Social stability risk assessment model for photovoltaic energy project under the background of artificial intelligence

Naiwen Li[1, a], Zijian Lu[1, b*]

[a]Email: linaiwen@lntu.edu.cn, [b]Email: 853279221@qq.com
[*]Corresponding Author

[1]School of Business Administration, Liaoning Technical University, Xingcheng 125000, Liaoning, China

Abstract: To scientifically and accurately assess the level of social stability risk of PV projects, through literature search, field research, accident analysis and expert consultation, build a PV project social stability stability risk system containing 4 level 1 indicators and 14 level 2 indicators, take the L PV project in Inner Mongolia Autonomous Region as an example, verify the validity of the evaluation model. The results show that, the overall risk index of the project is 1.58, risk level is low risk, where the ecological risk level is low risk, public management risk level is medium risk, policy specification and establishment level is low risk, project management risk level is low risk, highly compatible with the actual situation of the project, the evaluation model can reflect the social stability risk level of PV projects more accurately and objectively, and to provide a reference for risk management and early warning mechanism.

Keywords: Photovoltaic, Artificial Intelligence, AHP, EWM, Comprehensive evaluation, Social stability risk

1. Introduction

With the introduction of the "dual carbon policy", green energy industry is sprouting up. By the ministry of industry and information technology, ministry of housing and construction, ministry of transport, ministry of agriculture and rural affairs, national Energy administration jointly issued a notice on the "action plan for the innovative development of smart photovoltaic industry (2021-2025), marking the development of China's photovoltaic formally from a comprehensive to intelligent turn to upgrade. Started in 2014, smart PV continues to make major breakthroughs in digitization and internetization, construction of end, edge and cloud collaborative core architecture, artificial intelligence is becoming a completely new means of development in the field of photovoltaics.

Although photovoltaic has the same environmental effects as wind and hydropower, the devastation of its accidents far exceeds that of other new energy industries. For example, on the machine CNC 10 billion photovoltaic project fire 5 dead and 2 injured and Beijing 416 optical storage explosion and other accidents have occurred. In 2022, the Inner Mongolia Autonomous Region government's feedback on the 2018 Tongliao City people's letters and visits to the 20MWp pastoral photovoltaic project due to concerns about safety and pollution. It is clear that both the gloom caused by the accidents that have occurred, or the smooth

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operation of 4 years but still can not make the hearts and minds of the photovoltaic, strict management of social stability risk factors of photovoltaic projects are already a top priority. The concept of "strengthening risk identification and control around green energy development" provides a more scientific direction for the development of the power industry. Therefore, carry out safety supervision of new energy generation projects, preventing risks and hazards from the rapid development of new energy sources in advance, in-depth investigation of hidden dangers, ensure the healthy and sustainable development of the industry has become imminent.

Analysis by citespace, in the past decade, in our scholars' research on PV risk, 32.5% of investment risk, financial risks accounted for 17.6% of the total, the rest are dominated by credit risk, operational risk and political risk. For example, Xueqin Zeng [5] et al. from a policy, economic, technological and natural environment perspective , entropy-Topsis model is used to analyze and evaluate the investment risk level of eight typical PV building projects in China, Yidong Sun [8] analyzed the development status, risk situation and industry prospect of China's PV industry, provides countermeasure suggestions for banks to prevent and control credit risks in the industry, Zhanchi Huang [9] analyzed the management of financial risks of light enterprises, Yanfeng Ma and Zerong Luo [6] combined the ideas of full probability sampling, equal dispersion sampling and adaptive significant sampling, propose a risk assessment method to improve Monte Carlo mixed sampling, assess the operational risk of the system using a three-tier assessment index system, Zhifu Wang [10] analyzed the political risks in the process of international engineering new energy investment on the example of photovoltaic agriculture project, Yanying Chu [7] and other scholars took centralized PV as an example, investigation of its social stability risks, Xiaoyan Huang [9] analyzed in detail the tax-related risks in the bidding stage of EPC projects in the construction of "One Belt, One Road" by Chinese enterprises, and offered valuable advice on preventing tax risks, Jingchun Sun [2] studied by comparing domestic and foreign PV supply chains and risk pooling, sorted out the current status of PV supply chain risks. In summary, most of the current studies on the risks of PV projects focus on political and economic aspects, not many articles have been written on social stability risk studies of PV projects. This study aims to construct a social stability risk assessment model applicable to PV projects, constructing its evaluation index system, use hierarchical analysis and entropy weighting to determine the weights of each index, combining comprehensive evaluation methods to establish a social stability risk evaluation model for PV projects, and according to the actual situation of a photovoltaic project in Inner Mongolia Autonomous Region, assess the social stability risk of the project.

