China’s Experience in Developing a Healthy and Low-carbon Building Assessment Framework

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Key Technologies for Low Carbon and Healthy Buildings' Design, Operation and Assessment



Beyond Green Buildings:
Integrating Human Health and Low Carbon in Building Assessment

- China's building assessment system
- The Guideline for Integrated Evaluation of Green, Low-Carbon and Healthy Building
- Potential applications

Researches on green/healthy/Low-carbon building

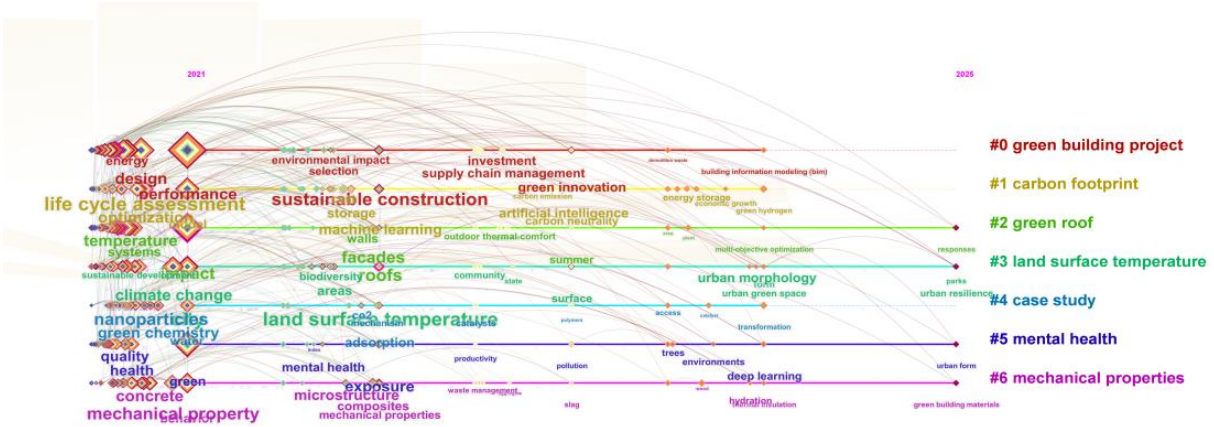


Fig.1 Timeline of researches focus on green building

