Frontiers of Engineering Management
DOI 10.15302/J-FEM-2016003

ENGINEERING MANAGEMENT REPORTS

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The Exploration and Practice of the Development of Green Eco-Urban Areas in Guangzhou International Financial City

Abstract Active exploration has been carried out to determine a pattern for developing green eco-urban areas in the Starting Area of Guangzhou International Financial City with an emphasis on the core role of comprehensive green arrangement. By comparing and analyzing existing research, development of green technologies at home and abroad, and indicator systems of green urban areas of similar sizes, the builders developed a green ecological indicator system. They proposed a new concept called "district-level indicator" in order to emphasize the importance of classifying indicators according to different project situations. By verifying the indicators for all land parcels and assessing future costs and efficiency, experience accumulated in this project can be beneficial for future green eco-urban area development projects.

Keywords: Guangzhou International Financial City, green eco-urban area, indicator system, case verification

1 A brief introduction to the Starting Area of Guangzhou International Financial City

The Starting Area of Guangzhou International Financial City is located along the north side of the Pearl River to the east of the Guangzhou downtown area. It is adjacent to the CBD of the Pearl River New Town area and faces the Pazhou International Exhibition Center across the Pearl River, constituting the core functional area and pioneering development area of the Financial City. The Starting Area covers a total area of 1.32 km^2. The total planned building area covers about 4,980,000 m^2, including an underground building area of about 530,000 m^2. Functions in this area cover offices, hotels, business, culture and entertainment, and residential buildings. The area accommodates a planned working population of 178,000.

In accordance with the development requirements of new urbanization featuring a "low-carbon economy, an intelligent city, and happy lifestyles" and adopting a global perspective, this project plans to build the Starting Area of Guangzhou International Financial City into a leading financial cluster in China. Set in Guangzhou, relying on the Pearl River Delta, and facing Southeast Asia, this project aims to build a best practice area of new urbanization, a leading financial cluster in China, a Central Activities Zone (CAZ) with local characteristics of the South of the Five Ridges region, and a world-class ideal eco-urban area. *Figure 1* shows the aerial view of this project.

2 Implementation philosophy of the green eco-urban area

The general purpose of the Starting Area of Guangzhou International Financial City is to embody the characteristics of green, ecological, energy efficient, and environmental friendliness throughout the whole construction process. To achieve the above purpose, one feasible approach is to build a quantifiable green building technology indicator system and monitor all buildings based on this indicator system to form scale effect, so that the overall green construction costs can be reduced while the demonstrable green effects can be reinforced.

To build a quantifiable green building technology indicator system, the following four questions need to be addressed:

1) What content does the green building technology indicator macro system in the entire area include?

2) How is the green building technology indicator macro system allocated to each land parcel?

3) How to select appropriate green building technology in order to meet the green building technology indicators allocated to each land parcel and to take the local

Manuscript received July 6, 2015; accepted November 7, 2015

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Figure 1. Aerial view of the Starting Area of Guangzhou International Financial City.

conditions into full consideration?

4) What are the benefits of the green building technology indicator system?

Figure 2 shows the implementation approach for the green eco-urban area in the Starting Area of Guangzhou International Financial City.

3 Exploration of the indicator system for the Green Eco-Urban Area

To ensure that the green technology indicator macro system is complete, advanced, and in line with current science, this project studies the existing project documentation, green building technology advances at home and abroad, and green technology indicator systems for urban areas of similar size. By analyzing the existing project documentation, we can determine the green ecological technology indicators already covered in the project from the regulatory plans and related research results to ensure that the indicators are complete (for example, the regulatory plan of each land parcel has mandatory requirements regarding the field comprehensive runoff coefficient and the green area ratio of the skirt building roof). Based on this, we have studied the updates of green building technologies and standards in China, selected green technological measures suitable for the Guangzhou climate and this project's functions, supplemented with additional green ecological indicators to ensure that the technical measures are advanced. Finally, we compare the green ecological indicators of this project with those of the districts of similar size (such as Shenzhen Qianhai Planned Area, Technology Ecological Park in Shenzhen Bay, Chongqing Yuelai Ecological Urban Area, and Xiamen Technology Innovation Park), so as to determine the indicator system for the green eco-urban area of the Starting Area of Guangzhou International Financial City (as shown in Table 1).

