Risk Management and Control Model of UHV Construction Cost Based on Risk Matrix Method

Tianqiong Chen*

1 State Power Economic and Technological Research Institute Company Limited, Changping District, Beijing 102209, China
* qiongxiaolemimixi@163.com

Abstract. Strengthening cost risk management and control is of great practical significance for promoting UHV project construction with high quality. Firstly, the UHV project construction cost index system which covers construction engineering fee, installation engineering fee, equipment purchase fee, other expenses and basic reserve fee was constructed. Secondly, the cost risk assessment model of UHV project construction based on the optimized risk matrix was proposed. Finally, a case study was carried out to verify the scientificity and rationality of the model.

1. Introduction
The construction and development of UHV project has great strategic significance in optimizing resource allocation, improving economic benefit and improving ecological environment[1]. UHV project construction in China has entered the stage of normalization of large-scale construction. Strengthening cost risk management and control is of great significance for promoting project construction with high quality[2].

Combining with the characteristics of UHV project and on the basis of technical and economic indexes, the cost index system of UHV project construction was established in this paper. The risk assessment model of UHV construction cost based on risk mean optimization is studied and constructed, and the rationality and scientificity of the model are verified by an example analysis.

2. UHV project construction cost index system
According to the Regulations on Budget Compilation and Calculation of Power Grid Project Construction (2013), the construction cost of UHV project mainly consists of construction engineering fee, installation engineering fee, equipment purchase fee, other expenses and basic reserve fee. Among them, construction engineering fee and installation engineering fee are composed of direct fee and indirect fee. Equipment purchase fee includes equipment cost, equipment transportation fee. Other expenses include construction site requisition and cleaning fees, project construction management fee, project construction service fee, production preparation fee, and large transportation measures [3,4]. The specific index system is as shown as in Figure 1.
3. Cost Risk Assessment Model of UHV Project Construction

3.1. UHV construction cost risk grading model

The risk matrix method[5] is a structural method for identifying the importance of cost growth risk in the construction process of UHV projects. According to probability and impact degree of construction cost risk of UHV projects[6], the size and priority of the cost items are determined, and potential impact of risk can be evaluated.

Divide the impact degree of UHV construction cost growth risk \( a_i \) into five levels: Critical, Serious, General, Small, Negligible. The probability of occurrence \( b_j \) is divided into 5 intervals: 0-10%, 11%-30%, 31%-60%, 61%-90%, 91%-100%. Although UHV projects construction cost evaluation and quantification of the scores are subjective, classification of risks makes the risk assessment more detailed and random.
Table 1. Classification of risk impact level of UHV project cost growth

| Impact degree | Explain | Score |
|---------------|---------|-------|
| Critical      | Once the risk event occurs, it will cause great damage to the construction of the UHV project, resulting in the stagnation of the project. | 9 |
| Serious       | Once the risk event occurs, it will lead to a significant increase in the construction cost of UHV projects, and the difficulty in cooperation, management and service, etc., may not be completed on schedule. | 7 |
| General       | Once the risk event occurs, the construction cost of the commissioned UHV project will increase generally, and the difficulty of cooperation, management and service will generally increase, but it will still meet the needs of meeting the scheduled completion. | 5 |
| Small         | Once the risk event occurs, it will lead to a small increase in the cost of construction of UHV projects. Only adaptive adjustment and control will be required. | 3 |
| Negligible    | Even the risk event occurs, there is almost no impact on the construction of UHV projects. | 1 |

Table 2. Probability division of UHV project cost growth

| Probability range | Explain | Score |
|-------------------|---------|-------|
| 91%-100%          | Very likely to happen | 9 |
| 61%-90%           | May occur | 7 |
| 31%-60%           | May occur in the middle of implementation | 5 |
| 11%-30%           | Less likely to happen | 3 |
| 0-10%             | Impossible | 1 |

Combine UHV project construction cost growth risk impact level with the risk probability range, frame the matrix for scoring \( R_{ij} = a_i \times b_j \), which is as shown in Table 3:

Table 3. Reference table of UHV project construction cost growth risk score

| Probability range | Negligible | Small | General | Serious | Critical |
|-------------------|------------|-------|---------|---------|----------|
| 0-10%             | 1          | 3     | 5       | 7       | 9        |
| 11%-30%           | 3          | 9     | 15      | 21      | 27       |
| 31%-60%           | 5          | 15    | 25      | 35      | 45       |
| 61%-90%           | 7          | 21    | 35      | 49      | 63       |
| 91%-100%          | 9          | 27    | 45      | 63      | 81       |

The construction cost growth risk of UHV project with a score of 1-9 is determined as the low risk interval, and construction cost increase of UHV project with the score between 10-44 is determined as medium risk interval, and construction cost growth of UHV project with the score between 45-81 is determined as a high risk interval.

