Study on Energy Efficiency Level and Energy Conservation Technology of Highway Passengers Stations

Tianjun Yang
Ministry of Transport Scientific Research Institute, Room 813-1, HePingli East Street, Chaoyang District, Beijing, China, 100029

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Abstract: Through research on energy consumption and energy efficiency of highway passenger station, it displays the consisting of energy consumption and entire level of energy efficiency on passenger station, which can provide technical support for energy saving reconstruction and ultimately promote the development of green transportation. Highway passenger station is an important node of the transportation system and an important public service facility, which is different from the common public buildings, as well as, need keeping a certain service level and has high energy consumption and great potential for reconstruction, what is lacking for researching on energy consumption influential factors and energy efficiency level of passenger station. Referring to the research results of energy efficiency of public buildings, considering the factors of energy consumption from the site, station construction, layout, equipment and operation aspects, energy consumption survey plans are designed based on five type of climatic divisions, through investigating the energy consumption, it can objectively obtain the reality of the highway passenger station energy consumption. Throughout data screening, it obtain energy consumption data of different building climate zones and study the characteristics of energy consumption data of different climatic divisions. Reference to evaluation method of energy efficiency level, indexes of unit energy consumption is putted forward. The method of energy efficiency gradation is defined, threshold values of energy efficiency level are confirmed basing on different climatic divisions, energy efficiency level of passenger station is divided into three-level. According to analyzing the key technologies of energy saving and combining the characteristics of energy consumption of the station, the intelligent energy-saving technology of passenger station based on cloud temperature controller is putting forward.

1 INTRODUCTION

The '13th Five-year plan' is a crucial period for upgrading and transformation of the transportation industry in China. This plays the leading role in advancing the modernization of transportation. Meanwhile, the traffic industry has also carried out research in many aspects, such as construction pilot cities with low-carbon transport system, green traffic provinces, green port, green highways and demonstration projects for energy conservation and emission reduction. The Ministry of Transport has gradually paid attention to the construction and green services areas.

2RESEARCH REVIEW OF DOMESTIC AND FOREIGN

As a significant node of the transportation system, the highway passenger station is another significant public building facility. It can draw on domestic and overseas relevant laws and regulations, as well as, energy efficiency management in the development of green construction. (ECCJ.2014,Moretra V D, et.al, 2009, Saidur R., 2009, Asia Business Council, 2014, Ministry of Economy, 2014, Building Research Institute. 2014,) Meanwhile, it also learns from the current research of green station in domestic and overseas. The Annual Energy Conservation and Emission

Reduction Capability Project for Transportation 'Study on Evaluation Index System of Green Low-carbon Highway Transport Stations' in 2014. A draft of the two traffic industry standards for 'evaluation Method for saving energy passenger station construction projects' and 'Evaluation Method for Saving energy of Freight Station (Field) Construction Projects' was proposed.

The significant technology of saving energy in current condition focus on heating, frequency conversion, climate compensation, adjustment the balance of hydraulics, waste heat recovery, as well as, heating system automatic control and heating of floor radiation. There are plenty of technologies of air condition area in current period, such as fire pool cold storage, primary variable frequency and flow, large temperature differential cooling, cooling tower provides cold, air conditioning self-control, pump of ground source heating, radiation ceiling, multi-zone air conditioning energy-saving and the recycle of heating in air condition system. Meanwhile, transportation area pays more attention on the technology using energy-saving. There is some technology using public transport region, such as setting up an energy management system, regenerative braking energy recovery technology for locomotives, distributed photovoltaic technology and reproduction lighting technology.

It can be seen a large number of scholars have conducted analysis of energy efficiency in buildings and there are also relevant studies on the energy efficiency classification of public buildings through the description of the study. As a large-scale public building, highway passenger stations require a certain level and quality of service. The relevant researches have been carried out in domestic and overseas in recent years. However, there is a lack of systematic analysis of the overall energy consumption and grades of domestic transportation terminals, the establishment of an energy efficiency benchmarking system, as well as, the lack of technical support for the reduction of energy saving and emission of highway passenger stations. This study will investigate and analyze the energy consumption status of highway passenger stations and establish a corresponding energy efficiency rating assessment method and research on energy conservation technology of passenger station.