4 Indicator allocation, verification, and cost-efficiency analysis of the green eco-urban area

4.1 Allocation of ecological indicators

To avoid previous problems such as grandiose macro indicators, failure to highlight characteristics of land parcels, and unclear area specialties, this project classifies and allocates indicators into three levels (area, district, and land parcel) according to the general objective, and sets preliminary indicator values based on the fundamental conditions of each land parcel. Technologies for the area and land parcel levels must be implemented for all land parcels. Land parcels differ from each other mainly in technology indicators at the district level. District-level indicators are set to avoid blindly investing the difficult and costly technologies into all land parcels with an emphasis on technology characteristics and highlights of each land parcel. Perform the following three steps to set such indicators:

Step 1: Divide districts based on the regulatory plan design concept of the Starting Area of Guangzhou International Financial City.

The regulatory plan generally divides the Starting Area into five parts: special living district, financial office district, waterfront leisure district, HQ office district, and comprehensive commercial district. Due to functional

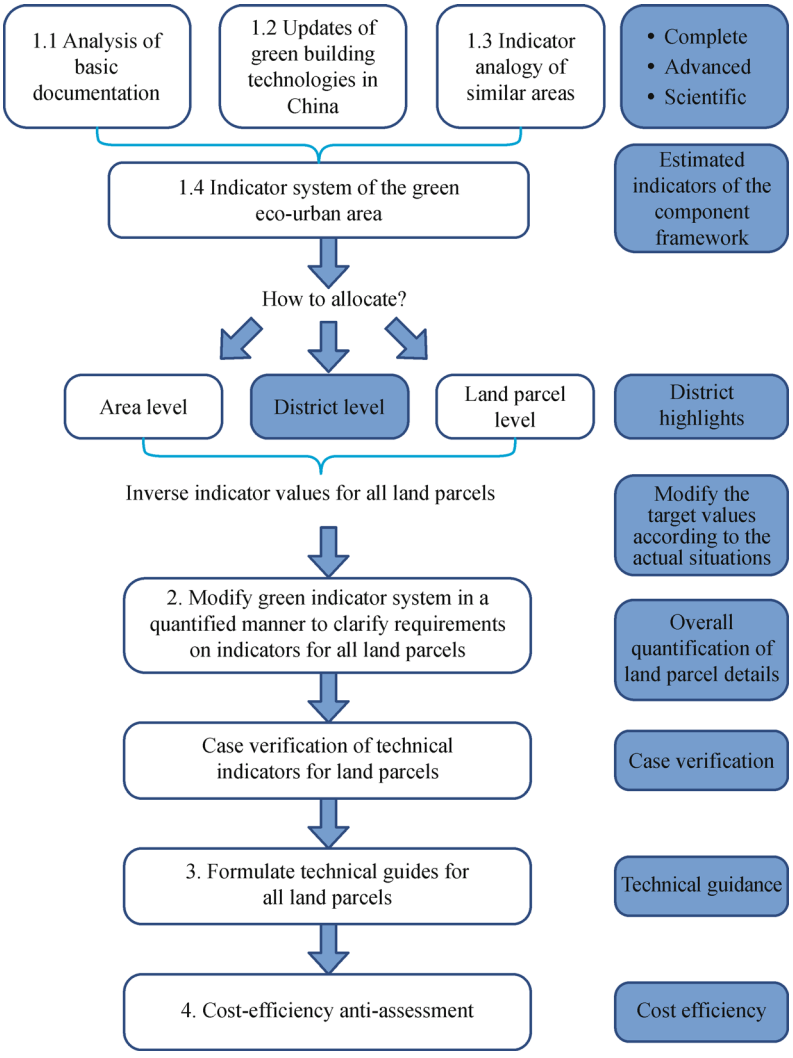


Figure 2. Implementation approach for the green eco-urban area in the Starting Area of Guangzhou International Financial City.

similarity and geographical connection, we combine the waterfront leisure district with the financial office district, and thereby the Starting Area is divided into four districts geographically.

Step 2: Analyze problems and external conditions of each district.

Figure 3 shows the external conditions, problems, and suggestions for each district.

Step 3: Clarify green indicator requirements for each district.

Comprehensively analyze the problems and conditions of each district according to step 2, provide improvement suggestions accordingly, and clarify green indicators for each district. For details, see *Figure 4*.

The indicator "renewable energy utilization ratio" is used as an example to describe how an indicator is generated.

