

Eco-intelligent Technology Integrated Planning—Application of ZZAEPZ General Planning

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1. The integration of Eco- intelligent technology to meet the challenge of urban planning

According to the system theory put forward by Qian Xuesen, the city is a typical open complex giant system. The system has exchange of material, energy and information, etc. with the surrounding environment, at the same time includes a large number of subsystems¹. Smart city and ecological city achieve efficient and reasonable operation of the whole urban in the aspect of the exchange of information, material and energy.

1.1. From ecological city² to positive ecological city³ and to the urban metabolism

Since Ecological City was clearly put forward by UNESCO in the “Man and the Biosphere” plan in 1971, the thought of harmonious development of man and environment has gradually won support among the people. The countries of the world are carrying out Ecological City planning and construction practice one after another.

However, “Ecology” was defined as minimum damage to nature (Register, 1982) in the 20th century, which was far from enough for the future development of city. An ecological city in the future will not be the enemy of the nature, instead it should be blessed by the nature and become the doctor and friend of the destroyed nature. The ecological city in the future is a positive ecological city, which is not to consume the ecology but to supply the ecology. In the city level, it includes such concepts as increasing green area, cold islands, capacity and water purification (Wu Zhiqiang, 2004). The positive ecological city is supported by green and ecological technology.

The theory of urban metabolism turns from the ecological-system perspective to research perspective centering on human activities. The theory of urban metabolism researches urban social economic activities, and the flow of material and energy in the regional and global biogeochemical process. The

characteristic of the material and energy flow and the relationship between the urban activities and natural process define the production and consumption behaviors in the city. Therefore, the urban metabolism system becomes a multi-disciplinary research field, and in order to realize the mutual response between human and ecology in the future, it focuses on analyzing all kinds of human behavior and material flow in the city. In *The Changing Urban Metabolism*, C. Kennedy points out that urban metabolism is that all social economic and technological process synthesize in the city. It should bring the growth and production of energy and the reduction of waste (C. Kennedy, 2007).⁴ With the climate change and the atmospheric degeneration, the urban metabolism system model has increasingly become a key element for sustainability and human health. The urban metabolism system helps to integrate all the activities of the city in a model.

1.2. Intelligent City

The Intelligent City has become the new idea and new practice of future urban development expanded in the global since the beginning of the 21st century, which mix together numerous concepts such as smart city, digital city and information city, etc. The smart city is based on the information and communication technology (ICT). The integration and development of ICT promote the formation and development of information society and knowledge society, profoundly changing people's living and working way, organization form, social formation and innovation pattern. Until the beginning of 2013, several cities in the world have carried out a variety of smart city practices. Dozens of cities in China as well enter this rank and put forward to build smart city. "Creating the future-oriented smart city" has become the strategic measure of future innovation drive and transformation development for the city.⁵

1.3. The integration of Eco-Smart technology to optimize urban metabolism process

At the present stage, when planning the urban metabolism system, a major challenge is the problem of incomplete information. In the urban planning and management, the planners and planning governors don't know the data such as how many energies are consumed in the city, how many water resources, how much sewage is discharged, and how much waste is produced, etc. And they don't clearly know how large the land area those resources and energy can support and how many human activities it can bear, etc. When the planners cannot judge objective problems of the city, the planning and compiling work are lack of logic supports. Changing the status quo needs ability of information acquisition, information understanding and information response.

Therefore, the planning and construction of Eco-Smart city should be integrated. Three core steps of construction of Eco-Smart city are perception, judgment and response. In ecological city, the construction of intelligent technology and intelligent system can make ecological city become measurable and more acute. The first step is to perceive, that is to know the changes of the city. The second step is to identify and judge the data information through reasonable analysis model. The third step is to forewarn, respond and give feedback to the emerging condition according to reasonable standard.

