Research on energy conservation of port public buildings

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Abstract. Energy is the basis of the survival and development of human society, and the energy needed is increasing. Our building energy consumption accounts for a large proportion of total social energy consumption, so the research and development of building energy-saving technology is the top priority. The energy conservation and emission reduction of port public buildings should also be paid attention to. Domestic and foreign scholars' research on port energy conservation mainly focus on the management and planning of port construction, less on the specific energy conservation measures of port public buildings, staying at a relatively macro and overall level, and lack of detailed research on the function positioning, site selection and layout, and structural form of port public buildings.

1. Introduction
Development is an eternal theme. Energy demand is increasing with the development of human society. Energy structure is changing constantly. Energy has a significant impact on social development and natural environment. With the development of economy and the acceleration of urbanization, the energy consumption of buildings is becoming more and more important in the composition of energy consumption. Due to the increasing shortage of energy sources of the world, building energy conservation has attracted the attention of all countries in the world, and relevant research has become an important part of energy conservation research in China.

The average energy consumption level of public buildings in China is high. As shown in Table 1, as building energy consumption accounts for a large proportion of the total energy consumption, building energy saving is very important to the development of a country. According to China Building Energy Consumption Research Report 2019, the national building energy consumption data in 2017 is shown in Figure 1. Public building area only accounts for 19% of the building area, but public building energy consumption accounts for 38% of building energy consumption. It can be seen that energy conservation of public buildings is of vital importance. According to incomplete statistics, by 2020, there will be only 320 million m² energy-saving buildings out of the 13.18 billion m² of housing buildings in China, so there is a big margin for improvement.
Based on the above thought, China formulates policies, management methods and systems related to energy conservation, and creates new technologies and processes for building energy conservation. Therefore, it can reduce the energy consumption of buildings and get better development.

Ports are very important to the transportation industry and have a great impact on China's economic development. At the same time, it produces a lot of energy consumption, so the energy conservation and emission reduction of port public buildings still have a large space for improvement. This measure has a positive effect on saving energy consumption and reducing environmental pollution, so the energy conservation measures for port public buildings should also be taken seriously.

| Table 1. Energy consumption data indicators of public buildings |
|---------------------------------------------------------------|
|                                                                 |
| 2014 | 2015 | 2016 | 2017 | 2018 |
| Total building energy consumption (million TCE) | 814   | 857  | 899  | 947  | 520 |
| Proportion of building energy consumption in national energy consumption (%) | 19.12 | 20   | 20.6 | 21.11| 11  |
| Total construction area (billion m²) | 60.5  | 61.3 | 63.5 | 63.4 | 60.1 |

Figure 1. Building energy consumption data in 2017: (a) Construction area and building energy consumption of three types of buildings; (b) Building energy consumption and construction area proportion of three types of buildings

2. Current situation of building energy conservation at home and abroad

2.1. Current situation of building energy saving in foreign countries
After the Middle East war in the 1970s, the oil crisis broke out, and Western countries began to realize the position of energy in economic development. Building energy conservation plays an important role in solving the energy problem, so the western developed countries begin to pay attention to building energy conservation.

Therefore, the western developed countries have been carrying out the research and development of new building energy-saving technologies, and have made some achievements in the improvement in energy utilization efficiency and renewable energy, and have formed relatively perfect policies and regulations [1].
In order to study the measures of reducing heat load, GA. Florides et al. [2] used TRNSYS program to simulate the modern residence. Inspection measures include natural ventilation and control ventilation, shading, direction, building shape and thermal quality.

Nurdil Eskin and Hamdi Turkmen [3] studied and analyzed the control strategy and cooling load of office buildings in four climate regions of Turkey through energy plus software. Based on their annual cooling capacity, heating capacity and total building load, the specific data of the influence of ventilation rate and different outdoor air control strategies on annual building energy consumption and annual energy consumption were obtained.

Holger König and M. Lisa De Cristofaro [4] specially developed a new building certification system to evaluate the sustainable quality level of buildings. The rating system includes the basic economic benchmark and the environmental input and output resulting from the construction, use and end-of-life stages of buildings of different use categories.

2.2. Current situation of building energy conservation in China

In China, the research on building energy conservation started late. Since the 1980s, China has promulgated a number of design standards and laws and regulations for building energy conservation. Domestic scholars focus on the analysis of building energy consumption and the application of renewable energy in the field of building. Based on this theory, new technologies and products related to building energy conservation are discussed and developed.

