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SIMULATION-GUIDED LOW-CARBON RETROFIT DESIGN FOR MOUNTAINOUS SCHOOL CAMPUSES: WIND ENVIRONMENT OPTIMIZATION AND ENERGY-EFFICIENT FACADE REGENERATION AT YEZHAI MIDDLE SCHOOL

H. A. Algarvio

The low-carbon renewal of school campuses is increasingly central to sustainable urban development, particularly in regions where existing public-building stock must be upgraded under climatic and topographic constraints. This paper presents a structured case study of Yezhai Middle School in Tianzhushan Town, Qianshan, Anhui Province, China, and frames the project as a smart-city public-infrastructure retrofit problem. The study integrates site planning, wind-environment simulation, facade regeneration, and exterior-wall thermal analysis in order to establish a practical method for upgrading mountainous secondary-school campuses. A simplified geometric model of the school complex was developed in SketchUp and analyzed in Ecotect using the WinAIR plugin. The wind model employed a 5 m/s inlet wind speed, 0 Pa outlet pressure, no-slip wall boundaries, an ambient temperature of 30°C, air density of 1.2 kg/m^3, and air viscosity of 1.8×10^{-5} Pa·s, with sectional analyses at 0, 10, 20, and 30 m. Field validation at four measurement points showed close agreement between measured and simulated wind speeds, with relative errors ranging from 3.13% to 6.67%. Thermal assessment of the renovated exterior wall adopted a 20°C indoor–outdoor temperature difference and a high-density expanded polystyrene (EPS) insulation layer of 0.15 m thickness with thermal conductivity of 0.038 W/mK. The calculated wall U-value was 0.253 W/m^{2}K, and the annual post-renovation winter heat demand was 2920 kWh. The facade strategy combined energy-saving wall improvement with campus-wide visual unification, gray-and-white material control, and a Hui-style architectural language. The study demonstrates that simulation-led retrofit design can improve outdoor wind conditions, reduce heat transfer, and provide a replicable planning framework for school renewal within the broader agenda of urban sustainability and smart-city infrastructure.

Index Terms — smart city development; campus renewal; school building retrofit; wind environment simulation; facade regeneration; thermal insulation; low-carbon design

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INTRODUCTION

The renewal of educational buildings has become an increasingly important component of contemporary urban sustainability policy because school campuses are not only instructional environments, but also long-duration public infrastructures that shape health, comfort, energy demand, and everyday environmental behavior. In the broader context of smart-city development, the retrofit of public buildings is no longer understood simply as an exercise in physical repair, code compliance, or visual modernization. Rather, it is now closely tied to data-informed planning, environmental simulation, energy-performance improvement, and the creation of healthier and more resilient learning environments [1, 3, 4]. As cities seek lower-carbon development pathways, educational facilities occupy a particularly important place because they combine high social value with significant opportunities for energy savings, operational optimization, and demonstration of sustainable design principles.

This policy and design challenge is especially significant in the case of existing school buildings in China, many of which face the dual pressure of aging physical fabric and rising expectations for environmental quality, safety, and performance. These pressures are even more pronounced in topographically complex and climatically demanding settings, where retrofit decisions must account for local wind behavior, solar exposure, moisture conditions, thermal loads, and the changing functional requirements of contemporary campuses. In mountainous areas and in hot-summer, cold-winter climate zones, building renewal cannot rely on generic solutions alone because the interaction between terrain, microclimate, building orientation, and envelope performance is more intricate than in flatter and more thermally stable urban sites. Under such conditions, low-carbon retrofit design must respond simultaneously to airflow organization, heat-transfer control, facade durability, public-space quality, and the environmental experience of users [2, 5].

Within this context, Yezhai Middle School in Anhui Province provides a particularly valuable case for examining how smart and sustainable campus renewal can be approached in an integrated way. The project is analytically rich because it does not concern a single isolated intervention, but rather a coordinated redevelopment process involving retained buildings, new construction, topographic variation, campus expansion, and facade upgrading within one educational environment [1]. This combination makes the site especially suitable for studying how simulation tools and design strategies can be brought together to support both campus planning and building-envelope improvement. Instead of treating wind environment and exterior-wall insulation as separate technical matters, the present study interprets them as interdependent components of a broader renewal strategy in which spatial planning, building performance, and environmental quality are mutually reinforcing.