According to the statistic analysis of 225 smart city projects carried out in Europe, 153 smart city projects take up a proportion of 68 percent (others are architecture, block, regional scale) in respect of urban scale; 83 projects target the energy conservation and emission reduction, and 83 projects are focused on people's livelihood, occupying a proportion of 76 percent (the other projects are focused on justice & clarity, resource intensivism, development transformation, and advertising and marketing). This shows that the planning and construction of smart city are very suitable for ecological goals of urban scale.⁶

The synthesis of ecological city and the smart city concept as well as the integration of ecological and intelligent technology will contribute to raising the qualitative problems of ecological city to quantitative level. Meanwhile, it also helps to track the material and energy flow in urban complex system in form of information and give feedback so as to provide information support for planning formulation and plan implementation,.

2 . Eco-intelligent technology integrated planning framework based on UM&MFA

2.1 *Urban metabolic system and material flow analysis*⁷

The urban ecological study divides ecological factors into abiotic factors and biological factors. The abiotic factors include: solar radiation, temperature, wind, atmospheric moisture, soil, rainfall and hydrology of the city. In urban planning in recent years, the analysis and research for abiotic factors gradually increased, but few were involved with biological factors and biological diversity.⁸

Compared with the theory of ecological city, the emergence of urban metabolism (UM) theory further focuses on the research on all kinds of energy and material flows in urban artificial material environment and it is more suitable for urban planning. The theory of urban metabolism considers the main flow system in urban environment as: energy, water circulation, land resources, atmosphere, matter, pollution and traffic flow, etc. (Paulo, 2013).

Material flow analysis (MFA, Baccinni and Brunner in the 1990's)⁹ is the analysis method of urban metabolism. It's used to measure how matter enter the city system, flow and gather in the city and ultimately discharge from the urban system in the form of pollutants, wastes and output. Material flow analysis provides a framework for researching the metabolism between nature and artificial system.

Urban planners and design use UM and MFA in the following four aspects: 1. Sustainable assessment report; 2. Emission measurements of urban greenhouse gas; 3. Mechanism modeling used for policy analysis and urban design; 4. Design tool: design tool is on the basis of the previous three. Urban metabolism analysis also can be used as a design tool to create more green and sustainable infrastructures. It is not end treatment but starts from the preliminary planning and design. Designing a closed-loop, recycling the resources and reducing the amount of the final wastes by tracking the urban energy, material and waste in the whole process of the urban system. Now they are using all kinds of technologies to make it easier for green buildings to reach their goals. Model use is not limited to functional analysis. It can also be used to examine and weigh the relationship between humans and infrastructures.¹⁰

2.2 *Eco-intelligent technology integrated planning framework*

The overall conceptual planning scheme of ZZAEPZ plans and formulates by using the planning framework of comprehensive integration of Eco-Smart.

As the fifth shock wave of transportation technology development, the air transport industry promotes the growth of new urban form -- aerotropolis (John Kasarda, 1992)¹¹, and it is the projection of global economic integration trend in the city. In spatial form, aerotropolis is shown as: a large complex centered on the airport, and integrated with multiple functions such as air transportation, logistics, commerce&trade, shopping, travel and leisure and industrial development, etc. (Mckinley Conway, 1993)¹². On March 7th, 2013, the State Council formally approved *The Development Planning of Zhengzhou Economic Practice Zone (2013-2025)*, proposed to construct the Zhengzhou airport area to

be the going-first area of economic development of the national aerial port (hereinafter referred to as “aerial port zone”), which covers an area of 415 sq. km.. The scale of the core area of aerial port (hereinafter referred to as “aerial port”) is 27.6 sq. km. The annual cargo throughput in near term is 3 million tons and the reserved is 5 million tons. The annual passenger transportation is 50 million and will reach 70 million in the near future. On the basis of *Development Planning*, the formulation of conceptual planning is made. We put forward and use the planning framework of comprehensive integration of Eco-Smart in the formulation. In the meantime, we think and explore the specific ecological characteristics and characteristics of information enrichment of the aerotropolis.

The horizontal direction of this planning framework consists of four steps: the definition of urban metabolism subsystem, the setting of ecological intelligent target, ecological simulation and planning response layer, intelligence platform building. In the analysis and planning response of each vertical subsystem, in order to reach ecological goal of urban development, we use material flow analysis through integration of smart technology in planning such as simulation technique, intelligent platform construction and the overall arrangement of intelligent infrastructure, etc.