3 RESEARCH PROGRAM FOR INFLUENCING FACTORS OF ENERGY CONSUMPTION

The 'Code of Design of Thermal Engineering for Civil Buildings'(GB50176-93) sets the national building thermal design into five points from the perspective of design. It divides the country into five districts, Freezing, Cold, Hot-Summer and Cold-Winter, Hot-Summer and Warm-Winter and Temperate Regions. Because different climates put forward different requirements for the standards of design building, as well as, the main facilities, equipment and energy consumption characteristics of the passenger station in a different region of China depend on different climatic conditions. Therefore, in the actual investigation, according to different construction climate zones, it is necessary to count the energy consumption of passenger station.

The project team conducts on-the-spot investigations of the highway passenger station through interviews with technical personnel of the station, expert consultation, and field trips. The research plan mainly focuses on the following eight aspects: (1)The basic conditions of the station (site station level, daily delivery volume, traffic convenience, room for development, etc.); (2) Site layout processes conditions (general layout, process flow, streamline design, etc.); (3) Production and living facilities of the station (total area, area of building facilities, area of station facilities, area of office facilities, area of facilities, area of living service facilities, etc.); (4) Station building conditions (body shape coefficient, thermal performance of fence structure, ratio of window to wall, external shading, openable area of external window, etc.); (5) Station equipment configuration: ticket sales, station security inspection machines, metering equipment, etc.; (6) Energy consumption types and consumption (coal, oil, electricity, heat, gas, etc.); (7) Station energy-saving management (setting of energy-saving organization, system construction, implementation of energy conservation); (8) Other aspects (resource recycling, new energy use, etc.)

4STUDY OF ENERGY CONSUMPTION DATA ANALYSIS AND EFFICIENCY RATING

4.1 Treatment of Energy Consumption Data Converted to Standard Coal

In order to facilitate the calculation, comparison and analysis of various energy sources, they must be uniformly converted into standard fuel refer to the calorific value of different energy sources. It is customary to use internationally standard fuel: standard coal (coal equivalent) and standard oil (oil equivalent). China uses coal as energy equivalent. Comprehensive energy consumption is the sum of all kinds of energy actually consumed in the statistical reporting period of the energy-using unit and the total sum calculated by the specified calculation method and unit (G.C. Dai., 2011, L.C. Li., 2015). According to the 'General Principle for Comprehensive Energy Consumption Calculation' (GB2589-2008), when calculating the comprehensive energy consumption of passenger station, various energy sources and energy consuming workers are respectively converted into the same unit of standard coal (tons) specified for primary energy. Table 1 reveals the commonly used energy index coefficients.

Table1. List of commonly used energy sources and standard of coal coefficient medium consumption.

Energy types and units		Standard and unit for coal discounted	
Variety	Unit	coefficient	Unit
raw coal	Ton	0.7143	Tons standard of coal/ton
Petrol	Ton	1.4714	Tons standard of coal/ton
Diesel	Ton	1.4571	Tons standard of coal/ton
Gas	M^2	1.2143	Tons standard of coal/ M^2
Electricity (equivalent)	10,000kwh	1.2286	Tons standard of coal/10,000kwh (Used to calculate thermal power)
Heat (equivalent)	GJ	0.03412	Tons standard of coal/GJ
	1000Kcal	0.14286	Kilograms standard of coal plant dry cards