For this project, it is suitable to adopt solar energy as the renewable energy. According to the above-mentioned district division, solar energy should be used in the special living district and financial office district, where the residential buildings adopt solar thermal power while others adopt solar photovoltaic power.

However, considering the high cost of implementing the renewable energy utilization system, when formulating technical requirements for all land parcels, we have to exclude the land parcels that are not suitable for solar power to ensure efficient operation of this technological measure and to reach the star-standard target for green buildings in each land parcel. Specific cases include the following (*Figure 5*):

1. Some land parcels, such as AT090938 and AT090940, are not suitable for solar energy utilization, because the overall efficiency of the solar system is affected by building shading.

2. Some land parcels such as AT091008 are long and narrow and stretch from east to west, and thereby are not suitable for solar panel pavement.

3. For land parcels with low star ratings (star 1), the

Table 1

Indicator System for the Green Eco-Urban Area of the Starting Area of Guangzhou International Financial City

Type	Indicator name	Indicator value
Land conservation	Underground space usage ratio	⩾1.6
Energy conservation	Renewable energy utilization ratio	⩾0.4%
	Energy conservation ratio of the building envelope	Public building: Star 1⩾50%; Star 2⩾51.5%; Star 3⩾52.5% Residential building:⩾50%
	Building lighting power density	Target value
	Efficiency enhancement of cold/hot sources in the heater and air conditioner	⩾6%
	Coverage of the building energy consumption monitoring system	Public building: 100%
Water conservation	Nontraditional water resource utilization ratio	⩾5.5%
	Field comprehensive runoff coefficient	⩽0.49
	LID construction ratio	⩾25%
	Popularity of water-saving instruments	100%
	Coverage of water-saving irrigation	100%
Material conservation	High-strength steel utilization ratio	⩾70%
Environment quality	Green volume ratio	⩾0.85
	Compliance rate of environmental noises	⩾90%
	Landscaping ratio of the skirt building surface	⩾40%
	Length ratio of sidewalk shade to sidewalk shelter	⩾5%
	Field ventilation suitability in the summer	⩾80%
	Compliance rate of the daylighting on the ground floor	⩾4.5%
	Indoor background noise of the building	Land parcels on both sides of the backbone road on the ground: average value of the lower limit and the higher standard Others: higher standard value
	Percentage of prioritized parking spaces	⩾10%

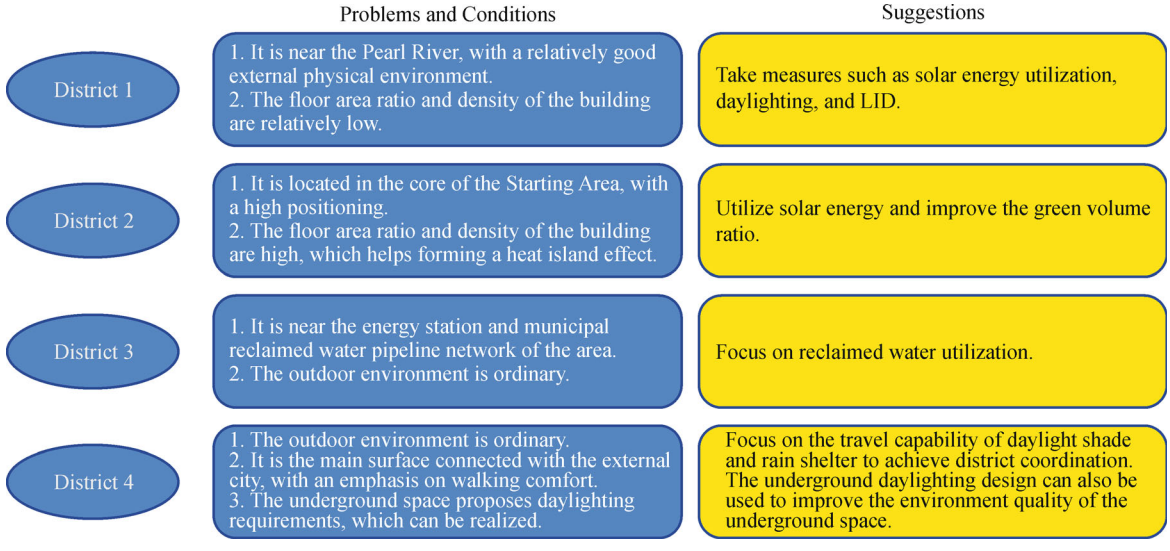
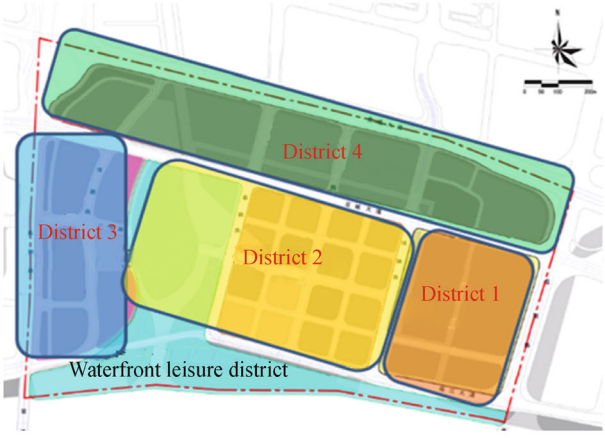