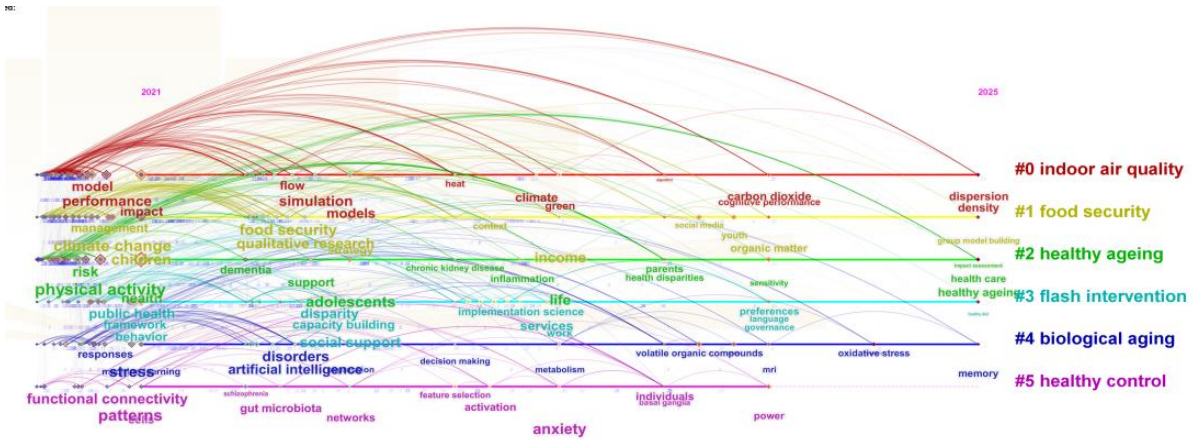


Fig.2 Timeline of researches focus on health building

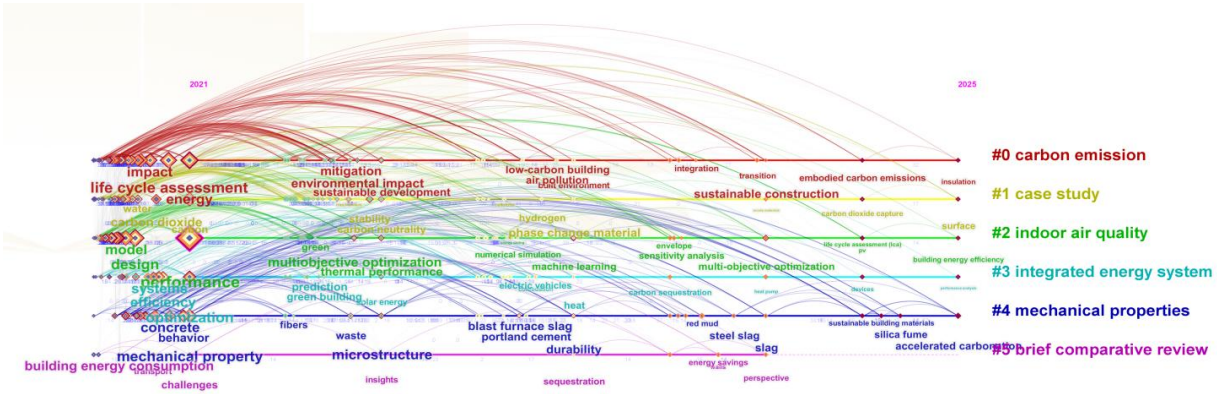


Fig.3 Timeline of researches focus on low-carbon building

Note:
Document Source: Web of Science
Document type: Article or Review Article
Database: SCI-Expanded & SSCI
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Time: Jul. 2020 - Jul. 2025
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Cluster objective: Keyword

Brief interrelationships green/healthy/Low-carbon building

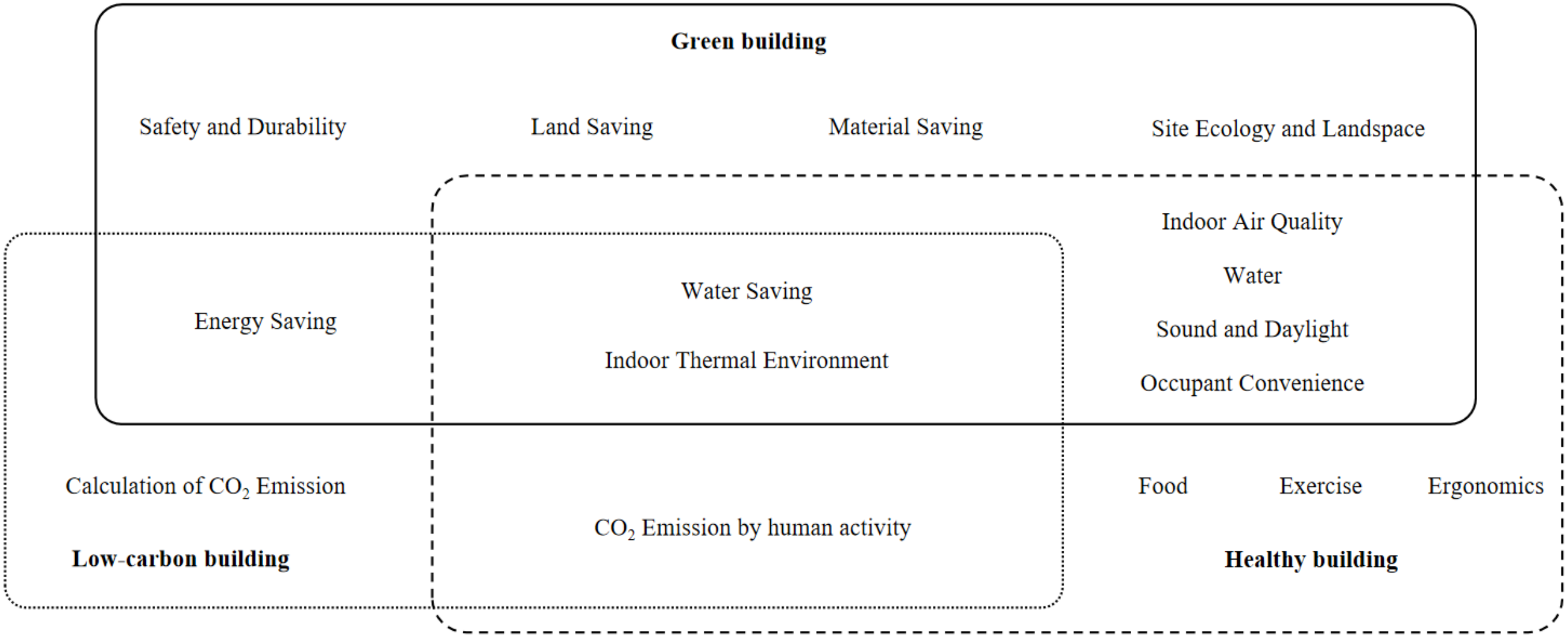
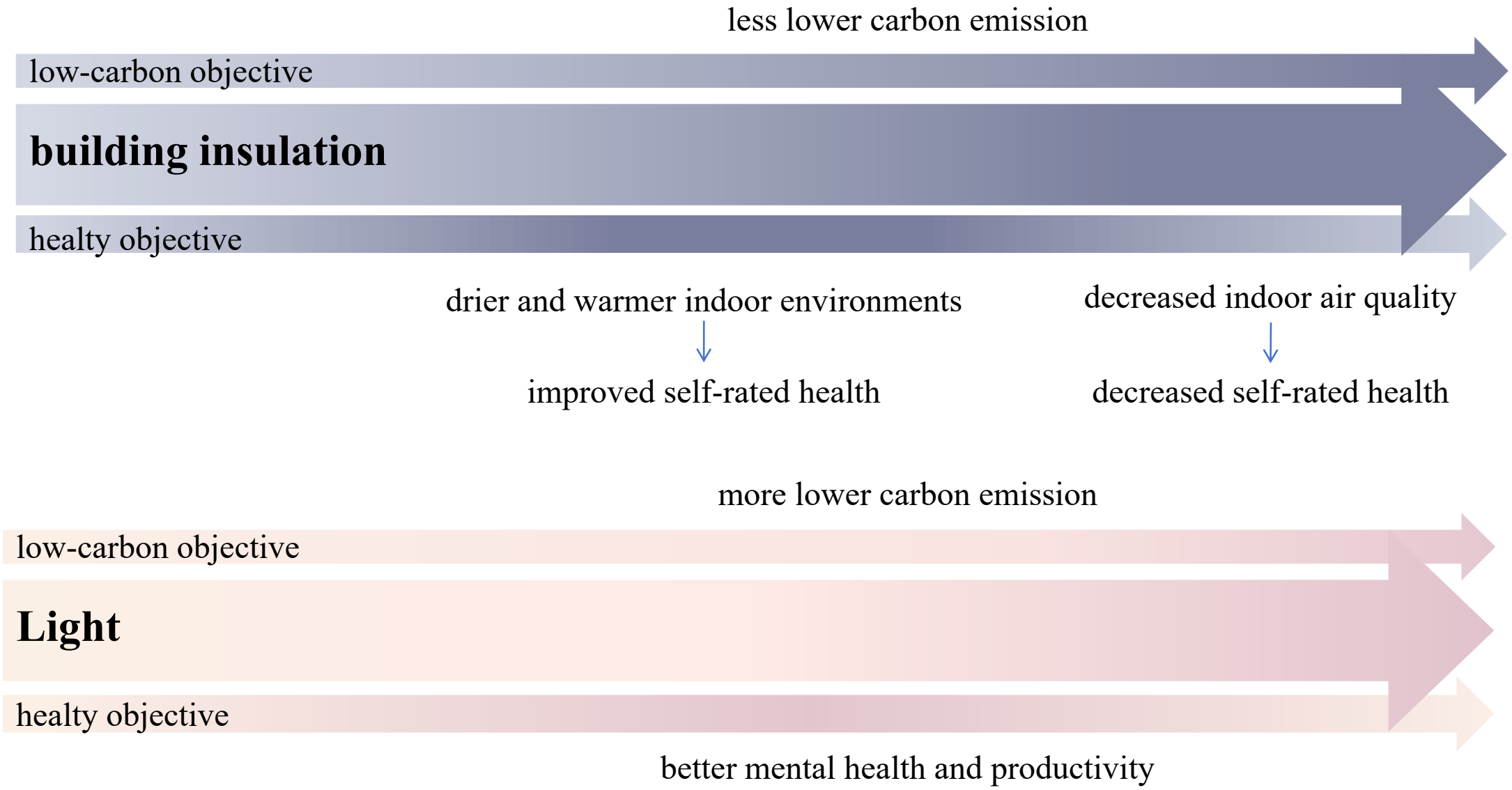


