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Production and Logistics Planning Method of New Energy Industry Supply Chain Under the Background of Low Carbon

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Abstract. In the context of low carbon, new energy, as an emerging financing method in the industrial supply chain, has obvious advantages in alleviating production costs and changing logistics methods. However, the limited energy storage of new energy and the path distance being smaller than that of traditional energy transportation modes bring specific challenges to supply chain logistics planning. With the help of the logistic model, this paper analyzes the path of the industrial supply chain logically, finds out the influencing factors that affect the logistics planning of the supply chain, and calculates it. Among them, the intervention factors in the path, such as traffic congestion, traffic light, and path angle, are analyzed and judged, redundant interference factors are eliminated, and the adjustment coefficient of logistics planning is increased to realize the effective planning of production logistics and expand the development of new energy industry, and the research results show that with the help of logical analysis method, the rational planning of production logistics can be shortened by about 20%, the transportation efficiency can be improved by about 15%, the traffic congestion avoidance rate can be reduced by 10%, and the transportation cost can be saved by about 104,200 yuan. Therefore, through logistics planning, the new energy industry supply chain can conduct a reasonable path analysis, meet the policy standards of green production and transportation, and expand the development scope of the new energy industry.

Key words. Low-carbon Policy, New Energy Industry, Supply Chain, Production Logistics, Planning Method.

1. Introduction

In the case of the rapid development of new energy, industrial chain planning is an important content that can save transportation costs and improve the endurance of new energy batteries. Although new energy is powered by photovoltaic cell hybrid and other forms, problems exist, such as short endurance and poor stability in the research process[1], [2]. Therefore, effective path planning is a way to solve the current bottleneck of new energy. In the context of the rapid development of China's logistics and transportation business, the supply chain model has been upgraded from 1.0 to 4.0, indicating a huge market gap in logistics and transportation. The "2022 Government Work Report" for the first time put forward the "supply chain reform service mode", aiming to promote the deepening of the supply chain and industrial chain structure[3], [4]. With the support of green environmental protection policies, the supply chain uses emerging technologies and provides objective conditions for developing new energy. Some scholars believe that the supply chain of the new energy industry can be planned through transportation GIS technology, but the problems of poor signal, traffic congestion, and randomness further increase the planning complexity of new energy. Therefore, effective logistics planning has become the focus of current research. Some scholars also believe that the qualitative analysis method in intelligent algorithms is relatively illogical [5], [6]. Although it can simplify the analysis process, it is poor in simplifying the results and path planning effect, and the case proves that its theoretical practice is not strong. Some scholars have applied the intelligent analysis method to logistics planning, but the method is too complex and will increase the resource occupancy of the system, so its scope of application is limited. Therefore, some scholars propose to use the logical analysis method as an auxiliary means to plan the new energy industry chain, call the transport vehicles and transportation equipment in it, and collect real-time information to complete the adjustment of the entire new energy industry. Still, there is a lack of specific practical cases. In this context, this paper takes the new energy supply chain as the research object, conducts logical analysis with the help of intelligent analysis methods, firstly collects the transportation data of the new energy industry supply chain, especially the supply data of photovoltaic energy, road condition data and GIS data, etc., and extracts the key data in it, analyzes the relationship between key indicators, and finds out the logic. The derivative method is used to obtain its eigenvalue, and the logical analysis method is verified by comparing it with historical data, which proves the effectiveness of the rational analysis method in production logistics planning. Compared with the supply distance of new energy batteries, the computer fitting rate and mileage compliance rate are also included. At the same time, traffic congestion, extreme weather warnings, round-trip time and transportation arrival time are analyzed to verify the optimization results of the new energy industry supply chain, and the specific flow chart is as follows (Figure 1).

