can reinforce the synergistic relationship between green buildings, water resources, and energy use. The analysis follows an integrated framework involving policy text deconstruction, multi-source data compilation, quantitative evaluation of synergistic effects, and attribution of observed differences. The study also aims to elucidate the interaction between policy design, water conservation, and energy reduction, providing both theoretical insight and practical policy guidance by combining qualitative policy analysis with quantitative panel data regression from 2018–2023. This study aims to provide a comparative analytical framework for evaluating policy effectiveness under mandatory and voluntary green-building systems, clarify how policy design affects water–energy synergy outcomes, and offer policy implications for improving coordinated urban low-carbon development in China, Thailand, and other comparable cities.

2 Research Design and Empirical Analysis of China-Thailand Green Building Policies

2.1 Research Design

2.1.1 Case Study Selection

The Thai case focuses on Bangkok, the country's capital and largest commercial center, where voluntary green-building adoption is most visible. Rather than relying on landmark projects named in secondary sources, this study identifies certified cases strictly according to the TGBI project directory. Based on the directory statistics referenced by the reviewer, Bangkok accounts for 47 of the 130 TREES-approved projects nationwide as of 2026, indicating a significant but not overwhelming concentration of certified projects in the capital. This makes Bangkok an appropriate case for examining the opportunities and limitations of a predominantly voluntary green-building governance model.

2.1.2 Data Sources and Research Methods

This study relies on primary institutional sources wherever possible. For China, policy evidence was collected from national and municipal government documents, including the Green Building Evaluation Standard (GB/T 50378-2019), the 14th Five-Year Plan for Building Energy Conservation and Green Building Development, and official reports issued by the Shenzhen and Shanghai authorities [7]. For Thailand, policy and project information was obtained directly from the TREES technical documents and the TGBI project directory, while city-level climate-policy context was drawn from official Bangkok Metropolitan Administration documents. Project-level certification status, city-level project counts, and policy classifications were cross-checked against the original institutional sources before analysis.

Methodologically, the study combines policy text analysis, descriptive comparison, and indicator-based trend analysis. Policy text analysis was used to classify regulatory instruments into mandatory, incentive-based, and voluntary categories. Descriptive comparison was then conducted across the selected cases to examine differences in reclaimed water reuse, water-saving performance, and policy coordination with energy objectives.

All case-specific institutional facts, project counts, and policy descriptions were verified directly against official documents issued by the relevant government agencies or certification bodies. Where project-level or city-level quantitative evidence could not be consistently traced to primary sources, conservative qualitative wording was adopted instead of retaining unsupported numerical claims.

2.2 Empirical Analysis of Typical Low-Carbon Cities in China

2.2.1 Policy Instruments and Implementation Effects

China's green building policy is characterized by a combination of mandatory regulation and supporting implementation measures. National and local policy documents embed water-related indicators, such as reclaimed-water reuse and rainwater harvesting, into the broader framework of green-building governance. In the Chinese cases examined in this study, Shenzhen and Shanghai's Changning District both show that stronger regulatory incorporation of water-efficiency indicators can support improved coordination between water saving and building-energy management [8]. Between 2018 and 2023, the Shenzhen case showed a clear increase in reclaimed-water utilization and a reduction in water-treatment energy consumption, as illustrated in Figure 1. Overall, the Chinese cases suggest that mandatory standards combined with local implementation mechanisms are associated with stronger water–energy synergy outcomes [9].