Figure 3. External conditions, problems, and suggestions for each district in the Starting Area of Guangzhou International Financial City.



District 1

1. Solar energy utilization (renewable energy utilization ratio)
2. Underground daylighting (compliance rate of daylighting on the ground floor)
3. LID (LID construction ratio)

District 2

1. Solar energy utilization (renewable energy utilization ratio)
2. Mitigate the heat island effect (green volume ratio)

District 3

1. Reclaimed water utilization (untraditional water resource utilization ratio)

District 4

1.Comfortable travel outdoors (length ratio of sidewalk shade to sidewalk shelter)
2. Underground daylighting (compliance rate of daylighting on the ground floor)

Figure 4. Green technology indicators for each district in the Starting Area of Guangzhou International Financial City.

renewable energy utilization technology is not required when comprehensively considering the cost performance ratio of the costs and technologies.

Figure 6 shows the land parcels with no requirements related to the "renewable energy utilization ratio" indicator in the special living district and financial office district. For other land parcels, renewable energy utilization measures should be taken.

After calculation, the renewable energy utilization is 0.381% for the field. To highlight the advancement of the Starting Area of the Guangzhou International Financial City, the technical standard of renewable energy utilization should be equal to or greater than 0.4% for this project.

4.2 Example verification of ecological indicators

The Guangzhou International Financial City project has 20 indicators in total for green eco-urban area construction. Among these indicators, 14 are technological measures of the area and land parcel levels, and these 14 technological measures should be implemented for all land parcels. For the remaining 6 district-level indicators, specific technical indicator requirements should be determined according to the corresponding district and actual project characteristics of each land parcel. To ensure that the work approach is in line with current science, we used the AT090908 land parcel as an example to conduct case verification, reviewed the case based on the indicator and design conditions, and provided suggestions. The details are shown in Table 2.

According to the case verification, although some indicators of AT090908 do not meet the requirements or cannot be determined, they can be improved in subsequent designs. That is, the working approaches of the indicator system for the green eco-urban area and values specified for each land parcel are basically in line with current science and preliminarily feasible.

4.3 Cost-efficiency analysis

4.3.1 Cost analysis

If the Starting Area of Guangzhou International Financial City is constructed according to the technical indicators (20 in total) of the green eco-urban area, the total incremental costs are about CNY 163,000,000 and the incremental costs for a unit of the building area are about CNY 33.90 per square meters. For details, see Table 3.

4.3.2 Efficiency analysis

1) Resourceintensification efficiency

After the indicators of the green eco-urban area are implemented, it is estimated that 106,000 m^2 of construction land can be saved; 27,908,000 kWh of energy consumption can be saved per year; 1,180,200 tons of municipal tap water can be saved; operation expenses of CNY 33,896,000 can be saved per year; the static investment payback period is about 4.8 years. For details, see Table 4.

2) Environmentally friendly efficiency

With this project, the sewage discharge is reduced by about 1,180,000 tons per year; the rainfall emission is reduced by about 600,000 tons per year; the energy saved per year is 27,908,000 kWh; the CO_2 emission reduced per year is 8470.5 tons. Table 5 and Table 6 list the environmentally friendly efficiency and other areas of increased efficiency respectively.