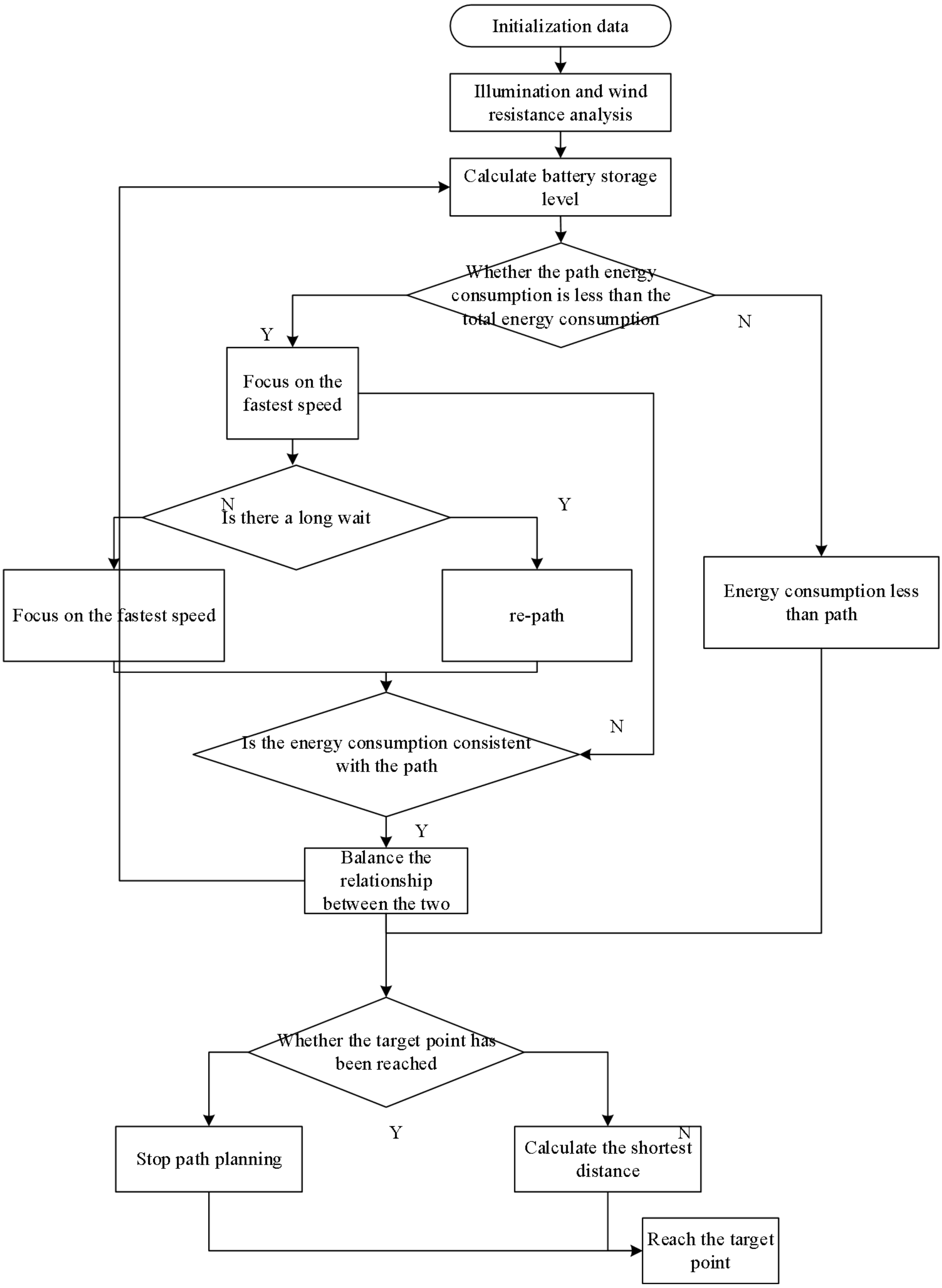


Figure 1. Production Logistics Planning Process of the New Energy Industry Supply Chain

2. Logistics Planning of the Supply Chain of the New Energy Industry in the Context of Low Carbon

A. Selection of Logistics Routes

In the supply chain path planning of the new energy industry, the routes that need to pass through the mediators of the supply chain and downstream customers are more complex. The path analysis is carried out using the new energy transport vehicle as a tool, and the position of the vehicle in the two-dimensional space is expressed as the position x of reaching the target point x_{goal} [7], [8], and the irresistible forces such as traffic lights and weather on the way are x_{obs} . The location area of each supply point is $L_{att}(x)$, the range of the obstacle is $U_{rep}(x)$, and the logistics area is $U_{all}(x)$, then the expression is:

$$L_{\text{all}}(x) = L_{\text{att}}(x) \cdot L_{\text{rep}}(x) + \Delta\lambda \tag{1}$$

The process of selecting a logistics route $U_{att}(q)$ is shown as follows:

$$L_{att}(x) = \begin{cases} K_{att} d^2(x, x_{goal}) \\ d^*_{goal} K_{att} d(\Delta x, \Delta x_{goal}) \end{cases} \tag{2}$$

Where, $d(q, q_{goal}) \le d^*_{goal}$ constrains the relationship between the logistics path and the actual path. Since path selection is an iterative process, the process of iterative analysis is as follows :

$$\nabla L_{att}(x) = \begin{cases} K_{att}(x - x_{goal}), all \\ \dfrac{d^*_{goal} K_{att}(x - x_{goal})}{d(x, x_{goal})}, loaction \end{cases} \tag{3}$$

Where, $d(x, x_{goal})$ is straight-line distance of the vehicle from the target, K_{att} is the current of the photovoltaic cell, and the light intensity d^*_{goal} of the area is described [9], [10]. The distance function is a piecewise function, and when $d(x, x_{goal}) \le d^*_{goal}$, the road is in good condition, you just need to select the shortest distance. The road conditions were congested at that time, and the route needed to be constantly adjusted.