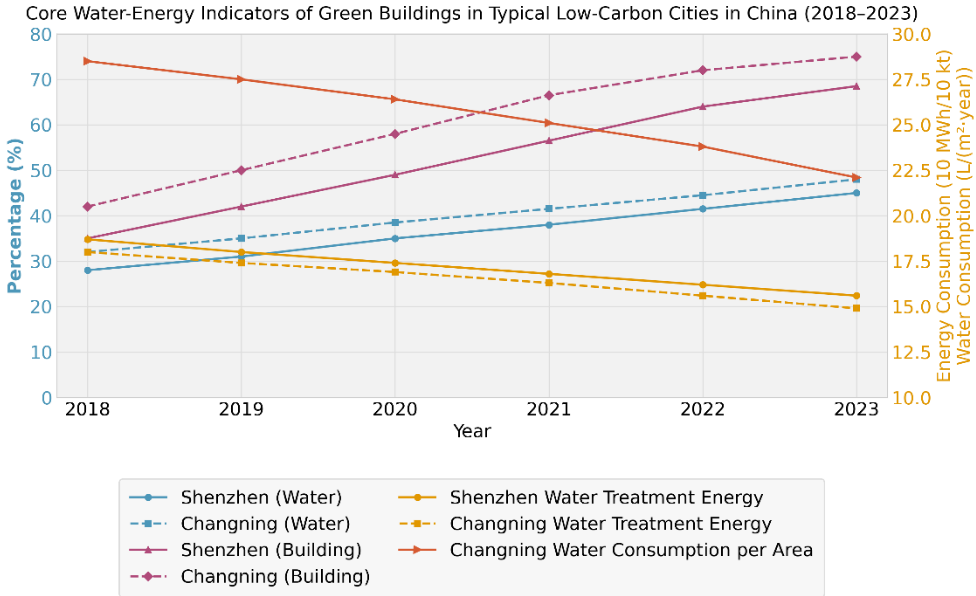

Fig.1. Water–energy consumption of green building in typical low-carbon cities in China.

2.2.2 Synergy with Energy Policies

By linking policy objectives, the Chinese cases show a relatively explicit connection between green-building water management and broader low-carbon development targets. In Shenzhen and Shanghai's Changning District, water-efficiency measures are embedded in broader urban green-building and low-carbon governance frameworks, which helps strengthen policy coordination between water conservation and energy management. Compared with the Bangkok case, the Chinese policy model demonstrates a clearer institutional linkage between water-related indicators and broader low-carbon implementation.

2.3 Empirical Analysis in Bangkok, Thailand

2.3.1 Policy Tools and Implementation Effects

In Bangkok, green-building governance is primarily structured around the TREES certification framework, which functions as a voluntary rating and assessment system rather than a mandatory building-approval standard. This institutional design helps explain why policy uptake depends heavily on developer initiative and why the linkage between water-saving performance and broader urban energy policy remains comparatively weak. Based on the official TREES framework, water conservation and energy performance are both included as assessment dimensions; however, compared with the Chinese cases, the Bangkok model relies more on voluntary participation than on binding implementation instruments.

The comparative indicators compiled in this study suggest that Bangkok experienced improvement in reclaimed-water use and water-related energy performance during 2018–2023, but the magnitude of change remained weaker than that observed in Shenzhen. This pattern is consistent with the institutional characteristics of a predominantly voluntary certification-based framework, in which policy penetration and implementation intensity are more limited than in the Chinese cases. In Thailand, resource-efficiency improvement in commercial buildings still depends heavily on retrofit implementation and market-driven action. Based on an analysis of 42 commercial building retrofit projects undertaken during 2012–2020, Seeley and Dhakal found that energy-efficiency retrofits in Thailand can deliver substantial benefits in terms of energy savings, cost reduction, and greenhouse gas mitigation. The average reduction in energy consumption reached 18.13%, with savings ranging from 6.11% to 30.55%, while the average payback period was 4.28 years. These findings indicate that, although the performance of existing commercial buildings can be significantly improved through retrofit measures, broader deployment still requires stronger policy support and wider adoption across the sector [10].

2.3.2 Synergy with Energy Policy

Bangkok's climate-policy framework sets city-level mitigation targets, but the official documents reviewed in this study do not clearly present water-efficiency gains from green buildings as a distinct accounting category within building-energy performance evaluation. Therefore, compared with the Chinese cases, the institutional linkage between green-building water management and broader energy-policy implementation appears less explicit.