The empirical basis of the study is the Qianshan Yezhai Middle School Campus Expansion and Upgrade Project, located in Tianzhushan Town, Qianshan, Anhui Province, China. According to the source study, the construction scope includes the existing main campus together with land on its west and north sides. The redevelopment incorporates the former site of Tianzhushan Central Primary School and the former Yezhai mining supply station, totaling 23.27 mu (approximately 1.56 hectares), in addition to 78 mu (approximately 5.23 hectares) of collective mountain ponds, terraces, and flower beds in Fengjing Village. Through this intervention, the total campus area increases by approximately 100 mu, or about 6.7 hectares [1]. These figures indicate that the project is not merely a building renovation exercise, but a substantial campus-scale transformation in which land consolidation, spatial reorganization, and environmental performance improvement are considered together.

The location and physical setting of the campus further strengthen its relevance as a study case. The site is connected to surrounding towns through National Highway 318 as well as provincial and county roads, and it lies approximately 8 km from downtown Qianshan, giving it both local accessibility and a degree of geographic distinctiveness [1]. The terrain descends gradually from north to south, with Tianzhushan

Mountain situated behind the site and the Qianshui River lying to the south. This landscape setting offers a high-quality ecological backdrop, but it also makes environmental response a central issue in planning and design. In such a setting, wind movement, thermal behavior, and facade performance are shaped not only by the buildings themselves, but also by topographic exposure, surrounding landform conditions, and the relationship between open space and built form. These characteristics make the campus an appropriate setting for simulation-supported renewal, since intuitive design decisions alone may not be sufficient to capture the environmental complexity of the site [1, 2].

The redevelopment strategy itself reflects the logic of phased and differentiated intervention. Obsolete buildings are identified for demolition, while others are retained and upgraded according to their structural condition and functional value. The project is organized into two major phases, namely the West Campus and the Main Campus. New construction is concentrated in the West Campus, whereas the Main Campus is the focus of facade renewal and public-space improvement [1]. This division is important because it illustrates a common challenge in public-building modernization: renewal rarely occurs on a blank site. Instead, planners must work across mixed conditions of retention and replacement, balancing construction efficiency, cost, environmental performance, and continuity of use. In smart-city and urban-renewal terms, such projects are important because they test how simulation, design, and phased implementation can be coordinated within a real public-infrastructure context.

The climatic and environmental conditions of Tianzhushan Town are equally central to understanding the design problem. The area lies within a subtropical monsoon climate zone and, according to the source study, is characterized by abundant rainfall, strong seasonal variation, hot summers, dry cold winters, and relatively mild transitional seasons [1]. The reported climate profile includes approximately 250–300 foggy days per year, annual sunshine duration of no more than 2000 hours, and annual precipitation of about 1900 mm, with up to roughly 150 rainy days annually. The multi-year average temperature is reported as 16.2°C. Annual solar radiation is approximately 154 $\mathrm{MJ\,m^{-2}\,d^{-1}}$, with the highest monthly level occurring in July at about 17 $\mathrm{MJ\,m^{-2}\,d^{-1}}$ and the lowest in January at about 8 $\mathrm{MJ\,m^{-2}\,d^{-1}}$ [1]. These conditions create a demanding environmental context in which building performance must respond to both heat and moisture as well as to seasonal thermal contrast.

From a design and simulation perspective, these climatic conditions matter for at least two major reasons. First, the prevailing summer wind direction from the southeast provides a strong basis for airflow-oriented campus planning, especially where outdoor comfort, natural ventilation potential, and building arrangement are concerned. In a school environment, where open space, circulation, and prolonged occupancy all matter, wind behavior influences not only the environmental quality of courtyards and walkways, but also the effectiveness of passive ventilation strategies [2, 5]. Second, the marked contrast between hot seasons and cold seasons means that facade insulation becomes a particularly high-impact intervention, affecting both indoor comfort and operational energy use. In such climates, exterior-wall upgrading is not only a matter of thermal efficiency, but also of improving the long-term performance and resilience of the campus envelope under variable and sometimes demanding environmental conditions [3, 4].