2. Social stability risk evaluation index system for photovoltaic projects

On the basis of the above, construct a social stability risk indicator system for PV projects containing 14 secondary indicators and 2 main assessment contents of level 2 indicators from 4 dimensions of ecological environment, public management, policy regulation and project management, the results are shown in Table 1.

Table 1 Social stability risk evaluation indicators for photovoltaic projects

Level 1 indicators	Level 2 indicators	Level 2 indicators main assessment content
Environment E	Soil erosion and vegetation destruction E1	(1) Whether there are factors that may lead to local vegetation destruction, soil erosion and social risks.
	Direct and secondary contamination E2	(1) Is construction waste cleaned regularly. (2) Is the domestic waste of construction workers cleaned up in time. (3) Whether the PV module solid waste is properly disposed of.
Public Administration P	Production impact and life impact P1	(1) Whether the noise, light, construction dust, etc. will affect the daily production and life of the surrounding residents. (2) Whether there is temporary occupation of public facilities or resources. (3) Whether it directly or indirectly affects the production income of the surrounding residents. (4) Whether there is a direct or indirect negative impact on local science, education, health and culture.
	Social Opinion P2	(1) Whether there is bad media coverage. (2) Whether the lack of understanding of AI has led to the dissemination of unfavorable information to the masses, resulting in "neighbor avoidance" or resistance from the surrounding residents.
	Job Competition P3	(1) There is competition for jobs for traditional basic workers and those who want the project to lead to related employment.
	Resettlement of residents and related impacts P4	(1) Whether the compensation scheme for the relocation of residents is reasonable and legal. (2) Whether the compensation was paid on time. (3) Whether the compensation program takes into account the special needs of the residents. (4) How well residents accept the compensation package.
	Social security and regional customs P5	(1) In the face of the increase in the number of mobile workers, whether the industrial management department and local departments have arranged appropriate security measures in advance. (2) Whether the construction unit forms a strict management system. (3) Whether to investigate the local religious beliefs and folk customs in advance to understand whether there is a possibility of conflict with the local religious customs.
Policies, regulations and project establishment R	Adjustment of industrial policy and industry-related access regulations R1	(1) Will legislation and oversight mechanisms be improved with the incorporation of artificial intelligence. (2) Faced with the opaqueness and interpretability of AI development, the improvement of policies and systems will also be tested.
	Public Participation	(1) Whether the public enjoys the right to know and part of the right to participate in accordance