B. Path Selection for Obstacle Avoidance

Among them, obstacle avoidance is the main content of the supply chain planning of the new energy industry, involving two aspects: 1. the type of obstacles, 2. the new energy battery power, the specific calculation formula is as follows:

$$L_{rep}(q) = \begin{cases} \dfrac{1}{2} K_{rep} \left(\dfrac{1}{d(x, x_{obs})} - \dfrac{1}{Q^*} \right)^2, 50\% \\ 0, d(x, x_{obs}) > Q^*, 100\% \end{cases} \tag{4}$$

Among them, when the battery amount is 50%, the shortest distance should be used as the planning scheme; When the battery level is 100%, the shortest time should be planned. The obstacle avoidance process should be carried out in a regressive manner, as follows:

$$\nabla L_{rep}(x) = \begin{cases} K_{rep} \cdot \left(\dfrac{1}{Q^*} - \dfrac{1}{d(x, x_{obs})} \right) \cdot \dfrac{1}{d^2(x, x_{obs})} + \Delta d(x, x_{obs}), 20\% \\ d(x, x_{obs}) \le Q^*, 50\% \\ 0, d(x, x_{obs}) \ge Q^*, 100\% \end{cases} \tag{5}$$

Where, K_{rep} is congestion coefficient, $d(x, x_{obs})$ is the distance between the vehicle and the target, and Q^* is the type of obstacle (1 represents congestion, 2 represents narrow road), if $d(x, x_{obs})$ is less than this value, the path optimization should be carried out. Otherwise, there is no need for path analysis.

Any obstacle is not independent, so there is an overlapping phenomenon of barriers, so to add a subjective judgment factor, the calculation expression is as follows:

$$F(x) = -\Delta L_{att}(x) \cdot \alpha + \Delta L_{rep}(x) \cdot \beta \tag{6}$$

In the formula, $F(x)$ is a one-way path, $F_{au}(x)$ is a two-way path to guide the vehicle to approach the target. When a vehicle approaches an obstacle, its path is affected by multiple routes, and the sum of the lines is $\sum_{i=1}^{n} L_{repi}$, and the path is calculated as $F(x)$:

$$F(x) = F_{att}(x) + \sum_{i=1}^{n} F_{repi}(x) \tag{7}$$

C. Fitting of Energy Consumption for New Energy Transportation with Local Carbon Emissions

Unlike traditional petrochemical energy, new energy needs to be analyzed in combination with the situation of sunlight to plan the corresponding path and maintain the continuous supply of subsequent energy. When designing the supply chain and product process of new energy, the impact of natural conditions such as photovoltaic and wind energy on the transportation of new energy industry should be fully considered, and its path should be analyzed as a whole to avoid long waiting times and reduce the overall energy consumption of energy. When $|H_{au}(q)| < |H_{req}(q)|$, it should choose a large light area, enhance the intensity of light on the solar panels, and adjust the corresponding angle until $|H_{au}(q)| > |H_{req}(q)|$, and then the vehicle moves to the target point with the lowest efficiency so as to achieve a balance between energy consumption and distance and improve the maximum journey of the transport vehicle. The following formula can express the optimization solution of energy consumption and journey:

$$|H_{att}(q)| > |H_{rep}(q)| \tag{8}$$

At the same time, to ensure low carbon emissions in production logistics planning, it is necessary to balance the path and the minimum energy consumption as follows:

$$\Delta d(x, x_{goal}) \approx \Delta H(q, q_{obs}) | C_i \tag{9}$$

Among them, $|H_{au}(q)|$ is single-way energy consumption, $|H_{req}(q)|$ is double-way energy consumption, and $\Delta H(q, q_{obs})$ is energy consumption increase; C_i is the minimum value of low carbon emissions. The ratio of photovoltaic energy harvested to consumed by the transport vehicle plays an important role in the relationship between the obstacle and the target point, which constantly fluctuates, so the local best advantage is required. Based on the regression analysis method, the nodes in the transportation process are analyzed to obtain the local optimal solution, which is used to select the path obstacle armband, calculate whether the transport vehicle can reach the target point, and verify the planning rationality of production logistics, as shown in Figure 2.

