Research of The Planning of Clean Energy Vehicles for Civil Airports

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Abstract: With the rapid development of the aviation industry, the concept of green and low-carbon has become a consensus of the development of global aviation industry. In order to solve the pollution problems caused by the application of conventional vehicles in airports, the Chinese government has called for the gradual conversion of conventional vehicles used in airports into Pure Electric Vehicles. On the basis of the study of the "Change from Oil into Electricity" project in the airport, the research analyzes the application status, advantages and existing problems of clean energy vehicles at airports, and makes planning proposals for airports airside clean energy vehicles on the formulation of clean energy vehicles planning objectives, the layout of charging infrastructure, model selection of CEVs and estimated power load of CEVs and supporting grid construction, airport intelligent charging management and other aspects.

1 INTRODUCTION

China is the world's second largest air transport market, with the traffic of international routes (including Hong Kong, Macau and Taiwan) ranked as the first in the world. CAAC is playing an increasingly important role in international civil aviation services, and is undertaking and facing heavier responsibilities. As important infrastructure of civil aviation, airports will embrace sizable expansions in the current period and the future. By 2025, the number of airports will increase to 370 from 229 in 2017. However, in face of the rapid development of the airports, the rigid constraints from resources and environment to the development of civil aviation are also getting stronger. Therefore, our country has proposed the implementation of green development concept in the whole process of design, planning, construction, operation and management to spur innovation along the path of green development.

At present, the development of new energy vehicles has been elevated to a national strategy, and the new energy vehicle is an important carrier of clean and intelligent development. Internationally, the CEVs are widely used in Los Angeles International Airport, Seattle Airport, and Stockholm Airport, etc. By estimation, the gasoline and diesel oil consumed by the airport's special vehicles account for about 15% of the total energy consumption in airports, which makes up an important part of operating costs in airports, and also the important emission source that influences the air quality of airport area. If the existing more than 16,000 special ground vehicles and equipment in the entire industry basically achieve electrification, 130,000 tons of oil can be saved every year and also air quality and working environment at airports can be effectively improved . To this end, the civil aviation has put forward the special project of "change from oil into electricity" for airport ground vehicles, transforming or replacing airports vehicles driven by traditional fossil energy to vehicles driven by electric energy and other clean energies, and several airports in this sector have been chosen to carry out the pilot work. The large new airports in China have also made the planning for CEVs and charging piles.

Therefore, on the basis of massive researches of airports implementing "Change from Oil into Electricity" project, this paper analyzes the application status, advantages and existing problems of CEVs in airports, and proposes suggestions for the implementation of planning for CEVs in airports.

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2 RESEARCH SCOPE

According to the regional function of an airport, it can be divided into airside and landside. The airside refers to the aircraft movement area and adjacent areas, buildings or a part of that area in the airport, which is more focused on the scope of airplanes movement. While the landside refers to other areas as opposed to the airside in an airport, which is more focused on the activity of persons (passengers, owner of the goods and staff). Therefore, airport vehicles can also be divided into airside vehicles and landside vehicles. The airside vehicles mainly include the ground service vehicles ensuring airside operation, aircraft flight and ground operation. The landside vehicles mainly contain the vehicles ensuring the landside traffic demand of passengers, staff and units stationed in the airport. The landside vehicles are mainly social vehicles and most of them do not belong to airports authorities. With this background, this paper takes only airside vehicles as the research scope.

There are many types of airside vehicles, including aircraft trailer, baggage transporter, passenger boarding stairs, platform truck, clean water truck, sewage disposal vehicle, garbage truck, power van truck, air source truck, air-conditioned vehicle, aviation catering vehicle, snow removal truck, aircraft deicer vehicle, patrol car, bird-control vehicle, friction coefficient test vehicle, glue-removing vehicle, command vehicle and other aircraft auxiliary vehicles among other special vehicles, as well as baggage tractor, baggage transporter, airport shuttle bus, boarding vehicle for the disabled, vacuum sweeper among other general-purpose vehicles. The configuration quantity and proportion shall be determined by the scale of the airport. Figure 1 is the configuration proportion of airside special vehicles in large airports.

3 TYPES OF CLEAN ENERGY VEHICLES (CEVS)

CEVs refer to vehicles using unconventional vehicle fuel as power source or using conventional vehicle fuel but adopting new vehicle power device and integrating advanced technologies on vehicle power control and drive. Such vehicles equipped with new technologies and new structures following advanced technical principles. The vehicles include gas (compressed natural gas) vehicles, electric vehicles, and hybrid electric vehicles, etc.