Gong J. C. and Yang X. L. [5] established a calculation model based on the whole life cycle theory for residential buildings, and introduced the calculation formula of energy consumption in the whole life cycle of residential buildings:

\[
Q_{Z} = Q_{WH} + Q_{YX}
\]  

(1)

Where, \(Q_{WH}\) is the physical and chemical energy consumption of buildings, and \(Q_{YX}\) is the operation energy consumption of buildings. This model is used to calculate the energy consumption of the research object and analyze the relationship between each energy consumption, so as to provide a theoretical basis for the construction of energy-saving housing.

Zeng D. [6] qualitatively studied the prediction method of the operation energy consumption of civil buildings, and established the macro prediction model of the operation energy consumption of civil buildings according to the macro factors of the energy consumption.

Liu K. [7] took the public office building with the largest proportion of energy consumption of China's construction projects as the research object. From the perspective of energy consumption and economy, he analyzed and studied the optimization of building energy conservation combined with BIM Technology, life cycle theory, economic evaluation and other tools and methods. Also, he explored the mechanism of energy consumption and economy on the optimization decision-making of design schemes, and provided new ideas and approaches for the optimization of energy-saving design of other similar buildings.

Wang L. [8] took a certain construction project as the research object, and enumerated the newly developed green energy-saving technologies in different categories, and provided theoretical basis for the application conditions and methods of new green energy-saving technologies in the construction of construction projects.

3. Current situation of energy conservation of port public buildings at home and abroad

3.1. Energy saving status of foreign port public buildings

Foreign scholars have made some achievements in the research of port energy conservation.

Cupta A.K. and rashmi S.Patil [9] pointed out that the environmental management plan (EMP) of port engineering plays an important role in port construction, and studied how to determine port pollution level and identify port related pollution sources, and proposed prevention, protection and control measures for different pollution.
Atulya Misra et al. [10] discussed how to effectively integrate renewable energy technologies with clean energy based DC micro grid to reduce greenhouse gas emissions in ports. This paper focuses on the advantages of using appropriate energy storage technology to realize the sustainable management of port energy based on the DC microgrid of renewable energy.

Julián Martínez-Moya et al. [11] studied the key information on the actual energy consumption and CO2 emissions of one of the most relevant container terminals in the Mediterranean region in Valencia, Spain. The results showed that station tractors and rubber tyred gantry cranes are the main emission sources. The transformation of RTGS cranes and the replacement of fuel driven terminal tractors for new LNG tractors can effectively improve the terminal energy efficiency and reduce carbon dioxide emissions.

Dayla Karolina Fossile et al. [12] adopted a multi criteria decision-making model based on FITradeoff to solve the problem of energy selection, so as to determine which type of renewable energy is the most feasible investment for Brazilian ports.

Although foreign countries have had in-depth research on port energy conservation and emission reduction, but mainly for the impact on port activities on the environment and the development and utilization of renewable energy. These studies pointed out the problems, challenges and development prospects. From the perspective of environmental protection system and its policies, the research on energy conservation and emission reduction of port public buildings is relatively few.

3.2. Energy saving status of domestic port buildings

Domestic scholars also put forward some opinions.

Yu Z. et al. [13] analyzed the characteristics and energy consumption status of Tianjin port buildings. He pointed out the development direction of energy-saving measures of Tianjin port buildings from the aspects of energy-saving design of enclosure structure, air conditioning and heating system, lighting equipment.

Zhang H. L. [14] first proposed that due to the improvement of solar energy utilization technology, the scope of application in the construction field will be improved, which will have a positive impact on the promotion and implementation of port energy-saving buildings. Solar buildings play an important role in the construction of energy-saving port public buildings, and also have a positive impact on the promotion and implementation nationwide.

Xu L. Q. [15] studied the comprehensive energy conservation of public buildings. The applicability of various energy-saving ways of public buildings in the port area was obtained through simulation calculation and analysis, and the most effective combination of comprehensive energy-saving measures was proposed.

Xu D. S. [16] proposed port energy conservation and emission reduction design and optimization measures based on the current situation of port energy conservation measures. He pointed out that the modern electrical products should not be ignored, and low energy consumption and small displacement equipment should be sought.