In enterprises view, integrated energy consumption refers to the total energy consumption of the major production systems, auxiliary production systems and subsidiary production systems during the statistical reporting period. Therefore, the calculation of comprehensive energy consumption by passenger station draws on the method of 'Comprehensive Energy Consumption Calculation Principles'. The comprehensive energy consumption calculation formula for a one-year passenger station is:

$$E = \sum_{i=1}^{n} (e_i \times p_i) \quad (1)$$

In the formula: E ——Comprehensive passenger station energy consumption in one-year passenger (kgce);

n ——Several varieties of energy consumption ;

e_i ——The 'i' energy amount consumed in production and service activities;

p_i ——Conversion factor of the 'i' energy source

4.2 Processing Methods in Survey Data

There are two common ways to justify the acute value. One is Physical Discrimination, timely detection and correction of errors caused by changes in instrument, personnel and test conditions during the observation process. The other one is Mathematical Statistics. This method makes the range of mistakes $\pm k\sigma$ and the corresponding confidence probability $1-\sigma$,σ is dangerous rate. Any measurement that exceeds this error range is a low-probability event and is considered as a bad value.

Rely on the calculating, to solve the bad value for the research data in each of five different climate region, the energy consumption of passenger station in each station adopt 3σ method to calculate deviation, if the measure value $x_i (1 \le i \le n)$ deviation $|\delta_i| > 3\sigma$, it should modify the survey data of the passenger station and continue to solve the remain energy consumption data for other passenger station.

Table 2. The number of sample before and after filtering.

Partition name	sample before filtering	sample after filtering
Freezing area	63	54
Cold area	30	25
Hot-summer and cold-winter area	123	104
Hot-summer and warm-winter areas	96	82
Temperate regions	114	95

4.3Unit Energy Consumption Index Standard for Passenger Station

This research uses the main building energy consumption as the research project, as well as, considering the energy consumed by the special service equipment, public welfare properties of highway passenger station. It can use the energy consumption of sending passengers to analysis the energy efficiency level of the passenger station through the statistics organization due to the passenger station s in the same area have similar architectural style, structure and management mode etc. this is not related to the current classification of the passenger station . The difference of the samples of passenger station can analysis and assessment base the 'Saving Energy Evaluation Method for Passenger Station Construction Projects'.

The total station energy consumption per hundred passenger is B .Due to the vast territory of China, the climate becomes complex and changing and there are notable features in each climatic region. Therefore, the national standard line should not be demarcated during the evaluation of the comprehensive energy efficiency index of the passenger terminal, as well as, it should be based on different climatic regions.

As the example of Hot-Summer and Warm-Winter region, base the total data in this area can calculate average station energy consumption per hundred passengers $\overline{B}^s$. The calculate formula is:

$$\overline{B}^s = \sum_{i=1}^{n} B_i^s \Big/ n \qquad (1)$$

In formula: $\overline{B}^s$ -- The average station energy consumption per hundred passengers in Hot Summer and Warm Winter Region (kgce/100per);

n—the number of passenger station s of survey in Hot Summer and Warm Winter Region.

B_i^s --the total of'i'station energy consumption per hundred passengers in Hot Summer and Warm Winter Region

Consider the related data in scoring articles under the "Effects" indicator in 'Green Port Class Assessment Criteria'(JTS/T105-4-2013),the scores of the comprehensive energy consumption of port production and the CO2 emissions of port production units in the relevant data of the "saving low carbon level" scoring clause are based on the average of 26 typical terminal statistics. These two indicators score of the lower than average of 20%, or higher than 20%.

Put the average station energy consumption per hundred passengers in Hot Summer and Warm Winter Region $\overline{B}^s$ below the 20% as the excellent indicator B_1^s , above the 20% as the normal indicator B_2^s . Therefore, when the average station energy consumption per hundred passengers in Hot Summer and Warm Winter Region less than or equal to excellent indicators represent high levels of energy efficiency. Less than the normal indicator and more than excellent indicatorsis a medium level. More than the normal indicator represent low level. Other climate region reference this method, the control value is given in table 3.

Table3. Control index of unit energy consumption of passenger station.