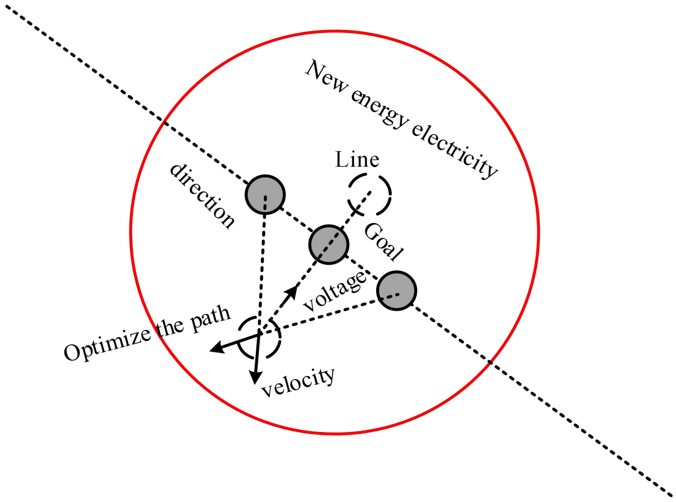


Figure 2. Local Calculation of Logistics Planning Routes

3. A Case Study of Industrial Supply Chain Logistics Planning for New Energy Enterprises

A. Introduction to the Supply Chain of the New Energy Industry

This paper takes the product logistics and transportation of photovoltaic energy enterprises as an example for analysis. The vehicle with solar panels is used as the means of transportation in the transportation process, which involves 3~4 urban path planning, passing through the city centre and the outer ring. The total logistics transportation distance is 78.64 kilometres, and the vehicle is not replaced in the transportation process, and the whole process is transported in the form of unique vehicles and exceptional delivery. The solar photovoltaic panels are automatically adjusted to collect light energy for the range extension setting during the vehicle's transportation. In addition, the transportation process adopts the method of computer judgment and does not carry out manual intervention. The shipping volume is 20.45 tons, the transportation time is 2.5 hours, and the transportation period is 24 hours. No fuel is fed during transportation, and a 106-hp electric motor is used for transmission. Weather and congestion data are mainly based on Baidu maps and local weather forecast information. In the path analysis process, the path iteration is carried out in units of 10 minutes, and the path data is mainly collected through the database. The logistic regression method measures the indicators under the threshold of 0.5, and the surveyed enterprises comply with the principle of green environmental protection, sign the number of informed agreements, and independently conduct sample analysis. Among them, photovoltaic cells use leaf cells and assemble them in the form of modules to ensure the safety of the cells during transportation and the total output of electricity, as shown in Figure 3.

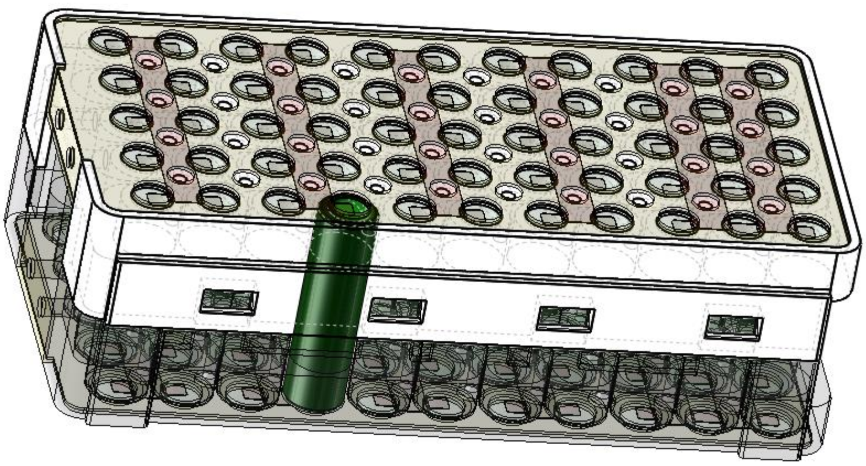


Figure 3. The Form of Battery Used in the Transportation of New Energy Enterprises

B. Shortest Planning of the Path

Path planning is the logistics planning content of the new energy industry supply chain, which is mainly based on different situations for admission planning, in the case of less than 50% of the power based on the shortest path, in the case of more than 90% of the battery, on the basis of the shortest time and planning, in the planning analysis of the specific planning results are shown in Figure 4.