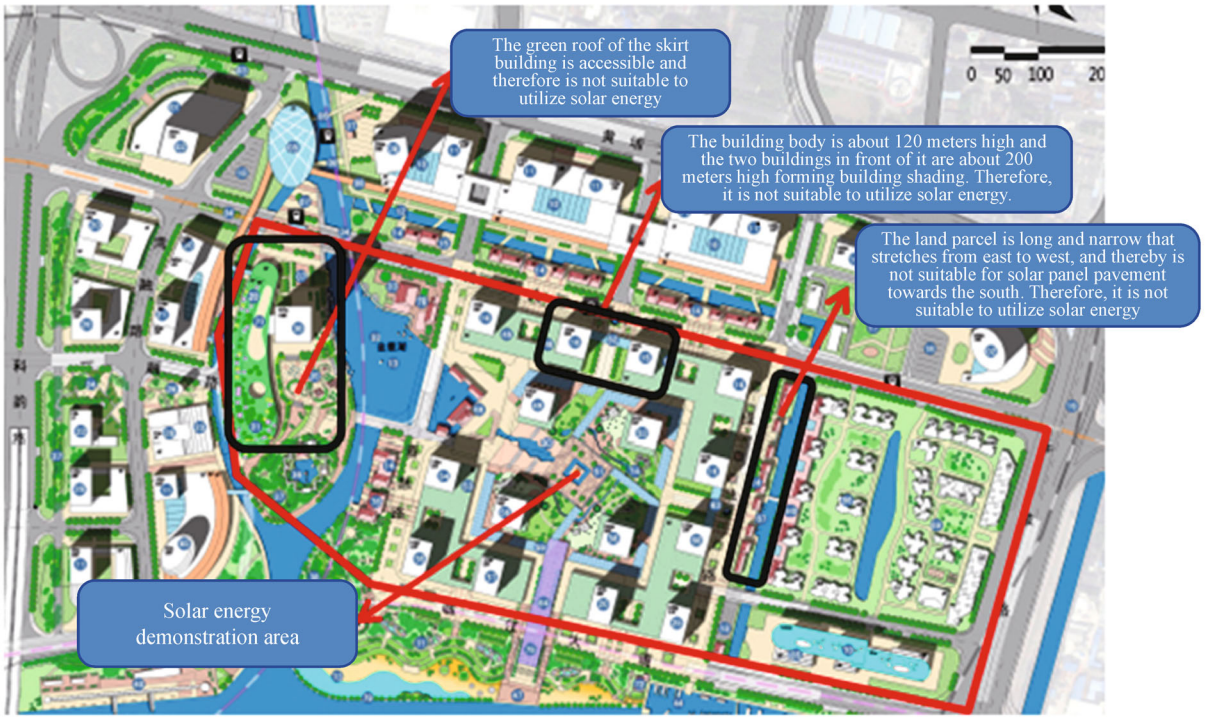


Figure 5. Centralized district for renewable resource utilization (land parcels are not suitable for such utilization).

Figure 6. Renewable energy utilization in the central district (land parcels with red crosses are not suitable).

Table 2

Indicator Case Verification and Suggestions for the Green Eco-Urban Area on AT090908 in the Starting Area of the Guangzhou International Financial City