The first step is the definition of urban metabolism subsystem. Through analyzing the urban metabolism of aerotropolis economic practice zone, we confirm the integrated planning consists of the following 6 subsystems: energy, transportation, solid waste, noise, hydrographic net and vegetation.¹³

The second step is the setting of ecological objective and index. The planning establishes the basic index of six dimensionalities to establish the direction for planning.

The third step is ecological simulation and planning response. We carry out the modeling and simulation of the system input and output for the ecological elements previously confirmed. The special aspects of aerial port are noise and restricted space, so this time we simulate the noise and restricted space. The planning response is to put forward the corresponding solutions for six subsystems such as energy, transportation and solid waste, etc. after the system simulation.

The fourth step is the intelligent platform building. It consists of perception, transmission and WEB-based 3D GIS system. Aiming at a variety of ecological technologies used by ecological elements, we carry through integrated systematic planning and design and we reach the intelligent monitoring of ecological goals through equipment system construction of three steps of perception, judgment as well as response.

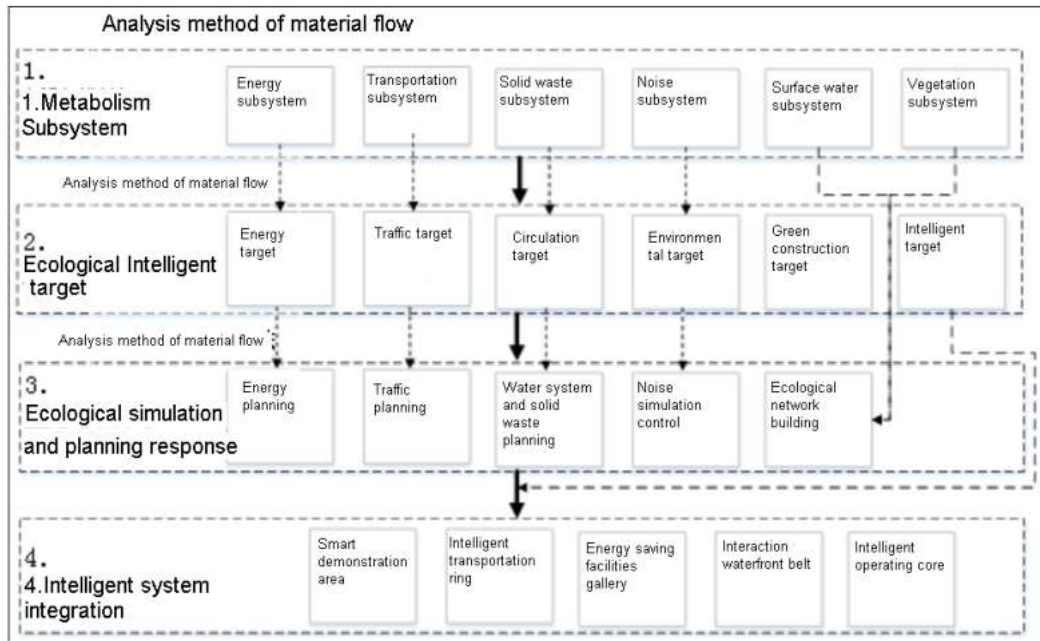


Figure 1 the planning framework of Eco-Smart technology integration of ZZAEPZ

3. Conceptual overall planning of ESIP applied to Zhengzhou airport zone

Based on the above framework of Eco-Smart Technology Integrated Planning (ESIP), we have finished the planning research of Eco-Smart integration in conceptual planning of ZZAEPZ. Now, we combine the second, third and fourth steps in the frame to briefly introduce six parts of the planning research achievement: objectives and indicators, noise simulation and control, energy planning, ecological network building, intelligent transportation system planning and intelligent inspection system.

3.1 Ecological intelligent goal and index



Figure 2 Ecological intelligent goal and index system of five dimensions and one core

The setting of ecological intelligent target system of the aerial port zone learns from the intelligent city evaluation system in European Union¹⁴ put forward by Giffinger and the *Eco-City Index System*¹⁵ formulated by Chinese Society for Urban Studies. Integrating the main content of the goal level and combining the actual demand of Zhengzhou aerial port zone, it puts forward the ecological intelligent target system of one core and five dimensions through the target of five ecological dimensions of energy, transportation, circulation, environment and building as well as various types of control center to realize the intelligent integrated monitoring operations of ecological goals.