Climate region	Total energy consumption per hundred passengers in station	
	B_1	B_2
Freezing area	16.74	25.11
Cold area	5.6	8.40
Hot-summer and cold-winter area	2.33	3.49
Hot-summer and warm-winter areas	2.34	3.50
Temperate regions	0.88	1.32

4.4Energy Efficiency Rating of Highway Passenger Station

On the basis of the 'General Principles for Energy Productivity Indexes for Energy-using Products', The Ministry of Transport put forward the transport industry standard 'General Principles of Energy Efficiency, CO_2 Emission Intensity Grades and Assessment Methods for Transportation Industry' (Draft for Soliciting Opinions). It identifies the energy efficiency, CO_2 emission intensity levels and assessment methods for transport enterprises. The core content of the standard is to determine the level of energy efficiency to stipulate the energy efficiency and CO_2 emission intensity level of transportation enterprises. There are three levels in total, among which first class is optimal and third class is the worst.

Learn from domestic and international research achievements in building energy efficiency and combine the transport industry standard 'General Principles of Energy Efficiency, CO_2 Emission Intensity and Assessment Methods for Transportation Industry' to solicit opinions. Comprehensively consider energy efficiency status of highway stations in China and the future development direction of highway passenger stations. This classifies the energy efficiency rating of highway passenger terminals (Alan Meier, 1996, J.W. Wen, 2009) . The level of energy efficiency of highway passenger stations is divided into three levels, in which the level of primary energy efficiency is high, the level of secondary energy efficiency is generally, and the level of tertiary energy efficiency is low. The energy efficiency rating of highway passenger stations is shown in Table 4 below.

Table4. Classification of energy efficiency of highway passenger stations.

Classification of energy efficiency	Reference
First class	$B \leq B_1^s$
Second class	$B_1^s < B < B_2^s$
Third class	$B \geq B_2^s$

4.5 Analysis of Energy Efficiency Standard Characteristics in Typical Climatic Division

In order to analysis the current energy consumption of passenger station in different climate region, project term make the survey for the first and second class of passenger station energy consumption to freezing region, cold region, Hot-summer and Cold-Winter region, Hot-Summer and Warm-Winter region and temperate regions. Statistical analysis was conducted on the data obtained from field surveys and correspondence, as well as, statistics Annual average energy consumption (Kgce), total energy consumption per hundred passenger (Kgce). The specific data are in the table 5.

Table5. Energy consumption of passenger station based on climatic divisions.

Partition name	Annual average energy consumption(Kgce)	energy consumption per hundred passenger(Kgce)
Freezing area	243749.76	20.93
Cold area	167401.2	7
Hot-summer and cold-winter area	64139.68	2.92
Hot-summer and warm-winter areas	73863.61	2.91
Temperate regions	14255.12	1.1

From the analysis results in Table 5, the highest of average annual energy consumption is freezing region, follow by cold regions. This is mainly due to the long heating time and high total energy consumption in winter. Temperate regions have the lowest energy consumption. The characteristics of climate, level of economy and lives habits have the effect on passenger station in different climate area. It bases the annual average energy consumption to analysis passenger station operation management for energy effectiveness.

5 THE ANALYSIS AND APPLICATION ON THE SIGNIFICANTENEGY-SAVING TECHNOLOGY

Tring best to reduce the building energy efficiency to the lowest level based on meeting the utilize function of building. It needs to adapt to different technology achieving. First of all, it shall operate the high level heat insulation to the surrounding protection of the building. Then, applying the

heating with highly efficient, cooling, lighting and home appliance equipment and systems. The purpose of these progress is decrease the efficiency of transfer heating and cooling and fully using the clean energy, expand cogeneration of heat and power or combined heat, power and cooling, as well as, the application of heat pump, energy storage, heat recovery and variable flow technology.