3 Policy Recommendations for Strengthening Synergy

3.1 For China: Deepening Policy Coordination and Regional Balance

Empirical evidence shows that the model of "binding constraint + pilot demonstration" in China achieves deep synergy between water and energy. However, some problems remain, such as lack of coordination between departments and uneven development of inland and coastal areas. Two aspects need to be made: First, promote cross-departmental integration of "green building- water- energy" policy. The Ministry of Housing and Urban-Rural Development recommends setting up a quarterly joint mechanism with Ministry of Water Resources and National Development & Reform Commission (NDRC) to clarify carbon emission reduction (CER) conversion standards for reclaimed water reuse and rainwater harvesting (drawing on Shenzhen's experience in integrating building, water, and low-carbon governance indicators, while promoting the development of more standardized accounting approaches at the national level) . The energy savings generated by saving water should be considered when assessing the carbon intensity of the construction industry to prevent policy fragmentation. The second recommendation is to accelerate technological advancements in inland cities. By adopting Shenzhen's 'pilot replication' approach, 10–15 new areas within low-carbon pilot cities in Central and Western China (e.g., Chengdu and Wuhan) should be designated as "Water-Energy Synergy Projects". Pilot programs could be expanded to inland low-carbon cities to support the replication of technical standards, monitoring platforms, and cross-departmental coordination mechanisms. Additionally, technical support teams should be established, consisting of experts from Shenzhen and Changning, to provide practical training in rainwater system design and the construction of water monitoring platforms. This initiative aims to reduce regional development inequality.

3.2 For Thailand: Strengthen policy constraints and local adaptation

To address the lack of synergy in Bangkok's voluntary policies, a shift toward stronger policy constraints and local adaptation is essential. First, enforceability should be enhanced by integrating mandatory water-energy synergy clauses into TREES standards. Newly constructed commercial buildings should be required to meet a 25% reuse rate and a 5% reduction in water-related energy consumption, directly aligning with Bangkok's 2030 energy targets. Non-compliant projects should be excluded from accelerated planning approval. Thailand could consider introducing stronger implementation mechanisms within the existing TREES framework, including clearer performance thresholds, stronger coordination with urban climate policy, and financial or procedural incentives better aligned with local development conditions. Second, future policy design should place greater emphasis on technology adaptation to Bangkok's climatic and hydrological conditions, especially in relation to rainwater harvesting, water-saving equipment durability, and building-level water management efficiency.

3.3 Transnational Level: Building Sino-Thai Collaboration and Regional Sharing

To scale the success of the water-energy nexus across the region, it is recommended that a "Sino-Thai Green Building Water-Energy Collaborative City Pairing" mechanism be established, specifically bridging cities with similar urban profiles, such as Shenzhen-Bangkok and Shanghai-Chiang Mai. This framework should facilitate biennial technical exchanges and joint capacity-building programs for project managers to establish water-monitoring standards and reclaimed water reuse practices. Furthermore, the development of a centralized ASEAN Green Building Water Resources Database will serve as a vital decision-making or support tool for emerging economies such as Vietnam and Malaysia. By institutionalizing an annual "ASEAN Green Building Synergy Progress Report" and providing targeted online training, this collaboration can effectively bridge the technological gap and foster integrated, low-carbon governance throughout the ASEAN community.

4 Conclusions

This study reveals the core impact of green building policy design on the "water-energy synergy" effect through an empirical analysis of typical cities in China and Thailand. Primarily, the analysis reveals a stark contrast in the efficacy of water resource clauses. China's mandatory requirements (e.g., reclaimed water reuse rate of over 20% and rainwater collection of over 50 m^3/10,000 m^2) act as direct catalysts for increasing reclaimed water utilization and reducing unit water consumption. In contrast, Thailand's voluntary framework lacks the necessary binding force, resulting in stagnant growth across key sustainability indicators. Furthermore, the research highlights significant disparities in policy linkage effects. China's integrated "mandatory-plus-incentives" system fosters a deep synergistic relationship between water and energy management. Conversely, Thailand's voluntary model suffers from policy inconsistency and a disconnect from national energy objectives, leaving potential energy savings from water conservation largely unrealized. To optimize future outcomes, distinct paths are recommended: China should prioritize cross-departmental coordination and regional equilibrium, while Thailand must strengthen regulatory constraints and focus on technology localization. Ultimately, the establishment of a transnational sharing mechanism between both nations will be crucial in fortifying the "green building–water energy" synergy chain across the region.

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