For these reasons, Yezhai Middle School serves as more than a localized architectural case. It represents a broader category of public-campus renewal problems in which topography, climate, aging building stock, and sustainability objectives intersect. The case demonstrates why school-building retrofit in smart-city discourse should be approached through an integrated framework rather than through isolated technical adjustments. Wind-environment simulation, heat-transfer analysis, facade regeneration, land-use restructuring, and public-space renewal are all interdependent when the goal is to create a low-carbon and environmentally responsive campus. The project thus offers a strong basis for examining how simulation-led design can guide not only building-level interventions, but also broader campus-scale modernization strategies [1, 3, 4, 2, 5].

Accordingly, this manuscript is framed to suit the interests of an urban-development and smart-cities audience. It emphasizes the relationship between campus-scale planning, environmental performance, and public-infrastructure modernization, while also showing how simulation methods can support design decisions in a concrete redevelopment setting. More specifically, the study documents the site and climatic context of Yezhai Middle School, reconstructs the simulation-based analytical workflow used to assess wind environment and heat transfer, synthesizes the project's facade-regeneration measures into a coherent retrofit strategy, and evaluates the implications of the reported energy-saving outcomes for future school-building renewal. In doing so, it contributes to a growing body of work that treats educational-building retrofit not simply as a construction task, but as a strategic part of sustainable urban transformation [1, 3, 4].

Table 1: Key project and environmental characteristics of the Yezhai Middle School case.

Item	**Case-specific information**
Project location	Tianzhushan Town, Qianshan, Anhui Province, China
Initial incorporated redevelopment land	23.27 mu (approximately 1.56 ha)
Additional requisitioned land	78 mu (approximately 5.23 ha)
Total reported campus increase	Approximately 100 mu (approximately 6.7 ha)
Distance from downtown Qianshan	Approximately 8 km
Topographic setting	Terrain slopes from north to south; Tianzhushan Mountain to the rear; Qianshui River to the south
Climate type	Subtropical monsoon; hot summers and dry cold winters
Annual sunshine duration	No more than 2000 h
Foggy days per year	Approximately 250–300 days
Average annual precipitation	Approximately 1900 mm
Maximum rainy days in a year	Approximately 150 days
Reported multi-year average temperature	16.2°C
Annual solar radiation	Approximately 154 MJ m^{-2} d^{-1}
Peak monthly solar radiation	July, approximately 17 MJ m^{-2} d^{-1}
Lowest monthly solar radiation	January, approximately 8 MJ m^{-2} d^{-1}

MATERIALS AND METHODS

Analytical Framework

The analytical strategy combines campus planning, wind-environment simulation, field validation, and steady-state heat-transfer assessment. The method is intended to support early-stage decision making for school-building renewal while remaining technically transparent and replicable.

The workflow begins with site and climate interpretation, followed by the construction of a simplified geometric model of the campus building group. Wind-environment simulation is then performed to understand pressure and airflow behavior at different heights and across different orientations. The results are checked against field measurements at selected points around the campus. In parallel, the exterior-wall assembly is assessed using a thermal resistance and heat-conduction model in order to quantify the effect of EPS insulation on heat-transfer performance. Finally, simulation findings are translated into architectural and facade-renewal design decisions.

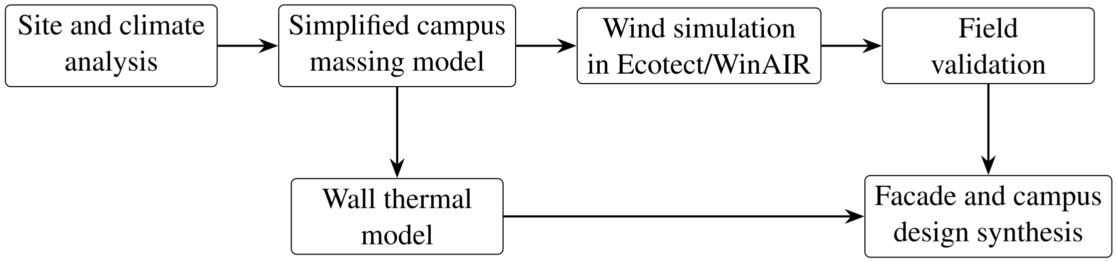

Figure 1: Integrated simulation-to-design workflow used for the Yezhai Middle School retrofit analysis.