It can be concluded from the above research literature that China is committed to establishing a relatively complete evaluation system and method of energy conservation and emission reduction, and further improving the energy conservation and emission reduction work of port public buildings. However, the research literature on the energy conservation of port public buildings mainly focuses on the comprehensive energy-saving effect, and they are all aimed at a specific port. They based on the utilization of some renewable energy, so the energy conservation of port public buildings has not been widely promoted for the time being.

4. Conclusions

Due to the change of industrial structure, the advancement of urbanization and the improvement of residents' living standards, the building energy consumption is bound to show a sustained and high-speed growth trend. Through the analysis of energy status, building energy consumption status and building energy saving status and trend at home and abroad, it is easy to see the important position of
building in the future energy consumption control and energy saving technology application in China, so it is very important to carry out the research on building energy saving.

Compared with foreign advanced ports, China's port construction has a shorter development time and some deficiencies. Domestic scholars mainly study and analyze the planning, production, management and other aspects of port construction, and implement improvement measures from the technical field. However, there is no clear ecological saving design concept for the port building, and the application of renewable energy is also insufficient, and the intelligent development is not fully reflected. For these deficiencies, the existing research in China is not well reflected, which requires further in-depth research and promotion of port building energy efficiency.

References
[1] Evans, M., Shui, B., Takagi, T. (2009) Country report on building energy codes in Japan. R. Washington:Pacific Northwest National Laboratory.
[2] GA.Florides, S.A.Tassou, S.A.Kalogirou, et al, (2002) Measures used to lower building energy consumption and their cost effectiveness. J. Applied Energy, 73 (7): 229. 0.
[3] Nurdil Eskin, Hamdi Turkmen. (2007) Analysis of annual heating and cooling energy requirements for office buildings in different climates in Turkey. J. Energy and Buildings, 40 (5) :763-773. 0.
[4] Holger König, M. Lisa De Cristofaro. (2012) Benchmarks for life cycle costs and life cycle assessment of residential buildings. J. Building Research & Information, 40(5).
[5] Gong J. C., Yang X. L. (2011) Calculation and analysis on energy consumption of residential buildings based on the whole life cycle theory. J. Sichuan Building Science, 37(05):313-316.
[6] Zeng D. (2012) The Prediction Method and Its Application of Civil Building Energy Consumption in China. D. Beijing Jiaotong University.
[7] Liu K. (2019) Energy Efficiency Optimization Design for Office Buildings Based on BIM Technology. D. Fujian agricultural and Forestry University.
[8] Wang L. (2020) Application of new green energy saving technology in Construction Engineering. J. Construction Materials & Decoration, 2020(10):30-31.
[9] GuPtaA.K. Rashid. (2005) Pail Environmental Management Plan for Port Sand Harbors Projects. J. Clean Technology Environmental Policy, 2005(7):17-19.
[10] Atulya Misra, Gayathri Venkataramani, Senthilkumar Gowrishankar, Elayaperumal Ayyasam, Velraj Ramalingam. (2017) Renewable Energy Based Smart Microgrids—A Pathway To Green Port Development. J. Strategic Planning for Energy and the Environment, 2017, 37(2).
[11] Julián Martinez-Moya, Barbara Vazquez-Paja, Jose Andrés Gimenez Maldonado. (2019) Energy efficiency and CO2 emissions of port container terminal equipment: Evidence from the Port of Valencia. J. Energy Policy, 2019, 131.
[12] Dayla Karolina Fossile, Eduarda Asfóra Frej, Sergio E, Gouvea da Costa, Edson Pinheiro de Lima, Adiel Teixeira de Almeida. (2020) Selecting the most viable renewable energy source for Brazilian ports using the FITradeoff method. J. Journal of Cleaner Production,2020,260.
[13] Yu Z., Li X. (2009) On architectural energy-saving on Tianjin port and its exploration for development direction. J. Shanxi Architecture, 2009, 35(28):213-214.
[14] Zhang H. L. (2011) Solar energy is the way of energy saving development of port buildings. J. Resources Economization & Environment Protection, 2011(01):42-44.
[15] Xu L. Q. (2013) Harbour District of Public Buildings Composite Energy Saving Research. D. Dalian University of Technology, 2013.
[16] Xu D. S. (2019) Discussion on the technical measures for the optimal design of energy conservation and emission reduction of Port Engineering. J. China Plant Engineering, 2019(02):133-134.