Fig.4 Brief interrelationships green/healthy/low-carbon building

Why do we need healthy and low-carbon dual-objective buildings?



China's building assessment development

Green building

1990’s the concept of green buildings

1998 the policy of energy conservation and emission reduction

2006 the national standard Evaluation Standard for Green Building (GB/T50378-2006)

2014 revised as GB/T50378-2014

2019 revised as GB/T50378-2019

2024 revised as Assessment Standard for Green Building (GB/T 50378-2019, 2024 Edition)

Healthy building

2009 China Association for Engineering Construction Standardization (CECSA)
- Technical Specification for Construction of Healthy Housing (CECS179-2009).

2017 Architectural Society of China (ASC)
- Assessment Standard for Healthy Building (T/ASC 02-2016) and “HBL” logo.
- revised in 2021

2017 CECSA
- Evaluating Standard for Healthy Housing (T/CECS 462-2017) and “Hi H” logo.

2020 Dalian city
- Code of Practice for Evaluation of Healthy Building (DB2102/T 0015-2020)

2023 Shandong province
- Assessment Standard for Healthy Building (DB37T5259-2023)

Low-carbon building

2011 the China Real Estate Chamber of Commerce
- China Green and Low Carbon Residential Technology Evaluation Manual

2012 Chongqing Municipality
- Evaluation Standard for Low Carbon Buildings (DBJ50/T 139-2012)
- revised in 2024

2014 Taiwan
- building carbon footprint certification system

2019 Standard for Building Carbon Emission Calculation (GB/T 51366-2019)

2023 the Ministry of Housing and Urban-Rural Development of China
- Technical Standards for Nearly Zero Energy Buildings (GB/T51350-2019)

2023 China Green Building Council of Chinese Society for Urban Studies (CGBC) and Qingdao University of Technology
- Assessment Standard for Low-carbon Building (T/CSUS 60-2023)

How are standards developed in China?