According to the practice of the pilot airports, the vehicles suitable for CEVs at present mainly include the tractor, mobile aircraft landing stairs, airport shuttle bus, guiding vehicle, baggage transporter, lifting platform car, baggage trailer, forklift truck, and VIP bus, etc. For class D and E airplanes, the platform cars with large tonnage, power vans, air source trucks, air-conditioned vehicles, deicing vehicles, snow removal trucks and other types of vehicles are not fit for adopting CEVs under current technical conditions, since the electric vehicles cannot provide sufficient power. While for the friction coefficient

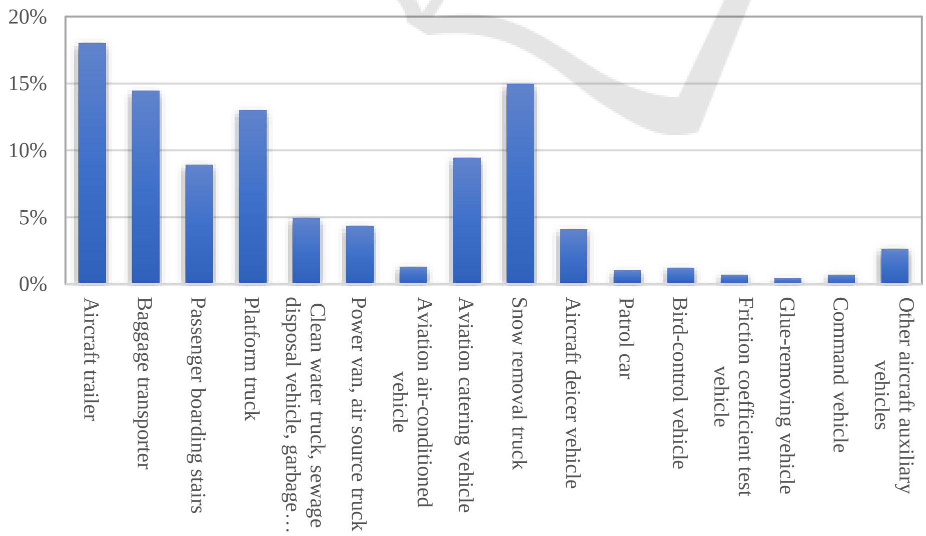

Figure1 Proportion of Airside Special Vehicles in Large Airports

test vehicles, deicing vehicles, snow removal trucks among others, there is no electric vehicle available yet at present.

4 APPLICATION STATUS OF CLEAN ENERGY VEHICLES AT AIRPORTS

In 2014, the Civil Aviation Administration of China listed the project of "Change from Oil into Electricity" as the priority of energy conservation and emission reduction. In January, 2015, the CAAC listed six airports with the throughput capacity of more than ten million passenger-time, namely Beijing Capital International Airport, Chengdu Shuangliu International Airport, Kunming Changshui International Airport, Changsha Huanghua International Airport, Harbin Taiping International Airport and Xiamen Gaoqi International Airport, as the first batch of pilots of "Change from Oil into Electricity" project. At present, the six pilot airports and their on-site companies have completed the construction of more than 160 charging facilities, with 412 electric special vehicles put into operation.

4.1 Benefit Analysis of Clean Energy Vehicles at Airports

Since there are varieties of airside vehicles in the airports, we have selected the widely used shuttle bus and the minibus for transporting passengers as comparison objects to analyze the benefits of CEVs. According to the measured data of an airport, a contrast analysis of the fuel powered vehicle and the electric vehicle burdened with the same guarantee area is carried out. According to Table 1, it can be seen that the energy consumption by the electric passengers' vehicle is only 9-13% of that by the fuel powered vehicle; carbon emission of the electric passengers' vehicle is only 30-43% of that of the fuel powered vehicle; and the cost of the electric passengers' vehicle is only 31-45% of that of the fuel powered vehicle. It can be stated that the CEVs can effectively reduce energy consumption and carbon emission in airports, and can improve the environment quality on the airside and reduce energy costs.

4.2 Existing Problems

During the implementation of the "Change from Oil into Electricity" project, it is found that the site and electric power resources in the movement area are quite scarce, and the electricity capacity enhancement and non-stop operation of flight for construction have posed some challenges to the implementation of the project. In order to guarantee operation safety and efficiency in the movement area, the new charging facilities and vehicle parking positions must meet ground service requirements and demands of nearby charging.

The primary problem facing airports built in earlier years, which have been saturated in airport operation is lack of power load for charging vehicles in the movement area. Instead, only AC slow-charging equipment can be built, the charging efficiency of which cannot suffice to meet operation requirements. The power reconstruction in the movement area encounters dual problems of high costs and engineering difficulty. In busy airports, positions facilitating power facility reconstruction are far away from aprons and vehicles have to travel a long distance to be charged, leading to lower operation efficiency of vehicles. As far as reconstruction cost is concerned, it is necessary to cross the taxiway for cabling system if the power supply facility is built at the remote aircraft stands on the apron, resulting in impact on operation efficiency of airports and high reconstruction costs.

