

Analysis of energy consumption status and development trend of cold chain logistics

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Abstract. As a new industry, cold chain logistics has attracted much attention. Under the strong support of national policies, the development of cold chain logistics has entered the fast lane. This study takes the energy consumption of cold chain logistics as the research object, uses the energy consumption benchmark evaluation model of regression analysis to present the current situation of energy consumption of cold chain logistics from different dimensions, puts forward the contradictions and problems existing in the current development based on the SWOT (strengths, weaknesses, opportunities and threats) analysis method. Finally, the development trend of cold chain logistics energy consumption is predicted and relevant suggestions are put forward. The purpose of this paper is to find out the rule of effect of each factor on energy consumption in cold chain logistics, and to provide the direction for energy-saving measures in production.

1 Introduction

Cold chain logistics is a systematic project to ensure the quality of frozen products in a certain period of time in the process of production, storage, transportation, sales and consumption. With the improvement of the living standards of urban and rural residents in China, the public has higher and higher requirements on the freshness of food, drugs and other products and the timeliness of distribution. In addition, the rapid development of e-commerce and other emerging marketing modes has laid the foundation for the development of cold chain logistics [1-2]. Cold chain logistics is very important in solving the quality of common people's food basket and improving the storage conditions of medicine and health. As a new industry, it has attracted much attention.

In recent years, the state has issued a series of supporting policies to promote the development of cold chain logistics. In March 2019, the National Development and Reform Commission (NDRC), the Ministry of Transport and other 24 departments jointly issued the "Opinions on Promoting the High Quality Development of Logistics and Promoting the Formation of a Strong Domestic Market", proposing to strengthen the construction of cold chain logistics system of agricultural products origin and develop new cold chain logistics modes such as "fresh e-commerce + cold chain home delivery", and "central kitchen + cold chain distribution of food materials". In 2019, the NDRC and other 19 departments pointed out in the "Opinions on Promoting the High-quality Development of Returning to Hometown Entrepreneurship" that

returning home workers were supported to engage in agricultural products processing industries such as storage and preservation, graded packaging, e-commerce, direct broadcast and other new industries. In 2020, the Central Document No. 1 explicitly proposed the construction of agricultural products storage and preservation cold chain logistics facilities. In March 2020, the NDRC issued the "2020 Action Plan for Poverty Alleviation Through Consumption", which proposed to study and formulate policies and measures to support poor areas to strengthen the construction of agricultural products storage and preservation cold chain logistics facilities. In July, the NDRC issued the notice on the construction of national backbone cold chain logistics bases in 2020, announced the construction list of 17 national backbone cold chain logistics bases, and built a national backbone cold chain logistics infrastructure network. In 2021, the No.1 document of the CPC Central Committee once again proposed to attach importance to the development of rural cold chain logistics.

Cold chain logistics has entered the fast lane of development. The Rural Revitalization Strategy and Rural Electrification Project further promoted the expansion of cold chain logistics market, and the epidemic situation boosted the growth of consumer demand for fresh products and contactless commodity distribution. In 2019, China's total demand for cold chain reached 233.08 million tons, and the number of cold chain enterprises registered exceeded 10000, an increase of 31% compared with that in 2018. According to the estimation of AI media consulting

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agency, the scale of cold chain logistics market has reached 378 billion yuan in 2019 and 485 billion yuan in 2020. Among them, the demand for cold chain logistics of fresh food, medicine and fine chemical products is the most prominent, which promotes the overall cold chain logistics industry to a high-quality development stage. Literature [3] points out that in 2020, China's fresh e-commerce transaction scale would reach 263.84 billion yuan, and the medical e-commerce B2C market scale would reach 70.85 billion yuan. According to the prediction of experts from iiMedia Research consulting agencies, China's cold chain logistics market will grow at a compound annual growth rate of more than 20% in the next five years.

2 Research Methods

Based on the energy consumption benchmark evaluation model of regression analysis, and SWOT (strengths, weaknesses, opportunities and threats) analysis method, this paper studies the contradictions and problems existing in the current energy consumption development of cold chain logistics.

2.1 Energy consumption analysis of cold chain logistics

With the development of the scale of cold chain logistics, the demand for energy is increasing. Because the cold chain logistics chain is long, it involves many links, the influencing factors are complex, and the energy structure and form are more complex.

In terms of energy consumption time, energy consumption of cold storage is related to season. Generally, the peak power consumption is from June to September, and the refrigeration system needs to be turned on all day. In other seasons, according to the actual situation, the refrigeration system runs or stops running in different periods.

From the perspective of energy varieties, electricity is the main form of energy consumption in cold chain logistics base. At present, the cold chain of rural agricultural products is mainly primary processing, which is mainly based on power consumption equipment, such as meat saw cutting equipment, ice making equipment, fruit and vegetable cleaning and sorting equipment, shelling equipment and so on. The cold chain base uses less gas and fuel oil, but the transportation link uses more fuel oil.