Algorithm 1 Simulation-guided workflow for school-campus retrofit assessment

Collect site, topographic, and climatic information for the campus.
Build a simplified geometric model of the school complex in SketchUp.
Import the model into Ecotect and activate WinAIR for wind analysis.
Define CFD boundary conditions, fluid properties, and mesh settings.
Simulate wind behavior at 0, 10, 20, and 30 m sections.
Compare simulated wind speeds with field measurements at representative points.
Construct the wall thermal-resistance model for the renovated exterior wall.
Calculate thermal resistance, U-value, and annual heat-demand estimate.
Translate environmental and thermal findings into facade and campus-renewal design actions.

Wind Environment Simulation

The wind-environment analysis uses Ecotect software, supported by the WinAIR plugin. The campus building group was first modeled in SketchUp. To improve computational efficiency while preserving the essential spatial logic of the campus, the buildings were simplified into cuboid forms according to the principle of architectural similarity. This reduction is appropriate for early-stage environmental analysis because it retains bulk, orientation, spacing, and obstruction effects while limiting unnecessary geometric complexity [1].

The wind simulation is based on CFD principles, with emphasis on wind speed, wind pressure, and flow-direction distributions. The source study analyzed sections at heights of 0 m, 10 m, 20 m, and 30 m to capture the effect of building height and ground friction on airflow.

The mesh strategy adopted an unstructured grid. The minimum general cell size was 0.05 m and the maximum was 0.5 m, with additional local refinement down to 0.02 m near windward and leeward surfaces and at the building–ground junction. This approach was intended to improve the representation of boundary-layer behavior and local gradients while maintaining manageable computational cost.

Thermal Conduction and Exterior-Wall Assessment

The heat-transfer analysis follows Fourier's law and a steady-state heat-conduction framework. The central objective is to determine the thermal resistance and transmittance of the renovated exterior wall and to estimate the corresponding annual heat demand.

The key equations are:

$$\nabla \cdot (k \nabla T) = 0 \tag{1}$$

$$R = \frac{d}{k} \tag{2}$$

$$U = \frac{1}{R} \tag{3}$$

$$Q_{\text{year}} = U \cdot A \cdot \Delta T \cdot t \tag{4}$$

where k is thermal conductivity, d is material thickness, R is thermal resistance, U is wall transmittance, A is wall area, ΔT is the indoor–outdoor temperature difference, and t is the total heating or cooling duration.

The insulation material selected for the case is high-density expanded polystyrene (EPS), chosen for its relatively low thermal conductivity and constructible thickness. The source study reports an EPS layer thickness of 0.15 m and thermal conductivity of 0.038 W/mK under a fixed temperature-difference condition of 20°C [1].

Table 2: Primary simulation and wall-analysis parameters used in the case study.

Parameter	**Value**	**Interpretation**
Inlet wind speed	5 m/s	Typical summer inflow condition for the campus
Outlet pressure	0 Pa	Free outflow boundary
Wall boundary condition	No-slip	Zero relative motion at solid surfaces
Ambient temperature	30°C	High-temperature summer condition for simulation setup
Air density	1.2 kg/m^3	Standard atmospheric fluid parameter
Air viscosity	1.8×10^{-5} Pa·s	Flow and shear parameter
General minimum mesh cell size	0.05 m	Finer grid in critical areas
General maximum mesh cell size	0.5 m	Coarser grid where gradients are smoother
Boundary-layer refinement	0.02 m	Local refinement near building surfaces
Wind-analysis sections	0, 10, 20, 30 m	Vertical sampling of airflow behavior
Indoor–outdoor temperature difference	20°C	Thermal gradient for wall assessment
Insulation material	High-density EPS	Primary exterior-wall insulation layer
EPS thermal conductivity	0.038 W/mK	Material property used in conduction calculation
EPS thickness	0.15 m	Renovated wall insulation thickness
Calculated wall U-value	0.253 W/m^{2}K	Reported thermal transmittance after renovation