China's Standardization system

National Standards

They apply to technical requirements of significant importance to China's economic and technological development that require nationwide uniformity

Industry Standards

Supplements to National Standards and are developed for unified implementation within specific industries nationwide.Different industries use unique codes to identify their standards.

Local Standards

Formulated and published at the provincial, autonomous regional, or municipal level. They address unique technical needs arising from local natural conditions, cultural practices, or regional characteristics.

Association Standards

Voluntarily established and released by social organizations (associations, consortia, etc.) following their own standardized procedures.

China's Standardization process

Research
↓
Draft preparation
↓
Expert review
↓
Public consultation
↓
Approval
↓
Implementation

Conformity assessment- General requirements for evaluation of green,low-carbon and healthy buildings

- Industry Standards
- Public consultation

Criteria Development for low-carbon and healthy building - Conceptual framework

Objective: Collaborative Optimization of Low-carbon and Healthy Dual-objective Performance for Public Buildings

Mechanism Analysis

Identification of how design elements affect low-carbon and health performance

Design Elements	Impact Mechanism
Spatial Layout	Natural ventilation Daylighting conditions Energy consumption Indoor environmental quality
Thermal Insulation Performance	Thermal load Energy consumption Thermal comfort Air quality
HVAC System	Temperature/humidity control Equipment energy efficiency Energy consumption Air quality
Luminous Environment Design	Energy consumption Visual comfort Building cooling and heating loads
Acoustic Environment	Acoustic comfort Indoor environmental quality

Key Influencing Factors Analysis

Identification of key influencing factors for low-carbon and health, and their synergistic/conflict relationships

Low-Carbon Factors	Synergistic / Conflict Relationships	Health Factors
• Thermal performance of building envelope • HVAC system efficiency • Lighting and equipment energy consumption • Renewable energy utilization • Building operation management • Whole-lifecycle carbon emissions	Synergistic: • Natural daylighting • High-performance envelope • Intelligent control Conflict: • Increase in fresh air volume increase in energy consumption • Improvement in comfort -> increase in energy consumption • Conflict between daylighting and heat gain	• Indoor air quality • Thermal comfort • Luminous environment • Acoustic environment • Humidity and thermal-moisture environment • Occupant health perception and comfort

Evaluation Foundation

Construction of evaluation indicators for low-carbon and healthy dual-objective

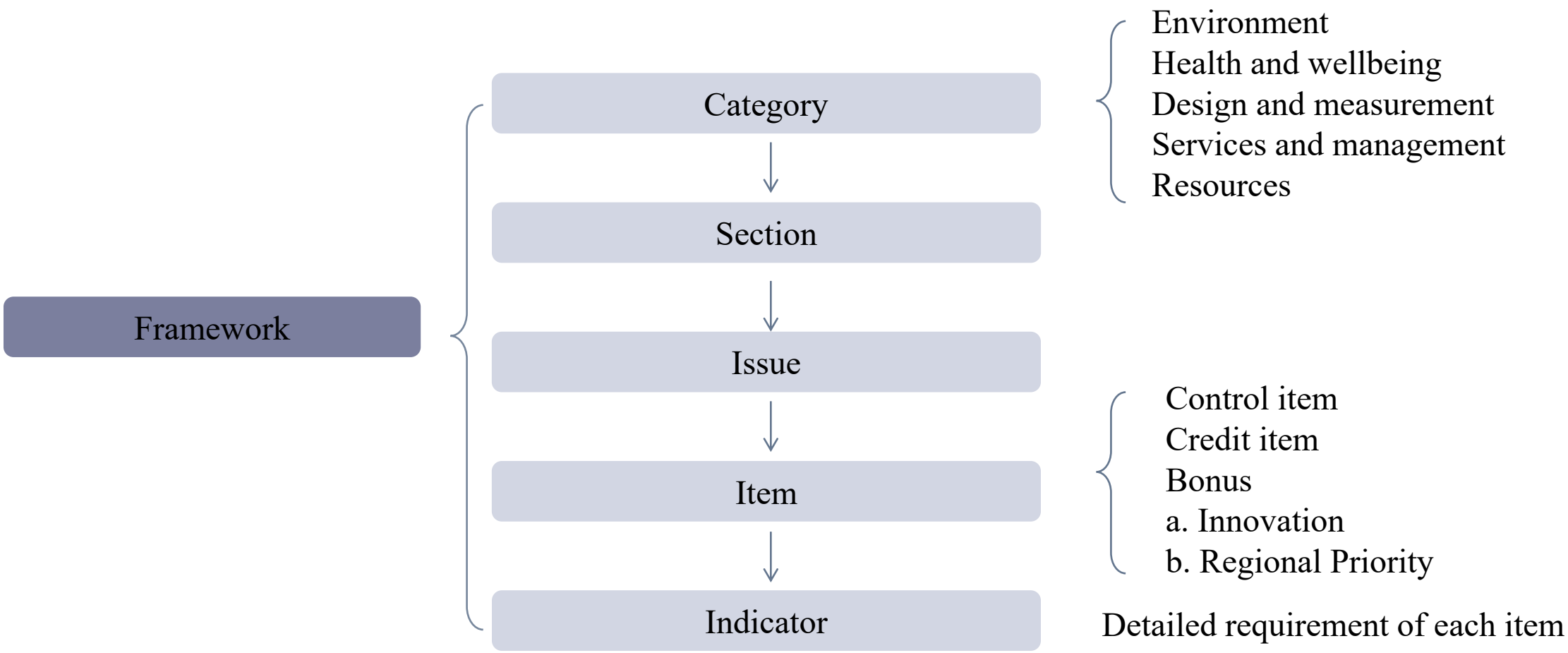
Low-Carbon Evaluation Indicators	Health Evaluation Indicators