Otherwise, maximum limited to have effect on using natural resources is pretty important. Green building is the conventional method of using natural energy. Wind power is one of the most significant resources of the earth. The utilizing of wind power shows in wind power generation and the use of wind energy promote ventilation indoors, as well as, the latter way is the major for the building to use.

5.1 The Production of Saving Energy

The price of production and equipment gradually decreases with the rapid development of energy-saving technology. Some passenger station also makes the great change and reform to energy-saving and emission reduction. For instance, using photovoltaic power make lighting of station and electric charging, as well as, using saving energy lighting products to transform the station etc. Because the rapid development and application for the internet, cloud technology, it gradually form the intelligent machine. Base on the traditional energy-saving methods to achieve cloud management, cloud diagnosis, cloud perception, cloud calculation and other cloud services with intelligent application. Depending on the part intelligence of internet technical, there are some representation products: Temperature-controlled heating billing valve, cloud thermostat and cloud remote control, central air conditioning billing system etc.

5.2 Analysis for Case Study

5.2.1 The Introduction of Cloud Thermostat and Cloud Remote Control

The cloud thermostat is an air-conditioning temperature-controlled device that based on traditional thermostats and mobile internet technology to implement a cloud operation and the management of energy-saving. It applies to all 'four-wire and three-speed' fan coils and can directly replace traditional thermostats.

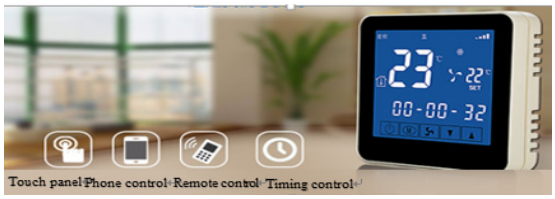

Figure1. Cloud thermostat and cloud remote control.

Cloud thermostat not only has the function of central intelligent thermostats control, but also has cloud management (mobile APP management, cloud diagnosis, cloud perception, cloud calculation and other cloud services), Time-saving management, multi-room management, remote control and other intelligent energy-saving modes.

5.2.2 Application of Case Study

There is a working area of passenger station which has a construction 1,024 m^2. It adapts cloud thermostats providing the centralize control of electric heating. There is only one cloud thermostat in each room, which controls from one to three electric heating. It utilizes the cloud center of the original internet access product of company, each computer or mobile phone can through the assigned account to connect the internet. According to the rights to management all electric heating in the working area, it can set the management of temperature range, overtime mode and plays a benefit energy-saving effect. It does not need to set up regional management equipment and terminal of management room, as well as, the simple system, convenient utilize and economical (it can save 8%-10% energy when turn down 1℃). Meanwhile, the fund of project equipment can through the savings of electronic fee to repay. Cloud thermostat not only has the function of central intelligent thermostats control, but also has cloud management (mobile APP management, cloud diagnosis, cloud perception, cloud calculation and other cloud services), Time-saving management, multi-room management, remote control and other intelligent energy-saving modes.

6 CONCLUSIONS

This report has conducted in-depth research on energy consumption and energy efficiency rating of highway passenger stations. Through statistical analysis of energy consumption data of different building climates, it propose an energy efficiency

rating method for highway passenger stations Study setting of the energy efficiency rating scales to obtain energy efficiency ratings for passenger stations in different climate zones. According to the characteristics of energy consumption of passenger station, there are the studies for several technology such as, the analysis and research of energy saving technology, the cloud temperature controller and cloud remote control device based on network and cloud technology are studied. The system is easy to use, easy to operate and saves the energy consumption of the station. The research results can assess the energy utilization efficiency of highway passenger stations. Through horizontal comparison, passenger stations can understand the level of energy consumption for itself located what kind of position in the same climatic region. Combining the energy influencing factors and evaluation results can provide scientific and technical basis for the future energy-saving, emission reduction and transformation of passenger stations. This has positive significance for promoting a conservation-oriented society, a low-carbon economy, green transportation, as well as, sustainable development of the station.

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