Experimental Validation

To assess the reliability of the CFD-based wind analysis, the study compared simulated results with field measurements obtained using anemometers at four locations around the building complex. The four points represent different aerodynamic conditions: the lower windward side, the side of the building at intermediate height, the leeward zone, and the space above the building. This layout enables the comparison of shielding, recovery, and elevated wind conditions within the same campus context.

RESULTS

Wind Environment Findings

The wind-environment analysis indicates that wind speed increases with height and that this increase is nonlinear. The rate of increase is stronger closer to the ground, where friction and building obstruction are more influential, and becomes more gradual at higher levels where airflow is less constrained. The study also reports a parallel nonlinear tendency in wind pressure, which remains especially important because wind pressure scales with the square of wind speed [1].

Directional interpretation of the simulation further suggests that the westward wind environment experiences the highest wind speed and wind pressure. This implies greater sensitivity to wind load and stronger exposure in outdoor spaces facing west. By contrast, the east and south are described as relatively mild and therefore more suitable for external spaces that seek to benefit from natural ventilation. The north side is comparatively sheltered, indicating the presence of either built or natural protection and suggesting its usefulness for more enclosed or wind-protected functions.

The broader design implication is that campus planning in mountainous settings cannot rely only on formal composition; it must also consider directional exposure and local wind behavior when organizing circulation, open space, and facade response.

Model Validation

Table 3 presents the reported comparison between field measurements and the corresponding CFD simulation results. The simulated values closely follow the measured values across all four points. The maximum reported pointwise relative error is 6.67%, and the mean absolute relative error across the four points is 4.42%, indicating acceptable agreement for early-stage design analysis.

Table 3: Comparison of measured and simulated wind speeds at the primary validation points.

Measurement point	Measured wind speed (m/s)	Simulated wind speed (m/s)	Relative error (%)
1	4.8	4.6	4.17
2	3.2	3.1	3.13
3	2.7	2.8	3.70
4	1.5	1.6	6.67
		Mean absolute relative error	**4.42**

The mean error shown here is calculated directly from the four reported pointwise relative errors.

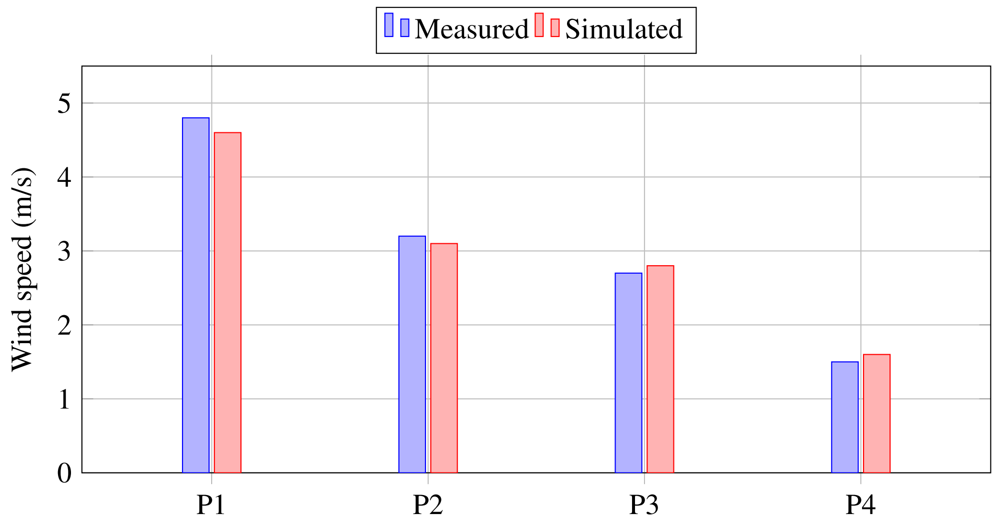

Figure 2: Measured and simulated wind speeds at the four primary validation points.