Dual-Objective Comprehensive Evaluation Indicators

- Energy consumption and carbon emission level
- Indoor environmental quality (Air, Thermal, Light, Acoustic)
- Building intelligent operation level
- Green materials and resource utilization level
- Building operational coordination and comprehensive performance

Fig.5 Conceptual framework of green/healthy/low-carbon building assessment

Criteria Development for low-carbon and healthy building - Evaluation framework



Key innovation 1 - From independent evaluation to integrated assessment

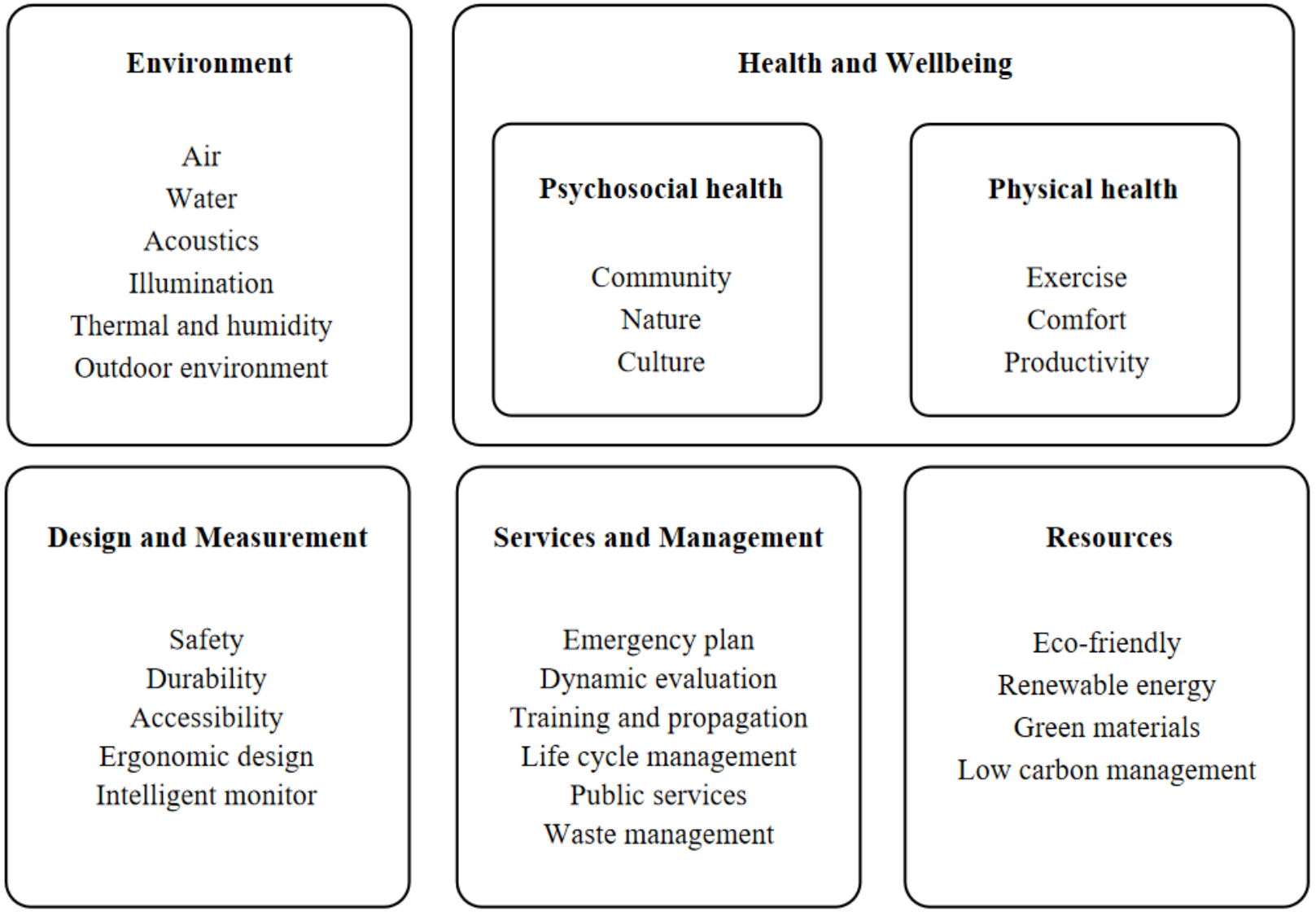


Fig.6 Integrated assessment of healthy and low-carbon building

Key innovation 2 - Advanced concepts and innovative approaches

Life-cycle perspective

Considering all stages of the building life cycle, which includes implementing continuous monitoring and periodic assessments during operation, as well as conducting a comprehensive life-cycle evaluation at the demolition phase

Dynamic sensor network

Allowing real-time data analysis to evaluate environmental performance under both normal conditions and during extreme or unusual climate events