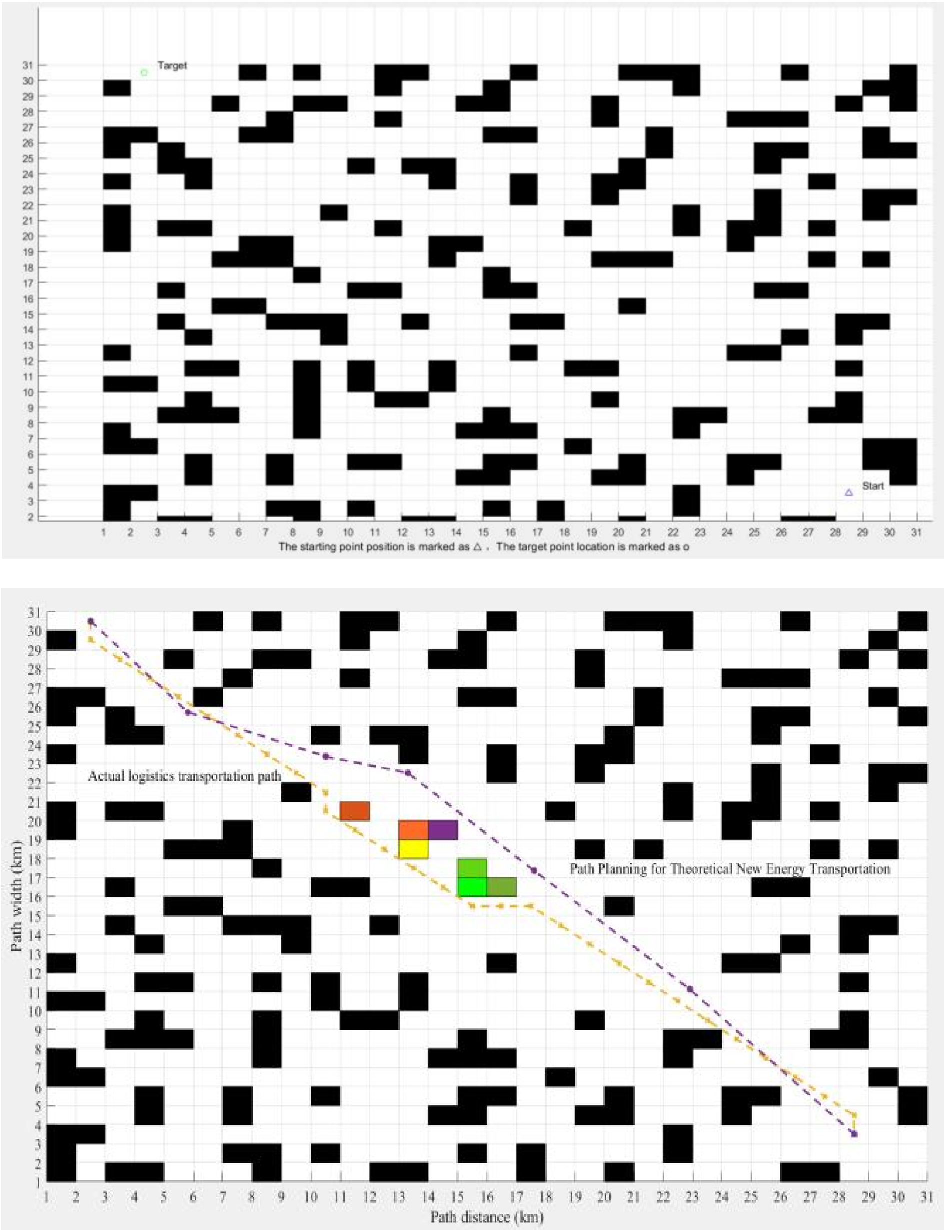


Figure 4. Path Planning of Regression Analysis Method

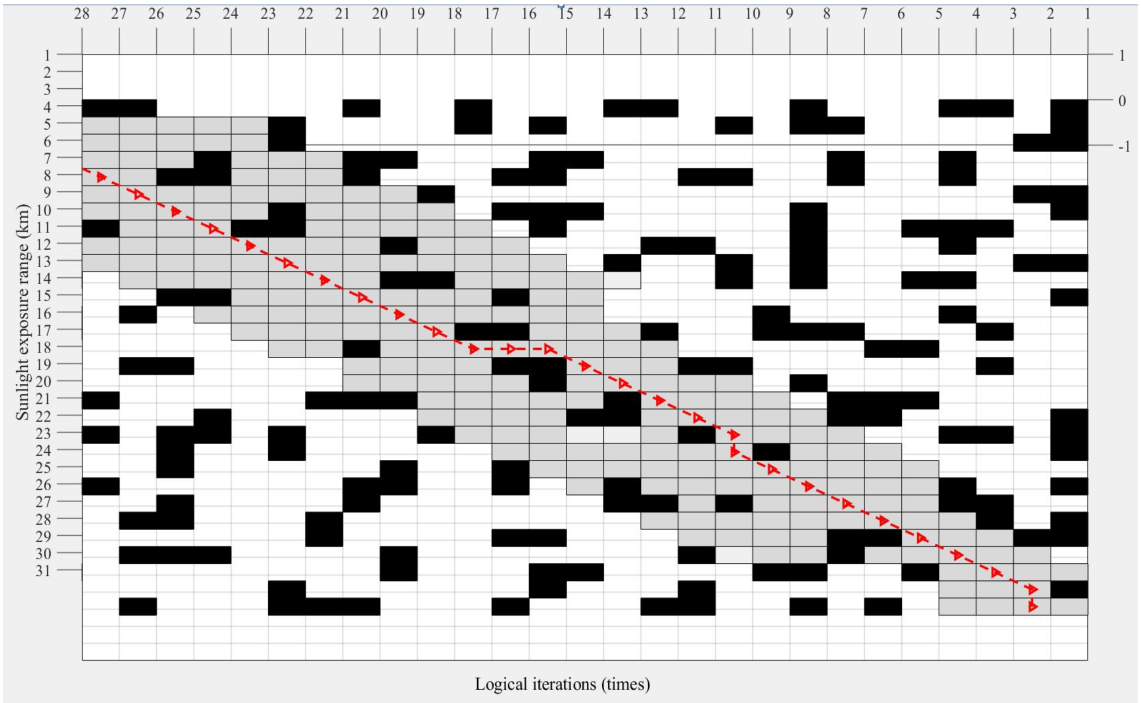
From the data analysis in Figure 4, it can be seen that the regression analysis method can effectively avoid obstacles and optimize the shortest path when carrying out path planning, and the total length of the path is smaller than that of the previous algorithms. Although the previous algorithm can select the path and avoid obstacles, there is a significant amplitude turn during its operation, and the path length is more significant than in the transportation process. The regression algorithm proposed in this paper is mainly because the regression analysis method can carry out iterative analysis of indicators and path planning for different situations, as well as photovoltaic energy, electricity and electricity. Generally speaking, the electricity of photovoltaic power in one-way path analysis is greater than 50%, so the path is based on the shortest. In this way, the efficiency of transportation is improved. In the process of method avoidance, the regression analysis method has always maintained linear transportation without turning and stopping, so the energy consumption of the total energy is relatively low, which meets the actual requirements of low-carbon transportation. In planning the shortest path, the obstacles can be effectively centralized, and their ranges can be superimposed to analyze the overlap of the challenges better and select the optimal path analysis. In the past, the analysis method only planned the debts separately and did not carry out overlap analysis, so the path length of the analysis process was relatively long. Table 1 shows the shortest case of the comparison path.