At the moment, few special vehicles are completely suitable for civil aviation airports and ground-type electric special vehicles available on market differ from each other in battery materials, battery voltage, battery capacity/specification of charging interface, charging connection control strategy and so on. As a result, such vehicles have a

Table 1: Benefit Analysis of Clean Energy Vehicles at Airports

Monthly Data	Large Shuttle Bus		Minibus	Minibus
	Fuel Powered	Electric	Fuel Powered	Electric
Energy consumption (kgce)	1928.00	255.05	1312.17	120.39
Reduced energy consumption (kgce)	1672.95		1191.78	
Carbon emission ($kgCO_2$)	4216.33	1800.49	2869.57	849.87
Reduced carbon emission ($kgCO_2$)	2415.85		2019.70	
Energy cost (yuan)	8506.73	3802.89	5789.56	1795.05
Reduced cost (yuan)	4703.83		3994.50	

variety of chargers to match, which have different safety protection functions and incompatibility has led to repetitive purchase and low utilization of such chargers, causing inconvenience in unified management, all of which are coupled with other problems to further lead to wastes of site resources in the movement area.

In addition, it is imperative to solve the issues of application of CEVs in severely cold zone and disposal of waste batteries among other problems.

5 AIRPORT'S CLEAN ENERGY VEHICLE PLANNING

5.1 Formulation of Planning Objectives of Clean Energy Vehicles

So far, some airports have applied CEVs around the globe and the percentage of CEVs in Seattle Airport, Stockholm Airport, and Hong Kong International Airport have reached 43%, 30% and 30% respectively. Against this backdrop, planning objectives of CEVs at airports shall be formulated in combination with the short-run and long-run plans of airports and CEVs development forecast, where unified planning and staged construction shall be made, with percentage of CEVs being specified at all stages and power load and interface being reserved. In line with principles of leading layout ahead of time and moderate reservation and in combination with airside facility layout and effective service radius of special vehicles, the space for service, parking and charging for airside CEVs shall be reasonably arranged and reserved.

5.2 Principles of charging infrastructure layout

The layout of an airport's charging infrastructure shall fully leverage the guide of airport's planning, where an overall layout shall be made by taking all factors comprehensively into account in the principle of "overall layout and elaborate configuration". In the meantime, charging infrastructures shall be provided in a differentiated and elaborate way in different areas in airports according to driving, parking and charging characteristics of all kinds of electric vehicles in the scope of airports. In the airside area, driving and working characteristics, consumption of electric energy, charging characteristics of batteries and other factors shall be considered comprehensively to reasonably determine percentages of vehicle piles for all kinds of special electric vehicles, plan the scale of construction of charging facilities for special electric vehicles, and ensure the demand of all kinds of special electric vehicles to replenish electric energy nearby is met.

5.3 Model Selection of Clean Energy Vehicles and Layout of Charging Piles

An airport's special vehicle operation areas are mainly situated at the airport's airside, which are the airport's special areas. A differentiation analysis shall be made on driving characteristics and daily operation and parking periods for all kinds of special vehicles, which are developing in mature areas of domestic airports and an assessment shall be made on the basic charging demands of all kinds of special electric vehicles after "replacement by electric energy" in all special vehicles to ultimately determine types of CEVs, positions and models of charging infrastructure and configuration percentages of "fast and slow charging" infrastructure.

5.4 Power load prediction and supporting power grid construction for clean energy vehicles

According to characteristics to use and charge CEVs, the capacity demand of the distribution power grid supporting charging piles of such CEVs shall be determined for different power loads categorized by respective areas and periods at airports, and effects of integration of massive charging infrastructure into the distribution power grid shall be analyzed and corresponding measures shall be put forward to satisfy power demand of CEVs in airports and guarantee safety of power grid and quality of electric energy.

5.5 Airport's Intelligent Charging Management

On the basis of Internet of Things, cloud computing, mobile Internet and big data technology, intelligent charging service management platform shall be planned and built to realize remote real-time monitoring of CEVs in operation and charging infrastructure and meet the demands of safety supervision over the airport's airside special CEVs. On the basis of big data collection on the intelligent charging network platform, load characteristics of demand side of CEVs shall be analyzed and studied, charging load control of CEVs in the airports shall be realized by area and period in peak hours and bilateral interaction technology between CEVs and power grid shall be applied to realize peak shaving, alleviate pressure of power supply from the distribution power grid, and maximize utilization of assets of power distribution equipment.

6 CONCLUSION

1) The planning and construction of CEVs at airports are important means to realize green and low-carbon development in the industry and important measures to implement the national strategy. The electrification of the special vehicles at airports is brand-new and requies attentions and efforts in all respects.

2) In application of CEVs at an airport, charging facilities are a fundamental guarantee, whilst advanced products, technologies and management are critical. The planning of CEVs at airports shall follow the principle of combining short-term and long-term perspectives and be effectively connected to the medium-term and long-term development plans of an airport, thus integrating green development, safety guarantee and service improvement, which shall also improve the network integration, intelligence and sharing capabilities of the project and reserve room for the project expansion at a later stage.

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