Type	Indicator name	Green indicators of AT090908	Case verification – review comments	Case verification – implementation suggestions
Land conservation	Underground space usage ratio	—	This is an overall indicator, and therefore does not need to be assessed for single land parcels	—
Energy conservation	Renewable energy utilization ratio	—	—	—
	Energy conservation ratio of the building envelope	⩾50%	This is a mandatory energy conservation requirement. Please implement this indicator according to the requirement	—
	Building lighting power density	Target value	Due to lack of electrical design drawings, this indicator cannot be determined temporarily	Implement this indicator according to the target value required by *GB 50034 Building Lighting Design Standard*
	Efficiency enhancement of cold/hot sources in heating and air conditioning	⩾6%	Due to lack of heating and ventilation design drawings, this indicator cannot be determined temporarily	Please select cold/hot sources of the air conditioner according to the requirement to ensure energy conservation effects of the building
	Coverage of the building energy consumption monitoring system	100%	Due to lack of electrical design drawings, this indicator cannot be determined temporarily	Electrical personnel should separately measure special electricity consumption of air conditioners, lighting sockets, and power units according to the requirement, and remotely transfer the data to the energy management center
Water conservation	Nontraditional water resource utilization ratio	—	Due to lack of water supply and drainage design drawings, this indicator cannot be determined temporarily	Water supply and drainage personnel should learn about the design status of the related municipal reclaimed water pipeline network, and set up the reclaimed water disposal equipment and related pipeline network according to the landscaping, road cleaning, and underground garage cleaning requirements of municipal reclaimed water
	Field comprehensive runoff coefficient	⩽0.56	Due to lack of landscape design drawings, this indicator cannot be determined temporarily	It is difficult to implement this indicator. The subsequent design should focus on increasing the permeable sidewalk pavement and roof landscaping coverage, and lowering the field comprehensive runoff coefficient through comprehensive measures
	LID construction ratio	—	—	—
	Popularity of water-saving instruments	100%	Due to lack of water supply and drainage design drawings, this indicator cannot be determined temporarily	It is relatively easy to implement this indicator. This indicator should be implemented subsequently according to the requirement
	Coverage of water-saving irrigation ratio	100%	Due to lack of water supply and drainage design drawings and landscape design drawings, this indicator cannot be determined temporarily	It is relatively easy to implement this indicator. This indicator should be implemented subsequently according to the requirement. Water-saving irrigation methods such as microspray irrigation are recommended for the surface landscaping of skirt buildings if conditions permit
Material conservation	High-strength steel utilization ratio	⩾70%	Due to lack of structure design drawings, this indicator cannot be determined temporarily	High-strength reinforcement bars or steel materials are recommended for three high or super high towers in this project. Ensure a utilization ratio of more than 70%. For the commercial building D, this indicator may not be applicable

(*Continued*)

Type	Indicator name	Green indicators of AT090908	Case verification – review comments	Case verification – implementation suggestions
Environment quality	Green volume ratio	—	—	—
	Compliance rate of environmental noises	⩾90%	The field is adjacent to Huangpu Road. The actual ratio of field noises is estimated to be less than 90%, which does not meet the requirement	It is recommended that landscapes or building structures be set up in the plaza on one side of Huangpu Road to mitigate traffic noises
	Landscaping ratio of the skirt building surface	⩾50%	Basically meets the requirement	According to the overall drawing of the project, this indicator is determined as basically meeting the requirement. This indicator should be implemented subsequently according to the requirement and the field comprehensive runoff coefficient
	Length ratio of sidewalk shade to sidewalk shelter	⩾20%	Basically meets the requirement	Design personnel should review subsequently whether this indicator reaches 20%. It is recommended that a shade and shelter corridor be set up in the northwest plaza of the field and between high buildings to meet the requirements
	Field ventilation suitability in the summer	⩾80%	Fail to meet the requirement	In this project, the overall floor plan is prone to wind amplification and high building ventilation problems. In subsequent designs, review this indicator through outdoor ventilation simulation and properly adjust the overall floor plan to increase the dimensions of the ventilation corridor between buildings A and B
	Compliance rate of the daylighting on the ground floor	⩾10%	Cannot be determined temporarily	Use the sunken plaza and daylighting roof to improve the daylighting design of the underground space. It is recommended that a simulation review be performed and this indicator be implemented according to the requirement. You can refer to the local improvement measures of landscape design such as light pipes and daylighting roofs
	Indoor background noise of the building	Average value of the lower limit and the higher standard	Due to lack of building construction drawings, this indicator cannot be determined temporarily	Implement this indicator according to the requirement. Focus on improving the building envelope, especially the soundproofing performance of glass walls
	Percentage of prioritized parking spaces	⩾10%	Cannot be determined temporarily	Implement this indicator according to the requirement

Table 3

Estimation of the Incremental Costs for Constructing the Green Eeco-Urban Area in the Starting Area of Guangzhou International Financial City

Type	Indicator name	Indicator value	Incremental costs/ (CNY 10,000)
Land conservation	Underground space usage ratio	⩾1.6	—
Energy conservation	Renewable energy utilization ratio	⩾0.40%	Photovoltaic: 3553 Thermal: 750
	Energy conservation ratio of the building envelope	Public buildings: Star 1⩾50%; Star 2⩾51.5%; Star 3⩾52.5%; Residential buildings:⩾50%	2708
	Building lighting power density	Target value	2400
	Efficiency enhancement of cold/hot sources in heating and air conditioning	⩾6%	5760
	Coverage of the building energy consumption monitoring system	Public buildings: 100%	410
Water conservation	Nontraditional water resource utilization ratio	⩾5.5%	346
	Field comprehensive runoff coefficient	⩽0.49	—
	LID construction ratio	⩾25%	—
	Popularity of water-saving instruments	100%	—
	Coverage of water-saving irrigation	100%	128
Material conservation	High-strength steel utilization ratio	⩾70%	—
Environment quality	Green volume ratio	⩾0.85	—
	Compliance rate of environmental noises	⩾90%	—
	Landscaping ratio of the skirt building surface	⩾40%	—
	Length ratio of sidewalk shade to sidewalk shelter	⩾5%	—
	Field ventilation suitability in the summer	⩾80%	—
	Compliance rate of daylighting on the ground floor	⩾4.5%	216
	Indoor background noise of the buildings	Land on both sides of the backbone road on the ground: average value of the lower limit and the higher standard; Others: higher standard value	—
	Percentage of prioritized parking spaces	⩾10%	—