Table 1. Metric Changes in the Shortest Plan of the Path

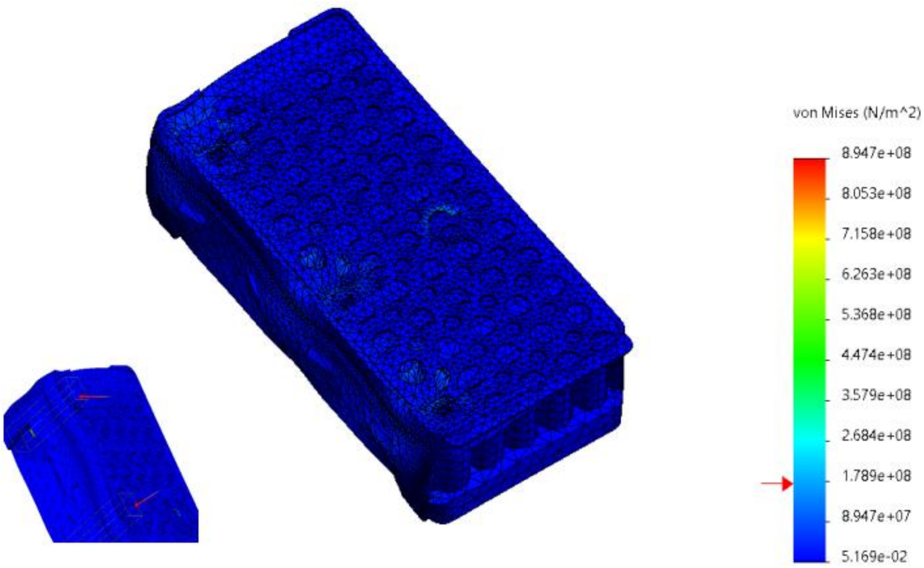
Journey	Distance adjustment factor	Path metrics			Transporter power output	Percentage of total paths
		Path	Illumination	Obstacle avoidance		
One-way	1.26	0(0.00)	0(0.00)	0(0.00)	1(11.11)	72.000
	1.37	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	1.67	0(0.00)	1(100.00)	0(0.00)	1(11.11)	
	2.54	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	2.94	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.09	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.76	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.77	0(0.00)	0(0.00)	1(100.00)	1(11.11)	
	4.69	1(100.00)	0(0.00)	0(0.00)	1(11.11)	
Round-trip	0.87	0(0.00)	0(0.00)	0(0.00)	1(11.11)	72.000
	1.04	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	1.62	1(100.00)	0(0.00)	0(0.00)	1(11.11)	
	1.98	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	2.98	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.07	0(0.00)	0(0.00)	1(100.00)	1(11.11)	
	3.55	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.77	0(0.00)	1(100.00)	0(0.00)	1(11.11)	
	4.99	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
Congestion	0.97	1(100.00)	0(0.00)	0(0.00)	1(11.11)	72.000
	1.00	0(0.00)	1(100.00)	0(0.00)	1(11.11)	
	1.69	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	2.98	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.05	0(0.00)	0(0.00)	1(100.00)	1(11.11)	
	3.73	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.74	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	3.90	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
	4.21	0(0.00)	0(0.00)	0(0.00)	1(11.11)	
Total		1	1	1	9	

C. *Comparison of Energy Consumption in Production Logistics Planning and Transportation*

The comparison of transportation energy consumption in production, logistics and transportation planning is mainly two aspects: on the one hand, whether the photovoltaic energy is effectively supplemented in the transportation process, and on the other hand, whether the energy consumption of its battery is highlighted, and the comprehensive result between the two is the main problem of energy consumption output in the transportation process. The specific results are as follows.



Lighting in the Path



Battery Consumption in Route Planning

Figure 5. Comparative Analysis of the Consumption of Batteries by Logistics in the Supply Chain of the New Energy Industry

The analysis results in Figure 5 show that the paths adopted by the new energy industry supply chain in the transportation process of production logistics have sufficient sunlight and good illumination, indicating that they can effectively supplement battery energy. Moreover, its light supplementation can enhance its transportation distance, reducing its own energy consumption and costs. Through the measurement of battery energy, it is found that the energy consumption in one-way transportation is relatively small, only 1/15, indicating that the vehicle is fully supplemented by energy in the transportation process, indicating that photovoltaic energy effectively improves the transportation distance, and also indirectly proves that the energy consumption of the new energy industry in the transportation process is in line with the low-carbon environmental protection policy. In the process of comprehensive judgment, it will be found that the logistics path planning of the new energy industry chain is relatively reasonable, mainly to analyze the indicators such as sunlight exposure, traffic congestion, and its battery capacity, and finally make the optimal logistics planning plan, which is shown in Table 2.

Table 2. Comparison of Energy Consumption in the Supply Chain of the New Energy Industry

Time	One-way	Round-trip

	Distance adjustment factor	PV Intensity change (mH)	Path increase (km)	Increase in energy consumption (kJ)	Interference energy consumption (kJ)	Distance adjustment factor	PV Intensity change (mH)	PATH increase (km)	Increase in energy consumption (kJ)	Interference energy consumption (kJ)
Morning	3.362	1.128	2.981	0.025*	-	3.406	1.326	2.568	0.050	-
Afternoon	-0.435	0.383	-1.137	0.299	-0.503	-0.452	0.457	-0.989	0.368	-0.522
Evening	0.220	0.445	0.494	0.639	0.219	0.224	0.489	0.458	0.666	0.223
Random						0.044	0.486	0.091	0.931	0.040
Adjust R 2	-0.093					-0.310				
The effect of the distribution of the data	F (2,6)=0.659, p=0.551					F (3,5)=0.369, p=0.779				

The above analysis shows that in the low-carbon background, the energy consumption of the new energy industry supply chain shows a changing trend. Still, the change range of one-way and two-way is relatively small, which means that the logistics planning is more reasonable and does not significantly impact the energy consumption results. In the process of energy consumption change, the change range and change law align with the normality requirements, indicating that the entire production logistics planning path is more reasonable regarding energy consumption. Based on the analysis of the relevant data, the study found that the importance index of the model was less than 0.05, which means that the model has a significant influence in 95% of the importance criteria. The five main elements selected in this study are essential for a company's production logistics planning risk. The importance index of the model reaches 0.992, indicating that the model is very well matched.