We set an index respectively for target of five dimensions and one core on the basis of target, a total of six groups of indexes to monitor and implement easily. Energy index: the proportion of clean energy saving shall reach 30 percent in 2020 and 70 percent in 2040. Transportation index: the proportion of transit trip shall reach 20 percent in 2020 and 60 percent in 2040. Circulation index: the consumption of tap water shall reduce by 40 percent in 2040 and the reuse rate of recycled water shall reach 60 percent; in solid waste treatment, the proportion of waste recycling, composting and electricity generation shall be maximized and the proportion of landfill shall reach 3 percent. Environment index: the proportion of carbon emission per GDP shall reduce 25 percent in 2020 and 55 percent in 2040 and the urban noise shall be up to standard. Construction index: the energy-saving standard of all new buildings shall reach 50 percent in 2040. Intelligent operation index: the coverage rate of intelligent facilities shall reach 20 percent in 2020 and 60 percent in 2040.

3.2 The simulation and control of noise

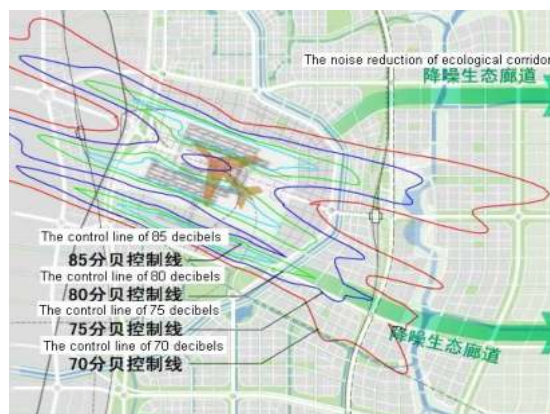


Figure 3 The noise simulation of aerial port

Noise impact is a specific ecological environment factor in aerotropolis and we plan to simulate the noise that 5 tracks do to airport space. According to the simulation, the noise in most of the land within the planning scope is lower than 70dB. The planning takes a full consideration of the influence of airport noise and arranges production land near the two sides of the airport and settles all kinds of living, culture and education, health, services, commercial and recreational activities in the distance of the airport, and sets noise reduction green corridor in the direction of freight runway.¹

Figure 4 The current situation and planning of ecological system in aerotropolis

3.4 Energy planning

In the aspects of new energy and clean energy, by using six kinds of new energy such as natural gas, solar energy, biological energy source, wind energy, geothermal energy and solid waste power generation in the planning area, the proportion of clean energy reaches 70 percent, the use of electric power reaches 30 percent and the carbon emission reduces by 55 percent in the year of 2040.

In the aspect of energy intelligent management system, set energy monitoring center in major public buildings and establish a city level energy center to implement networking and monitor and allocate the energy consumption of the city, building and municipal administration. By using WEB -based 3D GIS, realize the real-time monitoring of energy consumption of all departments and the condition of underground energy facilities and early warning of equipment accidents through the pipe sensors and equipment management systems lying underground.



Figure 5 Intelligent energy management system planning in the aerotropolis

3.5 Transportation system planning

Transportation planning is divided into three levels: the first is passenger transport - how to ship out 3 million tons per year; the second is freight transport - how to transport 50 million people; the third is the transportation inside the aerotropolis.

Relying on airport, the planning area builds the multi-modal transport system with high speed rail, interurban railway, rail transit, expressway and fast road as the backbones. Passenger traffic system planning: in the core area of Zhengzhou Xinzheng International Airport, using the join of interurban

railway, rail transit, BRT and conventional public traffic to form three-dimensional seamless transfer hub. Freight system building: in Zhengzhou urban area, realize the joint of three ports - the logistic harbor of arterial road as road port, the international multi-modal transportation center as rail port and the airport logistic park as aerial port, efficiently connected through the interlaced rapid commodity transport passage.