From the distribution of energy consumption, the energy consumption of cold chain logistics in China is mainly concentrated in East China, while the development of cold chain logistics in central and western regions, especially in the western region, is relatively backward. Literature [4] shows that 63% of the total cold storage in China is located in the eastern region, and the number of cold storage in the central and western regions is insufficient to meet the daily demand. In addition, the energy consumption of logistics has regional mobility. As a mobile terminal, refrigerated vehicle can flexibly obtain energy and

consume energy in transportation flow. The flow path highly depends on road, waterway, railway, aviation and other transportation networks.

From the perspective of energy chain, the positioning of cold chain logistics base includes rural product origin, park, concentration area, transit base, etc. The upstream of the base is mainly connected with product suppliers, and the downstream is mainly connected with chain catering enterprises, supermarkets, retail and wholesalers, etc. The intermediate link involves trunk transportation (mainly using heavy and medium refrigerated vehicles), urban distribution transportation (mainly using light and micro refrigerated vehicles). The whole chain involves many links, long process, geographical dispersion and high timeliness requirements.

In terms of energy consumption system equipment, large-scale refrigerators mainly use centralized cooling system, and generally use liquid ammonia, liquid nitrogen or Freon refrigerants. Although liquid ammonia refrigeration system is more energy-saving, it is prone to safety accidents and high operation and maintenance costs, so it is gradually replaced by Freon refrigeration.

2.2 Highlighting contradictions

Cold chain logistics has the problem of high cost and low utilization. In China's cold chain industry, the average full load rate of refrigerated vehicles is less than 70%, and the average vacancy rate of refrigerated warehouses is more than 30%. In particular, the industrial chain of rural cold chain logistics is scattered, the population is scattered, the degree of informatization is low, the information of supply and demand is asymmetric, and the degree of resource sharing is low. Due to the long distance and empty return, the distribution cost is often increased [5-6]. The logistics network is generally imperfect, the logistics infrastructure is relatively backward, and the practical level of informatization is low, which makes the resource integration of cold chain logistics more difficult. Logistics lag makes agricultural products can not be exported in time, can not guarantee the fresh quality, resulting in a great waste of resources, affecting the development of agricultural economy.

The main problem is the lack of cold chain logistics talents. Cold chain logistics involves many links and spans many professional fields, requiring practitioners to understand production, market and product characteristics. However, the rural conditions are poor, and the logistics industry is hard to attract talents. The shortage of talents, information resources and low management level further lead to the inefficient use of resources, the increase of logistics costs and the serious lack of driving force for industrial development.

The distribution network in some areas needs to be upgraded. In rural areas, a large number of cold chain processing and storage are connected to the rural power grid. With the rapid development of the cold chain of fresh agricultural products, the demand for electricity

in cold chain villages and cold chain logistics processing parks is increasing. With the in-depth implementation of the National Rural Revitalization Strategy, the demand for electricity is increasing, and the proportion of electric energy in the terminal energy consumption is increasing. In some areas with weak rural distribution network, the pressure of power load is increasing, and there are problems of insufficient power supply capacity and the need for capacity expansion, so it is urgent to strengthen the rural distribution network.

3 Results and Discussion

In terms of the development direction of total energy consumption, there is still room for improvement in demand. At present, the precooling rate of agricultural products in China is only 30%, which is far lower than 80% of developed countries in Europe and America. The cold chain circulation rate of China is between 35% and 69%, which is much lower than that of developed countries. With the development of economy and society, the energy demand of cold chain logistics will further increase.

From the perspective of energy utilization, green energy saving and intelligence of cold chain energy consumption is an important trend of development [7]. The energy consumption of refrigeration system of cold storage in China is generally high, so it is urgent to improve the energy efficiency level. Compared with Japan, Europe and the United States and other cold chain developed countries, the power consumption of China's cold storage is about three times higher than that of the same type of foreign cold storage, and users bear greater pressure on electricity expenditure. Therefore, improving the energy utilization rate is the general trend. Under the background of energy conservation, emission reduction and rapid development of science and technology, we use artificial intelligence, cloud computing, Internet of things and other new technologies to realize the whole process monitoring and tracking of fresh agricultural products from the source to consumers, and maximize the efficiency of logistics distribution. In the field of normal temperature transportation, we can help upstream enterprises to save costs through co allocation. In the cold chain, the whole process of cold chain can be traced and visualized, and an efficient "chain breaking" prevention emergency response mechanism can be established to further improve the overall energy and resource scheduling utilization.