Digital conformity assessment platform

Integrated with the sensor network, can provide functionalities such as data retrieval, indicator decomposition, automated evaluation, and intelligent analysis.

Public perception and habits

Including visual carbon emission rankings and enhanced social participation

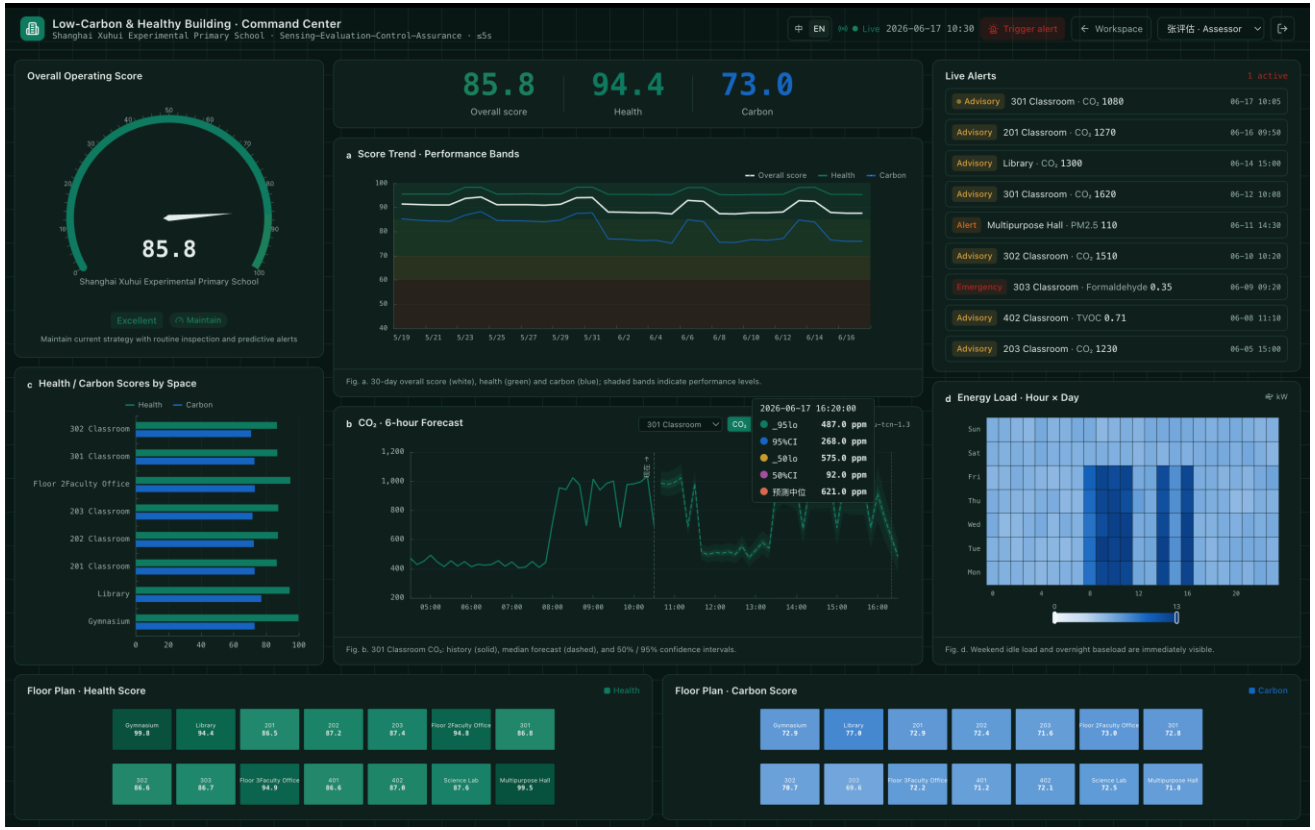


Fig.7 LCHB command center

Key innovation 3: Balancing Health and Carbon Objectives

Key ideas:
Minimization of lifecycle carbon emissions
Maximization of the overall indoor environmental quality (IEQ)
Nash Bargaining Solution (NBS)

Establish quantitative impact models:
window-to-wall ratio (WWR)
wall thermal transmittance (U-value)
solar heat gain coefficient (SHGC)
outdoor air ventilation rate
air-conditioning system coefficient of performance (COP)
lighting power density (LPD)

The Nash bargaining solution was then obtained using the Differential Evolution (DE) algorithm, resulting in a Pareto-optimal combination of design parameters.

