Short review of concepts and practices in green airports in China

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Abstract. Becoming a green airport is an inevitable trend of future airport construction. In recent years much effort has been put towards developing green airports in China. This paper reviewed the evolution of the concepts of green airports, analyzed the domestic green airport projects according to the publicity material, to provide some useful suggestions for the future development of green airports in China.

1. Introduction

The airports are the important infrastructure of civil aviation, and to become green airports is an inevitable trend of future airport construction because of its large energy consumption of terminal buildings, the high energy consumption of a lot of support equipment on the airfield, and serious carbon emission of aircraft on the ground.

China’s green airport development can be roughly divided into four stages [1]: (1) the application stage of green airport technology (2006 – 2007). In this period, energy-saving and emission reduction technologies and projects have gained promotion and application, and the typical representatives are the East Extension Project of Beijing Capital Airport and Pudong International Airport in the Second Phase. (2) the exploratory pilot stage (2007-2012). The main characteristics of this stage are to build pilot demonstration projects, carry out green airport research, form the basic procedures of green airport construction, and accumulate experience in green airport construction. This stage is represented by Kunming New Airport Construction. (3) the guiding demonstration phase (2012-2017). The focus in this stage is top-level design, scientific and technological innovation guidance, more in-depth green airport research and practice, bringing in the concept of construction and operation integration. This stage is represented by Beijing Daxing International Airport Construction. (4) The promotion and development phase (since 2018). The characteristics of this stage are to promote the green operation of airports and help the sustainable development of airports. The green operation practice and research experience of representative airports are promoted from the aspects of policies making for the green development of civil aviation, airport operation management mode, standard formulation method, green operation index system, green procurement, and solid waste resource treatment, to improve the operation level of green airports and realize the sustainable development of airport system.

This paper will review the evolution of the concept and green airports in China, analyzing its main connotation and characteristics, compare the domestic green airport projects according to the public information, to provide some useful suggestions for the future development of green airports in China.
2. Definitions and regulations of Green Airports
The green airport is a concept in constant evolution, which is transformed from the previous "large and comprehensive" into a "specialized and intensive" concept. Its connotation is also in the development of continuous clarity and refinement with the deepening of understanding.

In 2006, the Civil Aviation Administration of China (CAAC) put forward the idea of "green airports" for the first time in the visions of the new generation air transportation system in China. In 2007, the CAAC proposed the guidance of "building a Green Kunming new Airport" in combination with the construction of Kunming new Airport, and the concept of "Green Airport" began to prevail in the civil aviation industry in China.

In the initial stage of putting forward the concept of green airports in China, green airports were defined as those economical, environmental, scientific, and humanized airports, which make full use of the latest scientific and technological achievements, with efficient use of resources (energy, land, water resources, materials), the minimum impact on the environment, to construct the safest, healthy, efficient and comfortable work and activity space under the minimum environmental load, for promotion the balance between man and nature, airport environment and development, construction and operation, economic growth and social progress, in the whole life cycle of airport facilities (site selection, planning, design, construction, operation and maintenance, and scrap, reuse process). The connotation of green airports mainly includes four aspects: environmental protection, economy, science-technicalization, and humanization.

To regulate terminal green construction and operation, and further promote resource-saving and environment protection, Beijing's new airport construction headquarters developed the industry standard "Green Terminal Standards" for work, which takes effect on February 1, 2017. On the other hand, the green airport construction guide (AC-158-CA-2017-02) was established by CAAC in 2017 to guide civil airport construction.

The 2018 National Civil Aviation Working Conference clarified the strategic deployment for building a strong civil aviation country, and proposed the establishment of "safe Airport, green Airport, smart Airport and humanistic Airport", which is summarized as "Four Characteristics Airport". After the Four Characteristics Airport concept is put forward, green airport begins to be distinguished from safe airport, smart airport and humanistic airport. The features previously involved in the green airport, such as collaborative efficiency, intelligent operation, and people-oriented, are included in the features of the smart airport and humanistic airport respectively.

"Green Airport Planning Guidelines" (AC-158-CA-2018-01) issued in 2018 is mainly guided from the perspective of planning and design. In this guideline, the green airport refers to an airport that is resource-saving, environment-friendly, highly efficient, and people-oriented, provides a healthy, convenient, and comfortable space for the public, and provides a safe and efficient operating environment for aircraft, and develops in coordination with the region during its whole life cycle. A green airport should have four characteristics. Resource conservation is the primary feature. Environmental friendliness is an important principle. Operational efficiency is the core. People-oriented is an important embodiment.

"A green airport is an airport that is resource-intensive, economical, low-carbon and environment-friendly in the whole life cycle" has been clearly defined in the “Action Framework of Four Characteristics Airport (2020-2035)” and “four characteristics airport development guidelines” in 2020. The main features of green airport focus on "resource-intensive saving, low carbon operation, environment friendly". In these latest documents, safe Airport, green Airport, smart Airport, and humanistic Airport were treated as organic, and the cross-content is merged. For example, green airports and humanistic airports contain "people-oriented" in the previous definition, now "people-oriented" is included in the construction of humanistic airports rather than green airports. However, "efficient operation" is still considered as the feature of a green airport.