Plan an airport logistic zone around airport, build a set of intelligent logistics management system through the construction and integration of intelligent settings in seven aspects such as security airport, E-port, rapid logistics, seamless outsourcing, efficient commerce, intuitive information and safe farm, realizing the transfer of aerial port from logistics center to information center.



Figure 6 Intelligent logistic park planning in the airport

In the airport economic zone, as a demonstration project, plan an intelligent transportation ring road with a length of 43 kilometers, set 18 base stations covering a width of 1 kilometer on both sides of the road respectively. The traffic replacement is composed by information indicating, intelligent monitoring and integrated control center, providing information such as route guidance, parking guidance, deceleration prompt, peccancy detection, accident pretreatment, bus information, real-time control of traffic signals and emergency rescue, etc.

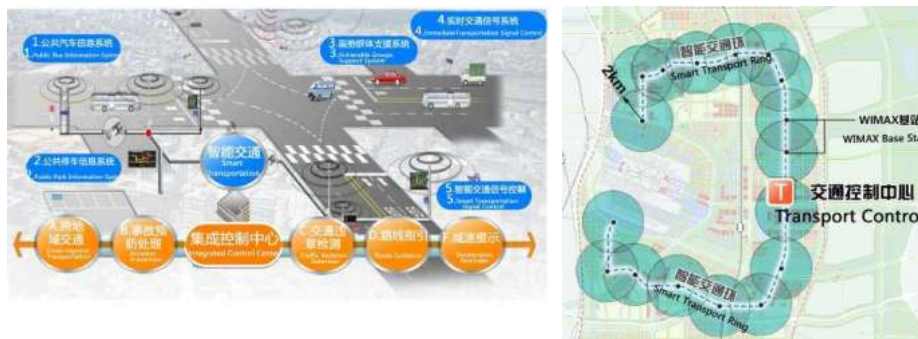


Figure 7 Intelligent road system planning in the aerotropolis

3.6 Intelligent monitoring system planning



Figure8 Intelligent monitoring and control system planning in the aerotropolis

At last, the intelligent integrated planning integrates such subsystems of urban metabolism as energy, transportation, building energy efficiency, noise control, atmospheric monitoring and water quality monitoring with the intellectual technology used in environmental ecological factors, making the information acquired can be connected and integrated to reach the ultimate goal of ecological city through intelligent integration. The planning integration forms one area, one ring, one region, four galleries and four cores, all of which act as the outcomes of intelligent integration. One area: one airport intelligent demonstration area. It manages the aviation, passenger flow and logistics through intelligent technology, stores and analyzes the laden huge amounts of high-grade passenger flow logistics information to make airport transfer from logistic harbor to information port. One ring: intelligent transportation ring. One belt: dynamically monitoring the water quality of Xiaoqing River, and setting a large number of interactive experience devices in the waterfront belt, making it a demonstration area of water ecological education, exhibition and recreation. Four galleries: setting energy saving facilities galleries along Yingbin road, connecting line of Daguang expressway, Wansan road and S102, using solar street lamp and breeze electric generator to supply electricity for urban lighting, adopting moderate LED nightscape lighting. Four cores: setting an intelligent integrated operation monitoring center in airport, northern, eastern and southern area respectively, monitoring and evaluating the ecological efficiency in the overall urban operations to make ecology and intelligence predictable, evaluable and adjustable.

4. Conclusion

Regarding the ecological environmental impact probably caused in the large-scale and rapid development and construction of ZZAEPZ and problems such as incomplete information and the inter-departmental information isolated island existing in each subsystem of urban metabolism, the

research uses MFA to build an ecological intelligent integrated planning framework and apply it to overall planning of experimental area, which achieves preliminary planning results.

Through the planning formulation process we can see that about the six subsystems defined in this planning, the research and planning for transportation, light green subsystem and noise factors are sufficient. The coordination of department is relatively successful because the planners have a certain stock of knowledge on these aspects. However, energy subsystem is a new problem emerging in recent years, so there are several attempts, but cross-functional coordination is not very successful. For recycling, because of absence of communication mechanism among planners, environmental protection, and sanitation departments, the planning result is difficult to implement.

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