Key innovation 3: Balancing Health and Carbon Objectives

Design Parameter	Sensitivity to Carbon Emissions (μ)	Sensitivity to Health Score (μ)	Overall Sensitivity	Screening Result
Window-to-wall ratio (WWR)	0.23	0.31	0.27	Retained
External wall U-value	0.35	0.22	0.29	Retained
External window U-value	0.12	0.08	0.10	Excluded
Solar heat gain coefficient (SHGC)	0.18	0.25	0.21	Retained
Design outdoor air supply rate	0.28	0.42	0.35	Retained
Air-conditioning energy efficiency ratio (EER)	0.32	0.15	0.24	Retained
Lighting power density (LPD)	0.19	0.27	0.23	Retained
Roof U-value	0.09	0.05	0.07	Excluded
Floor U-value	0.04	0.02	0.03	Excluded
Airtightness	0.11	0.13	0.12	Excluded
Shading coefficient	0.15	0.18	0.16	Excluded
Equipment power density	0.07	0.03	0.05	Excluded

Key innovation 3: Balancing Health and Carbon Objectives

The low-carbon objective function is defined as the $f_1(x)$

$$f_1(x) = C_{life}(X) = C_{mat,base} + C_{con,base} + C_{op}(X) + C_{dem,base}$$

The health objective function is defined as the $f_2(x)$.

$$f_2(x) = \frac{1}{8760} \int_0^{8760} Q_{health}(X, t)dt$$

The Nash bargaining solution seeks the fairest point on the Pareto frontier by maximizing the product of the gains of the two parties.

$$X^* = \underset{X \in x}{\operatorname{argmax}} [(f_1^0 - f_1(X)) \cdot (f_2(X) - f_2^0)]$$

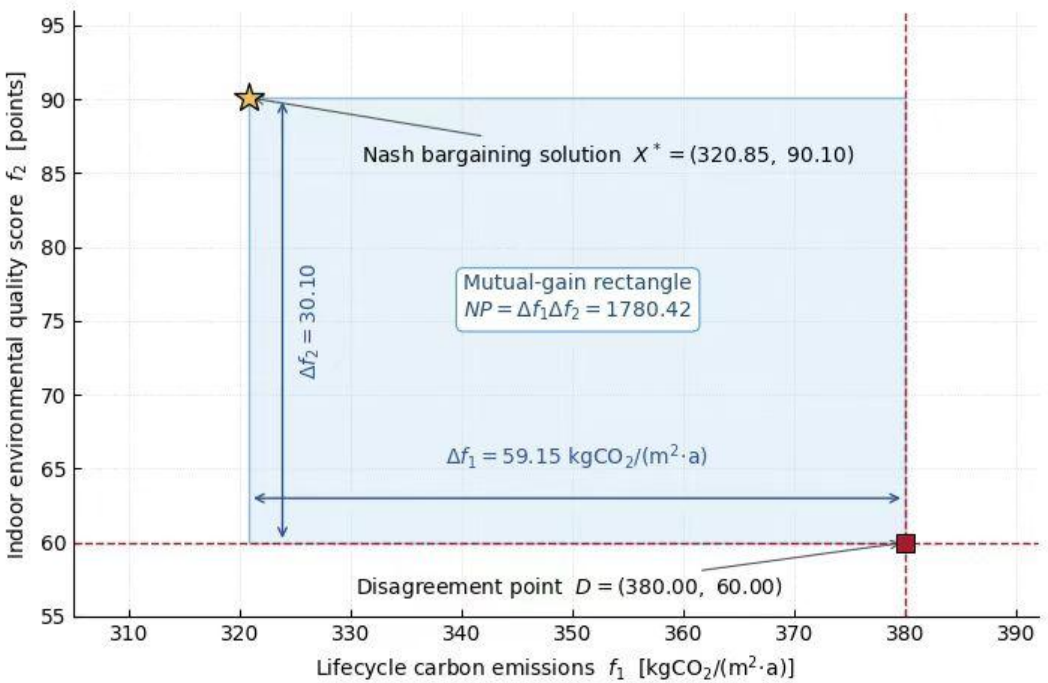


Fig.8 Low-Carbon–Health Dual-Objective Optimization and Nash Bargaining Solution Space