To meet the requirements of green airport development, the CAAC has taken a series of related measures, such as promoting and implementing ground power unit (GPU) to replace auxiliary power unit (APU), putting forward requirements on APU and GPU usage management and operation
standards, and unifying the charge standard of GPU. In 2014, the CAAC listed the project of "oil to electricity" for airport ground vehicles as a key work of energy conservation and emission reduction. The CAAC carried out research and testing on the green performance of terminals, and issued the industry advisory circular "Research and Test Report on the Green Performance of Civil Airport Terminals" to guide and improve the green performance of terminals.

3. Example of green airports practice in China

Kunming Changshui International Airport is the first green airport identified by the CAAC. Since then, Beijing Capital Airport, Shanghai airport, Guangzhou Baiyun Airport, Nanchang airport, etc. have claimed to carry out green airport construction. According to the 2020 Four Characteristics Airport construction and development achievements exhibition in CAAC News, 7 Green Airport Construction projects were displayed. They are Daxing International Airport, capital airport, Baiyun Airport, Shangrao Sanqingshan airport, Changsha airport, and Chengdu Shuangliu Airport, with the IATA Airport Code of PKX, PEK, CAN, SQD, CSX, and CTU, respectively. Among them, Daxing International Airport has two construction projects, namely paperless travel and green airport construction. To show the difference, mark PKX¹ and PKX² respectively.

Now, based on the open information on the Internet, we compare the above seven projects according to the three important characteristics of the green airport, namely, resource-saving, low carbon emission, and reduction environment friendly, and according to the development stages of green construction projects (mainly plan, design, build and operate). The results are shown in the table below.

**Table 1. Green Airport Construction projects in the exhibition in CAAC News.**

| projects | resource-saving | low carbon emission reduction | environment-friendly |
|----------|----------------|-------------------------------|---------------------|
|          | Plan | Design | Build | Operate | Plan | Design | Build | Operate | Plan | Design | Build | Operate |
| PKX¹     | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |
| PKX²     | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |
| PEK      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |
| CAN      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |
| SQD      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |
| CSX      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |
| CTU      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      | ★    | ★      | ★     | ★      |

The star mark indicates that the construction project has reflected the feature of a green airport at this stage. As shown in Table 1, the above construction projects have made great efforts in resource conservation, low carbon emission reduction, environmental friendliness. Among them, resource-saving focuses on land-intensive, energy-saving, water-saving, and material-saving, emphasizing reducing resource consumption and improving resource utilization. For instance, 100 % green building standard construction in PKX², the basic balance of excavation and filling amount of earthwork in SQD. Low-carbon construction and management emphasize the optimization of the energy structure and the allocation of new energy facilities to enhance the level of carbon emission management. Such as paperless travel in PKX¹, buying green power through the power trading center in PKX², 100 % use of APU alternative equipment in CSX, implementing airport vehicles “Oil to Electricity” in CTU, optimizing aircraft taxiing route to reduce carbon emission in CAN. Environment friendliness focuses on environmental governance and optimization. For example, using prefabricated buildings to reduce noise impact in PEK.

The practices of SQD, PKX² almost cover the life circle of an airport, other projects take place in the operation stage.

It may need to be discussed here, Some projects aimed at improving operational efficiency should be classified as smart airports. The paperless travel project of Daxing international airport can reduce the waste of paper, namely, the boarding pass, reduce the CO₂ output in the production process, and the pollution to the environment. However, we need to further discuss whether to reduce the carbon emission in general because of the increase of carbon emission in the production and operation of face
recognition equipment if consider the overall process. What’s more important, the effect to improve the speed of passengers' security check-in and boarding is more remarkable. Similarly, optimizing aircraft taxiing routes and pre-management of flight trailers in CAN are also mainly to improve the operation efficiency. As a result, it seems more appropriate for them to be classified as smart airports.

4. Conclusion
The connotation and extension of the concept of the green airport are becoming more and more clear. As an important feature of high-quality airport development, the concept of the green airport can be divided into broad and narrow sense. In a broad sense, a green airport is an airport with sustainable development, and all the characteristics of the four characteristics airport should be satisfied. However, if the four characteristics airports have been mentioned, it is suggested that the green airport here should be distinguished from the smart airport and humanistic airport in terms of resource-saving, environment-friendly, and low carbon requirements.

Green airport construction is a systematic project. It’s necessary to formulate a scientific evaluation index system, mainly quantitative indexes. All quantitative indicators should meet measurable, reportable, verifiable (MRV) requirements.

Green airport construction should involve the whole life cycle, with the planning and design stages being the most important. Special attention should also be paid to the abandoned stage to make sure the abandoned airports can still be greenly disposed of in the final stage.

References
[1] Qiang Li, Shiman Sun, Wen Zhang, Construction Science and Technology, 08, 38-41 (2017)