From the development trend of logistics energy users, electric refrigerated vehicles have a greater market competitive advantage. Transportation plays an important role in cold chain logistics. The traditional transportation is mainly driven by fuel, and some vehicles are driven by gas. At present, the market share of electric refrigerated vehicles is not high, but the application prospect is good. In 2019, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, the Ministry of Finance and

the NDRC jointly issued the notice on further improving the financial subsidy policy for the promotion and application of new energy vehicles, which specifies that the central financial subsidy standard for pure electric vehicles is 350 yuan / kWh, and the central financial subsidy limit for single vehicle is 55000 yuan. After calculation and comparison, the price of the subsidized pure electric refrigerator car is similar to that of the traditional fuel refrigerator car, and the operating cost is lower. The driving range of new energy cold chain vehicle is between 150-250km, which can meet the demand of urban distribution cold chain market. In addition, there is no limit to the number of electric refrigerated vehicles in urban areas, which is also a kind of market competitiveness in addition to economy. The electric refrigerated vehicle has a high degree of intelligence, which can set the appropriate temperature for transporting goods. Through intelligent management and control, it can reduce the damage rate of materials and the incidence of chain breaking. Power grid enterprises can connect with logistics enterprises, build and operate charging stations according to the logistics network situation, meet the demand of power supply during distribution, and integrate with the Internet of vehicles platform. Through intelligent scheduling and other optimization and control, the circulation time and economic cost can be reduced, and the competitive advantage of electric refrigerated vehicles can be further increased. In addition, for regions rich in renewable energy, electric refrigerated vehicles can also be used as a supplementary carrier to absorb new energy and improve the clean utilization rate of energy.

From the perspective of energy consumption, comprehensive energy services can make a big contribution. First, the base can implement energy management system, online monitoring of refrigeration unit, condenser, evaporator, warehouse temperature, pressure, operation status data, combined with peak and valley electricity price, season, weather, all kinds of refrigeration business operation law and other factors, formulate refrigeration system optimization operation strategy, through data analysis and mining, explore energy consumption improvement link, carry out energy saving transformation. Second, on the roof of the refrigerated warehouse (or the top of the base), distributed photovoltaic power generation system and electric energy storage system can be built in the open space of the base to store energy with valley power. At the same time, guide the energy consumption behavior of the base, excavate the flexible load, participate in the interactive regulation of the power grid, realize the peak load cutting and valley filling, and reduce the electricity expenditure.

Taking the installation area of 10000 square meters as an example, a 1MW distributed photovoltaic power generation system can be installed with 33 ° fixed inclination angle. The system adopts the grid connection mode of "self use, surplus power on". The calculations are as shown in Table 1.

Table 1. calculation list of power generation income

Calculation items	Calculation basis and process
Construction cost	According to the construction cost of 5 yuan / W, the construction cost of 1 MW distributed photovoltaic system is 5 million yuan.
Operation and maintenance cost	According to 0.05 yuan / W per year, the annual operation & maintenance cost is 50000 yuan / year.
Power generation	According to the relevant data of the Meteorological Bureau: the annual peak hours of the photovoltaic power generation system at 33 ° inclination angle is about 1693h, assuming that the system efficiency is 80%, the first year full generating hours is 1354.4h, and the first year generating capacity is 1354000 kwh; according to the generation attenuation rate of 10% in 10 years and 20% in 25 years, the average annual generating capacity in 25 years is about 1209000 kwh.
Power generation income (KWH)	The industrial and commercial electricity price of 1-10kv in Shandong Province is implemented in the park: the peak electricity price (10:30-11:30, 19:00-21:00 from July to September) is 1.0692 yuan / kWh, the peak electricity price (8:30-11:30, 16:00-21:00) is 0.9468 yuan / kWh, the valley electricity price (23:00-7:00) is 0.3350 yuan / kWh, and the average electricity price (other periods) is 0.6409 yuan / kWh.

According to the above-mentioned electricity price, the cost per kilowatt hour of electricity saved in the park is 0.778 yuan / kWh.

The project cycle is 25 years, the payback period is 5.61 years, the average annual power generation income is 940000 yuan, and the annual profit is about 690000 yuan.

4 Conclusion

The construction and operation of cold chain logistics is a systematic project, which needs to complement the short board of cold chain logistics supply chain. As the main body of energy supply, power grid should speed up the upgrading of weak distribution network to provide better energy infrastructure for rural cold chain logistics to speed up the application of information technology. Through the promotion of electrification, the cold chain logistics chain can further improve the level of intelligence, apply ICT such as automatic identification, efficient perception, real-time transmission and intelligent computing to the whole process of cold chain operation, reduce the backlog and loss of fresh agricultural products, strengthen the suitable all season production of fresh agricultural products, ensure the business balance of local logistics points, avoid loss operation, and achieve efficient cost reduction green and clean supply.

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