Performance Evaluation Indicator	Baseline Utility	Nash Bargaining Solution	Collaborative Improvement
Whole-life carbon emissions (kgCO₂/m²·a)	380.00	**320.85**	15.57% reduction
Overall indoor environmental qualityscore (0–100)	60.00	**90.10**	50.17% improvement
Maximum Nash bargaining product	0.00	**1782.93**	Substantial Pareto improvement achieved

Fig.9 Comparison of Low-Carbon and Health Performance Before and After Optimization

Evaluation Processes

Basic Process

- Application Submission
- Document Review (Verification of Mandatory Items)
- On-Site Assessment (Item-by-Item Scoring)
- Review and Verification
- Electronic Certification

Assessment Modes and Process Requirements

- Third-party assessments must undergo **independent review** and be publicly disclosed at the certification issuance stage.
- Three assessment organization modes are supported: first-party (self-assessment), second-party (commissioned assessment), and third-party (independent assessment).
- For automatically calculated indicators, the platform pre-populates scores based on continuously monitored data; for manually assessed indicators, the assessment team assigns scores online with supporting evidence attached.



Fig.10 Evaluation processes



Fig.11 Evaluation report

Case Study Application



Fig.12 Digital monitoring

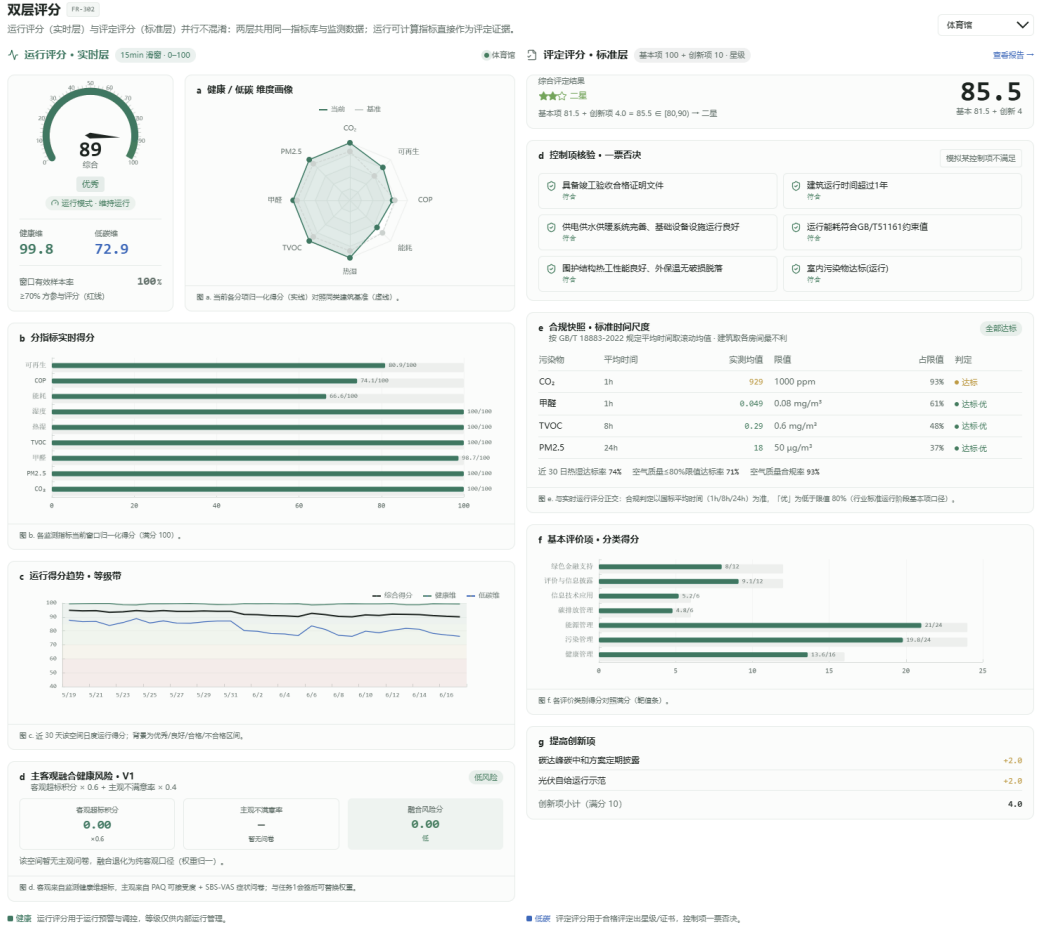


Fig.13 Evaluation detail

Future Enhancements

Looking ahead, the guideline will continue to evolve in four key directions.

- **Regional adaptation**
  Ensuring that assessment criteria better reflect local economic, cultural, and climatic conditions.

- **Broader applicability**
  Extending the framework to different building types, including schools, hospitals, and elderly care facilities.

- **Digital empowerment**
  Reveraging AI and big data technologies to enable faster analysis, smarter decision-making, and more integrated building performance assessment.

- **Continuous refinement of indicators**
  Improving the precision and practicality of the evaluation system.

A more intelligent, adaptable, and future-oriented healthy and low-carbon building assessment framework.