D. Enlightenment of New Energy Production and Logistics Planning Path for Low-carbon Development

All work processes for new energy companies and identify the needs of packaging development in advance to build a consistent logistics solution to achieve overall economic benefits. In addition, considering the transition of new energy sources and fuels, the battery/battery module has a special auxiliary role in the transition from the engine to the battery stage. At the same time, the cost of planning the traditional single logistics path is relatively high. Therefore, new energy companies should devote themselves to exploring and developing existing paths that can be optimized to reduce costs. One strategy for new energy is to reuse and repair existing transport vehicles by "turning waste into value", exploring the optimization of battery components, and adapting to the storage of batteries of various sizes. At the same time, new energy companies repeatedly make battery packs and modules to enhance the flexibility of recycling storage and significantly reduce their transportation costs. To more effectively promote the growth and expansion of the supply chain of new energy enterprises and reduce the possibility of a crisis in production and logistics planning, this research proposal puts forward the following suggestions according to the current situation of the supply chain of the new energy industry, aiming to promote the smooth operation of the industrial chain and supply chain in related fields: First, new energy enterprises in the supply chain need to appropriately improve the scale of production and operation and improve profitability; Second, this study needs to establish a timely, fair and standardized information disclosure mechanism, create an excellent corporate culture, establish a high-quality corporate brand, and continuously improve the market competitiveness of the enterprise. This study needs to strengthen the company's earnings and repayments continuously, and at the same time, it is also necessary to build a sound corporate financial database to accurately assess and control the company's production logistics plan risks. Second, local governments should establish a measurable risk assessment framework for the production and logistics planning of new energy enterprises, mainly looking at the financial data of new energy enterprises in the network with a high probability of default. These key elements are incorporated into the supply chain's risk assessment model of the production logistics plan, and the model is used to estimate the hidden dangers in transportation to effectively assist the government in production logistics decision-making and risk control. To optimize the financial information service system of the supply chain and promote the effective use of information resources, the government must establish a database responsible for managing the plans and risks of production logistics. It is necessary to improve the level of government management and clearly define the tasks of all parties involved in the supply chain. At the same time, for supply chain operations with greater risks, this study must be comprehensively sorted out from multiple perspectives. We will guide the path of production and logistics, optimize local transportation facilities and systems, reduce traffic congestion, further optimize corresponding laws and regulations, and actively guide new energy enterprises to improve the operational efficiency and quality of production and logistics operations.

4. Conclusion

In view of the problem of high cost and complex transportation path in the transportation process of new energy enterprises, I propose a regression analysis method, combined with the low-carbon background for the logistics planning of the industrial chain, in the planning fully consider traffic congestion, transportation weather and other factors, and the path analysis and regulation of transportation equipment, among which the light and battery energy consumption in the transportation process are not supported, combined with the local traffic congestion and the location of obstacles for comprehensive analysis, the research results show that the Hefei analysis method can effectively plan the path and increase the light intensity and time in the path planning, so as to prolong the power generation time of photovoltaic panels, reduce the loss of battery energy consumption of transportation vehicles, and increase when the battery amount is less than 50%, the path planning should be based on the shortest distance, and when the battery volume is greater than 80%, the path planning should be based on the speed to achieve dynamic analysis. Logistic regression models have shown high efficacy in identifying risks in supply chain and production logistics planning. After fitting the model, the overall prediction accuracy of this study was 91.7%. Therefore, the new energy industry in the new energy industry has a significantly different path planning method from traditional diesel mainly in the following aspects, compared with the diesel engine, the new energy battery combination system is larger and heavier, resulting in a significant increase in the cost of the entire package, and this increase in weight may also have a negative impact on the internal load of the transport vehicle. Therefore, the lightweight packaging is realized during transportation, which increases the carrying capacity of the truck by 11% and greatly saves transportation costs. In this paper, the safety issues such as the weight and strength of transportation vehicles are not analyzed, and the design and automated driving of transportation vehicles will be analyzed in the future.

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