This level of agreement supports the use of Ecotect-based airflow analysis as a decision-support tool for preliminary school-campus planning. Although it does not substitute for more detailed high-fidelity simulation in later design stages, it is sufficiently robust to guide massing, orientation, and facade decisions in retrofit projects with limited time and resources.

Facade Regeneration Strategy

The facade-renewal strategy at Yezhai Middle School is notable because it combines environmental retrofitting with architectural and public-space unification. On the Main Campus, the project re-integrates the landscape resources of the East Campus and introduces a landscaped plaza in front of the main teaching building, strengthening the sense of arrival and campus identity. At the same time, the facade language of the existing buildings is unified through gray-and-white material control and a visual expression associated with Hui-style architecture [1].

The source study identifies multiple building-specific and campus-wide interventions. Rather than replacing the entire facade system indiscriminately, the project adopts wall-cladding replacement and targeted facade enhancement while preserving the broader historical and cultural character of the school. This approach is particularly suitable for existing public campuses, where full replacement is often economically or institutionally impractical.

The architectural significance of these measures lies in their dual role. They improve visual coherence and public-space quality while also supporting the energy-performance objectives of the exterior envelope.

Exterior-Wall Energy Performance

The exterior-wall retrofit is the clearest quantitative energy intervention in the project. Using an EPS insulation layer of 0.15 m thickness and thermal conductivity of 0.038 W/mK, the wall thermal resistance can be expressed as:

Table 4: Source-grounded summary of facade-regeneration measures at Yezhai Middle School.

Element	**Orientation / scope**	**Reported design action**
Comprehensive Building (Nanyue Academy)	Facing south, slightly westward	Partial addition of ventilated and transparent aluminum–plastic panels; adjustment of color and style to maintain harmony with surrounding buildings
Teaching Building 1	Facing south, slightly westward	Optimization of the building lobby and central-axis sequence; adoption of a more unified design language to strengthen architectural consistency and ceremonial presence
East Campus foreground	Campus entry zone	Re-integration of landscape resources and design of a landscaped plaza in front of the main teaching building to reinforce campus identity
Campus-wide facade language	Multiple retained buildings	Unification of facade style through gray-and-white color control and material coordination referencing Hui-style architectural character
Science and Technology Museum and adjacent buildings near the Martyrs Shrine	Main Campus cluster	Exterior renovation, interior decoration, and exhibition arrangement as part of the broader facade-renewal program

$$R = \frac{0.15}{0.038} = 3.95\ \mathrm{m^2K/W} \tag{5}$$

The corresponding thermal transmittance is:

$$U = \frac{1}{3.95} = 0.253\ \mathrm{W/m^2K} \tag{6}$$

The study reports that this renovated wall assembly reduces heat transfer sufficiently to yield an annual post-renovation winter heat demand of approximately 2920 kWh. It further states that the renovated facade achieves approximately 24% energy savings. The interpretation offered by the case is consistent: the insulation layer reduces cold-air intrusion in winter, limits external heat gain in summer, and improves indoor comfort while lowering operational energy demand [1].

This result is significant because it demonstrates that even a relatively straightforward facade retrofit can produce measurable energy benefits when material properties, wall thickness, and climatic conditions are properly aligned.

DISCUSSION

Relevance to Urban Development and Smart-City Practice

Although the project is a school-campus case, its relevance extends beyond educational architecture. The study treats the campus as a component of public infrastructure and demonstrates how simulation tools can support data-informed design in an urban-development context. This aligns closely with smart-city objectives:

using digital methods to improve environmental performance, support better resource use, and guide the renewal of existing public assets [1, 3, 4].

From an urban-governance perspective, the Yezhai Middle School project is valuable because it shows that low-carbon renewal need not be confined to new-build demonstration projects. Instead, existing campuses can become testbeds for incremental but meaningful interventions that improve comfort, identity, and environmental performance simultaneously.

Design Lessons for Public Educational Buildings

Three lessons emerge from the case.