Table 4

Resource Intensification Efficiency of the Project

Type	Indicator name	Indicator value	Resources intensification efficiency
Land conservation	Underground space usage ratio	⩾1.6	Saving a land area of 106,000 m^2
Energy conservation	Renewable energy utilization ratio	⩾0.40%	Saving 1,877,000 kWh per year
	Energy conservation ratio of the building envelope	Public buildings: Star 1⩾50%; Star 2⩾51.5%; Star 3⩾52.5%; Residential buildings:⩾50%	Saving 3,270,000 kWh per year
	Building lighting power density	Target value	Saving 14,016,000 kWh per year
	Efficiency enhancement of cold/hot sources in heating and air conditioning	⩾6%	Saving 8,640,000 kWh per year
Water conservation	Nontraditional water resource utilization ratio	⩾5.5%	Saving 408,200 tons of water per year
	Popularity of water-saving instruments	100%	Saving 772,000 tons of water per year
Environment quality	Compliance rate of the daylighting on the ground floor	⩾4.5%	Saving 105,000 kWh per year

Table 5

Environment Friendly Efficiency

Energy saved per year/kWh	Standard coal saved per year/ton	CO_2 emission reduced per year/ton	SO_2 emission reduced per year/ton	Dust emission reduced per year/ton
27,908,000	34,299,000	8470.5	68.7	33.9

Table 6

Other Efficiency

Type	Indicator name	Indicator value	Descriptions of other efficiency
Water conservation	Field comprehensive runoff coefficient	⩽0.49	More than a half the rainfall runoff volume can be reduced. This efficiently reduces the peak discharge of rainfall drainage, relieves municipal drainage pressure, increases the water retention properties of the field, and reduces the heat island magnitude of the area
	LID construction ratio	⩾25%	Technical measures can be taken to increase the rainfall infiltration such as field landscaping and permeable pavements
Environment quality	Green volume ratio	⩾0.85	The green area ratio of equivalent ground cover plants is about 85%, creating more green space and volume in a limited space
	Compliance rate of environmental noises	⩾90%	This ensures quietness and comfort for main personnel in the outdoor areas of the land parcel
	Landscaping ratio of the skirt building surface	⩾40%	This efficiently improves thermal comfort of the skirt building roof and reduces temperatures of interior roof surfaces by 3°C to 5°C
	Length ratio of sidewalk shade to sidewalk shelter	⩾5%	This provides a barrier-free travel space with daylight shade and shelter from rain, improving the comfort level of outdoor activities
	Field ventilation suitability in the summer	⩾80%	This ensures that over 80% of the occupied area outdoors is ventilated and that people will feel comfortable
	Indoor background noise of the buildings	Land on both sides of the backbone road on the ground: average value of the lower limit and the higher standard; Others: higher standard value	This can create a comfortable and quiet indoor environment with reference to the surrounding environment
	Percentage of prioritized parking spaces	⩾10%	This can promote the usage of small-displacement or new-energy vehicles, which contributes to urban traffic emission reduction

5 Conclusions

The green ecological civilization construction pattern is an inevitable choice for new urbanization in China. The green eco-urban area indicator system for the Starting Area of Guangzhou International Financial City has been researched based on a full understanding of the local conditions and resources. Taking the area's development purpose into consideration, we have formulated a green eco-urban area indicator macro system for the Starting Area and innovatively divided technical indicators into three levels: area, district, and land parcel. As for district-level indicators, indicator policies can be formulated according to the external conditions and requirements of each corresponding area, thereby achieving consistency between the advancement of the overall green indicators and the feasibility of green indicators for each land parcel.