	R2	with the law. (2) Whether the project operator and builder have proper credibility.
	Information platforms and reporting channels R3	(1) Whether a transparent and timely information disclosure platform is in place. (2) Whether to establish efficient and unobstructed channels for letters and visits.
Project Management S	Project Privacy and Security S1	(1) In the context of big data collection, the development of artificial intelligence brings efficient and accurate analysis capabilities, which poses a great risk to the privacy and security of the project.
	Management System S2	(1) Failure of traditional internal management. in the face of artificial intelligence, previous rewards and punishments are destined to lose their effectiveness, the development of the discipline of artificial intelligence has put tremendous pressure on the improvement of management systems.
	Project Construction S3	(1) Whether the selected site meets the structural stability criteria, building adaptability criteria, and whether it is a seismically favorable location. (2) Adequacy of grid capacity. (3) Whether the quality of engineering components and construction quality are up to standard. (4) Whether there is a bad working environment. (5) Are safety accidents, such as falls from height, object strikes, mechanical injuries, electric shock injuries, collapses, fires, etc., prevented in advance. (6) Whether to set up safety signs as required. (7) Whether there is a complete security management system. (8) Whether regular safety education for employees. (9) Whether to check regularly for safety hazards.
	Technology Development S4	(1) Does the development of PV + AI technology have enough risk plans to correspond. (2) Whether the development and application of technology will lead to blind competition and have a damaging impact on the industry.

3 Determination of indicator weights

3.1 Weight calculation method

Refer to the calculation steps in Ref [1], AHP and EWM methods were used to calculate the weights of each index separately, based on the calculation results, the combined weighting method is then used to determine the combined weight Mi, as shown in equation (1).

$$W = y_j \beta + (1-\beta) z_j \tag{1}$$

y_j is the subjective weight, z_j is the objective weight, β is the weight compromise factor, takes the value of 0.5. The integrated weight vector is obtained after combining the results of the weight calculation. $W = (W_1, W_2, \ldots\ldots, W_j)$.

3.2 Calculation results of indicator weights

A total of 10 PV experts with more than 8 years of experience were invited to determine the weights for this study. As shown in Table 2.

Table 2 Weight calculation results of each indicator

Guideline layer	Percentage of guideline layers in the target layer			Indicator layer	Percentage of the indicator layer in the guideline layer			Percentage of indicator layer in target layer		
	AHP	EWM	Combined weights		AHP	EWM	Combined weights	AHP	EWM	Combined weights
E	17.6%	9.47%	13.5%	E1	60.00%	57.66%	58.83%	10.60%	5.46%	8.03%
				E2	40.00%	42.34%	41.17%	7.07%	4.01%	5.54%
M	28.4%	36.5%	32.4%	M1	17.39%	9.71%	13.55%	4.94%	3.55%	4.24%
				M2	21.69%	29.05%	25.37%	6.16%	10.60%	8.38%
				M3	24.08%	26.73%	25.41%	6.84%	9.76%	8.30%
				M4	17.64%	13.97%	15.81%	5.01%	5.10%	5.06%
				M5	19.19%	20.55%	19.87%	5.45%	7.50%	6.48%
F	23.1%	27.0%	25.1%	F1	40.12%	33.23%	36.67%	9.28%	9.00%	9.14%
				F2	29.79%	34.87%	32.33%	6.89%	9.45%	8.17%
				F3	30.09%	31.90%	31.00%	6.96%	8.64%	7.80%
S	30.8%	26.94%	28.87%	S1	18.86%	20.96%	19.91%	5.81%	5.65%	5.73%
				S2	26.88%	17.23%	22.06%	8.28%	4.64%	6.46%
				S3	28.02%	31.35%	29.68%	8.63%	8.45%	8.54%
				S4	26.23%	30.46%	28.34%	8.08%	8.20%	8.14%

4 Establishing a comprehensive evaluation methodology

4.1 Set evaluation level

According to the relevant provisions of the national and provincial ministries, Social stability risk level is divided into three levels: high, medium and low, in this paper, the social stability risk level of PV projects is accordingly classified into 3 levels, V=(I, II, III)=(High risk、Medium risk、Low Risk).