First, environmental simulation is most useful when it is directly linked to planning and facade decisions. In this project, wind analysis is not treated as an isolated technical exercise; it informs spatial organization, directional exposure, and the placement of more open or more protected external areas.

Second, facade renewal should be understood as both a cultural and a thermal operation. The Yezhai Middle School intervention improves the visual coherence of the campus while using targeted material selection and envelope improvement to deliver measurable energy savings.

Third, relatively accessible software can still be useful at the conceptual and schematic stages of school-building renewal. The practical value of Ecotect in this case lies in its speed, clarity, and ability to support rapid iteration, even if more advanced simulation tools may later be required for detailed design validation.

Limitations

Several limitations should be acknowledged. The case focuses on one campus in a specific climatic and topographic setting, so its findings should not be generalized mechanically to all school-building retrofits. The wind-environment analysis relies on simplified geometry, which is appropriate for early-stage decision support but necessarily omits certain fine-grained aerodynamic effects. The thermal assessment is steady-state and envelope-centered; it does not include dynamic occupancy schedules, HVAC control logic, or full-building seasonal simulation. Finally, the source study reports one principal quantitative energy outcome for the facade renovation, which is sufficient to demonstrate impact but not enough to establish a complete building-energy benchmark across all end uses.

These limitations do not diminish the study's value. Rather, they define its proper contribution: a rigorous and practically useful simulation-led framework for early-stage campus retrofit planning.

CONCLUSION

This paper presents a complete case-study manuscript on the low-carbon retrofit of Yezhai Middle School and positions the project within the broader agenda of urban development and smart-city infrastructure renewal. The study combines site analysis, environmental simulation, facade regeneration, and steady-state heat-transfer assessment in order to show how school-campus renewal can be made both environmentally effective and architecturally coherent.

The key findings are clear. Wind speed increases nonlinearly with height across the campus environment, and directional differences in wind pressure and airflow have direct implications for massing, open-space organization, and facade exposure. The Ecotect-based wind model shows acceptable agreement with field measurements, with pointwise relative errors between 3.13% and 6.67%. The exterior-wall retrofit using 0.15 m high-density EPS insulation with thermal conductivity of 0.038 W/mK achieves a calculated U-value of 0.253 W/m^{2}K. The reported annual post-renovation winter heat demand is approximately 2920 kWh, and the facade intervention yields approximately 24% energy savings.

Equally important, the project demonstrates that technical environmental upgrades can be integrated with campus identity, public-space renewal, and architectural continuity. The Yezhai Middle School case therefore offers a credible template for the retrofit of school buildings as part of broader smart-city and low-carbon urban agendas. For planners, designers, and institutional decision makers, its central lesson is that simulation-guided design can improve both performance and planning quality when it is embedded early in the redevelopment process.

REFERENCES

[1] Li, Y.; Chen, H.; Yu, P. Green Campus Transformation in Smart City Development: A Study on Low-Carbon and Energy-Saving Design for the Renovation of School Buildings. *Smart Cities 2024*, *7*, 2940–2965.

[2] Huang, H.; Wang, H.; Hu, Y.J.; Li, C.; Wang, X. Optimal Plan for Energy Conservation and CO_2 Emissions Reduction of Public Buildings Considering Users' Behavior: Case of China. *Energy 2022*, *261*, 125037.

[3] Wu, B.; Maalek, R. Renovation or Redevelopment: The Case of Smart Decision-Support in Aging Buildings. *Smart Cities 2023*, *6*, 1922–1936.

[4] Mayouf, M.; Afsar, F.; Iqbal, A.; Javidroozi, V.; Mohandes, S.R. Synergies Between Digital Construction Technologies in Smart Buildings and Smart City Development to Meet Building Users' Expectations. *Heliyon 2024*, *10*, e28585.

[5] Ng, W.; Chin, M.Y.; Zhou, J.Q.; Woon, K.S.; Ching, A. The Overlooked Criteria in Green Building Certification System: Embodied Energy and Thermal Insulation on Non-Residential Building with a Case Study in Malaysia. *Energy 2022*, *259*, 124912.

H. A. Algarvio, University of Southampton, Southampton, UK

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