4.2 Determine the judgment matrix

Invite experts to assess and score the social stability risk indicators of PV projects, The secondary index evaluation matrix H = $[h_{ji}]19 \times 3$ is determined based on the score x. h_{ji} denotes the relative affiliation of Fj in the evaluation index, corresponding to the ith rank in the rating set, The ith row of the evaluation matrix H is the affiliation vector of the indicator Fj. In this study, the more common ascending and descending semi-trapezoidal and triangular distribution functions were used to construct the affiliation functions to determine the affiliation of each index (Zhang 2012). where low risk (I) and high risk (III) levels use ascending and descending half trapezoidal functions, The functional expressions are shown in Equation (2) and Equation (3), and the triangular distribution function is used for the medium risk (II) level, The expression of this function is shown in equation (4). The lower limit of the score is 0, the upper limit value is 100, the range of values of x is [0, 100], choose a1=10, a2=30, a3=55 as the separation point, as shown in Figure 1.

$$H_{j1} = \begin{cases} 1 & (x \le a_1) \\ \frac{a_2 - x}{a_2 - a_1} & (a_1 < x \le a_2) \\ 0 & (x > a_2) \end{cases} \tag{2}$$

$$H_{j3} = \begin{cases} 0 & (x \le a_2) \\ \frac{x - a_2}{a_3 - a_2} & (a_2 < x \le a_3) \\ 1 & (x > a_3) \end{cases} \tag{3}$$

$$H_{j_2} = \begin{cases} \frac{x - a_1}{a_2 - a_1} & (a_1 < x \le a_2) \\ \frac{a_3 - x}{a_3 - a_2} & (a_2 < x \le a_3) \\ 0 & (x \le a_1 \vee x > a_3) \end{cases} \tag{4}$$

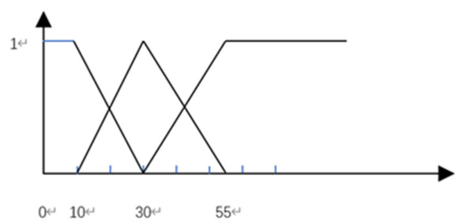

Fig.1 Graph of membership function

4.3 Calculation of evaluation results

Equation (5) is the formula for calculating the comprehensive evaluation affiliation vector.

$$S = WH = [b1, b2, b3] \tag{5}$$

The characteristic values for the three evaluation levels I (low risk), II (medium risk) and III (high risk) are 1, 2 and 3, formula (6) is the formula for the social stability risk evaluation index of PV projects。

$$L = 1 \times b1 + 2 \times b2 + 3 \times b3 \tag{6}$$

The relationship between the social stability risk level of PV projects and the risk index L value is shown in Table 3.

Table 3 Risk grade and risk index table

Risk level	Corresponding risk index L value
Low risk	L ∈ [1, 2)
Medium risk	L ∈ [2, 3)
High risk	L = 3

5 Evaluation Model Application

Take a 10MW PV project in Inner Mongolia Autonomous Region as an example, assess their project risk level by using the model in this paper, Comparison with the actual situation, verify how well the model fits the actual situation.

5.1 Project Overview and Background

The L10MW PV project is located in Huolinguole City, inner Mongolia Autonomous Region, the installed capacity of the project is 10MWp, total land area is approximately 60 acres. The project adopt self-generation and surplus feed-in mode of power generation, connected to 10kV substation through 1 x 10kV line, for use and remote deployment of public grid power equipment.

5.2 Data Acquisition

Five experts were invited to assess the 14 secondary risk indicators and the main assessment elements of the project. Removing the highest and lowest values, the average was used as the final score, then determine the affiliation vector based on the affiliation function and perform the risk assessment. The results of the five experts' scoring for each indicator are shown in Table 4.

Table 4 Calculation results of expert scores and membership degrees of each index

Indicators	Expert Ratings						Affiliation vector
	A	B	C	D	E	Final Score	
E1	25	30	18	18	27	23.3	(0.335, 0, 0.665)

E2	8	10	9	11	14	10	(1, 0, 0)
M1	40	52	63	58	45	51.7	(0, 0.868, 0.132)
M2	30	24	32	15	30	28	(0.515, 0, 0.485)
M3	65	60	57	52	62	59.7	(0, 1, 0)
M4	10	6	6	0	4	5.3	(1, 0, 0)
M5	20	14	18	22	10	17.3	(0.635, 0, 0.365)
F1	5	0	10	2	0	2.3	(1, 0, 0)
F2	10	25	12	18	15	15	(0.75, 0, 0.25)
F3	0	0	0	0	0	0	(1, 0, 0)
S1	10	6	8	5	6	6.7	(1, 0, 0)
S2	50	28	38	35	40	37.6	(0, 0.304, 0.696)
S3	2	5	8	10	6	6.3	(1, 0, 0)
S4	8	10	8	6	8	8	(1.0.0)

5.3 Project Evaluation Results

Based on the data in Table 4 and equations (5) and (6), the comprehensive evaluation vector and risk index were calculated to derive the evaluation grade. As shown in Table 5.

Table 5 Photovoltaic agriculture project risk evaluation results

Risk Type	Risk evaluation vector S	Risk Index L	Risk Level
L PV project overall risk	(0.64, 0.14, 0.22)	1.58	Low Risk
Ecological and environmental risks	(0.61, 0, 0.39)	1.78	Low Risk
Public Management Risk	(0.31, 0.372, 0.318)	2.01	Medium risk
Policy regulation and project risk	(0.92, 0, 0.08)	1.16	Low Risk
Project Management Risks	(0.78, 0.067, 0.153)	1.37	Low Risk

According to the table it can be seen that the overall risk index L for this project risk is 1.58, the corresponding risk levels is I (Low Risk). Based on the assessment results of indicators at all levels, analysis with the actual situation of the project, the main problems of risk prevention and control in this project are as follows.

(1) The ecological risk index L is 1.78. The corresponding risk level is I (Low Risk), Specifically, the daily construction wastewater waste cleaning of the project was not timely enough, and the occupation of public resources and damage to roads during construction had undue impact on social stability risks.

(2) The public management risk index L is 2.01. The corresponding risk level is II (Medium risk), This is reflected in the psychology of concern caused by the lack of awareness of AI among the people around the project, and the fear of local residents about the employment impact of AI in basic jobs.

(3) Policy Regulation and Project Risk Index L of 1.16, The corresponding risk level is I (Low Risk), The main manifestation is the lack of transparency and interpretability of AI development, which makes it difficult to form effective management system constraints in a short period of time.

(4) The project management risk index L is 1.37. The corresponding risk level is I (Low Risk), this is reflected in the current mismatch between technology and prognosis due to the rapid development of artificial intelligence.

5.4 Application Effect Analysis

From the evaluation results and the actual situation of the project, there is a good match between the two, this evaluation model can more accurately reflect the social stability risk level of PV projects. However, the model still has some limitations in practical application. Extreme value effects cannot be avoided in the presentation of the overall risk index, for example, in the L PV project. Although the overall risk rating is low risk, the Public Management Risk Index is in the medium risk range. Therefore, when using the model, attention is also paid to the indicators at each level.

6 Conclusion

(1) According to the social stability risk characteristics of PV projects, fourteen secondary indicators were selected from four primary indicators, including ecological environment, public management, policy regulation and establishment, and project management, Building a social stability risk evaluation model for combined photovoltaic projects, the risk level of the PV project in terms of social stability risk was obtained.

(2) AHP and EWM are used to determine the weights of each level of indicators, respectively, the comprehensive evaluation constructs a qualitative and quantitative social stability risk evaluation model for PV projects, take the L-shaped PV project in Inner Mongolia Autonomous Region as an example, validated the science and accuracy of the model.

(3) The evaluation results show that, the project risk level is I (Low Risk), the evaluation model can more accurately reflect the true risk level of social stability risks of PV projects, however, the level of automation is low and the calculation process is complex. In practice, for PV projects with different conditions or sites, the processing can be simplified and combined with computer processing results.

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