3.2. Risk classification optimization model considering risk mean

Assume that there are a total of \( n \) risk construction risk points (risk matters) for UHV projects, and risk level of construction cost growth for UHV projects is shown in Table 4:

Table 4. Reference table for risk score of UHV project cost growth

| Grade    | Single risk value | Maximum risk value | The highest value of \( n \) risk points |
|----------|-------------------|--------------------|----------------------------------------|
| Low risk | 1-9               | 9                  | 9\( n \)                                |
| Medium   | 10-44             | 44                 | 44\( n \)                               |
| High risk| 45-81             | 81                 | 81\( n \)                               |

In order to further strengthen the practicality of risk interval division, the product of mean value in table “Reference table for risk score of UHV project cost growth” and \( n \) risk points is regarded as one of the boundary points of risk interval, i.e. 25\( n \). Optimized reference table for risk score of UHV project cost growth is as shown as in Table 5.
Table 5. Optimized reference table for risk score of UHV project cost growth

| Grade                        | Explain                                                                 | Total value of risk |
|------------------------------|------------------------------------------------------------------------|---------------------|
| Ideal to promote construction| Cost increase overall risk is small, can be ignored.                  | 1-9n                |
| Can continue to build        | Cost growth risks are general, and can be timely communicated to resolve related issues. | (9n+1)-25n          |
| Cautiously promote construction| The risk of cost increase is large, and the cost increase and growth reasons should be deeply diagnosed to avoid potential hazards and impacts. | (25n+1)-44n        |
| Suspend construction         | The risk of cost increase is large, construction should be suspended, and the risk should be investigated and resolved. | (44n+1)-81n        |

4. Example analysis

Taking an UHV project as an example, there are 12 risk points such as direct construction fee increase. According to "Optimized reference table for risk score of UHV project cost growth", risk intervals of UHV project construction cost growth are respectively: Ideal to promote construction1-108, Can continue to build109-300, Cautiously promote construction301-528, Suspend construction529-972. Assuming that in the process of UHV project construction, the risk items assessed are shown in Table 6, risk of UHV project construction cost growth is as follows:

Table 6. Risk assessment of construction cost increase for a UHV project

| Risk points                        | Impact level   | Incidence probability | Risk value | Order of importance |
|------------------------------------|----------------|-----------------------|------------|---------------------|
| Construction engineering fee       |                |                       |            |                     |
| Direct fee increase                | Serious(7)     | 11%-30%(3)            | 21         | 4                   |
| Indirect fee increase              | Small(3)       | 91%-100%(9)           | 27         | 2                   |
| Installation engineering fee       |                |                       |            |                     |
| Direct fee increase                | Serious(7)     | 11%-30%(3)            | 21         | 4                   |
| Indirect fee increase              | Small(3)       | 91%-100%(9)           | 27         | 2                   |
| Equipment purchase fee             |                |                       |            |                     |
| Equipment cost increase            | Critical(9)    | 0-10%(1)              | 9          | 12                  |
| Equipment transportation fee increase| Small(3)      | 31%-60%(5)            | 15         | 7                   |
| Other expenses                     |                |                       |            |                     |
| Construction site requisition and cleaning fees increase | Serious(7)     | 11%-30%(3)            | 21         | 4                   |
| Project construction management fee increase | General(5)    | 61%-90%(7)            | 35         | 1                   |
| Project construction service fee increase | Small(3)      | 31%-60%(5)            | 15         | 7                   |
| Production preparation fee increase | Small(3)      | 31%-60%(5)            | 15         | 7                   |
| Large transportation measures increase | Small(3)      | 31%-60%(5)            | 15         | 7                   |
| Basic reserve fee                  | General(5)     | 11%-30%(3)            | 15         | 7                   |

Total risk value 236
From the assessment point of view, the UHV project construction is located in the “Can continue to build” interval, indicating that the cost growth risk is general, only need to pay attention to the key cost items, and reasonable control cost growth can be. Among them, project construction management fees, installation engineering fees, construction engineering fees, construction site requisition and cleaning fee growth need to be focused on.

5. Conclusion
The UHV project construction cost risk assessment model is constructed, taking into account the risk impact of cost growth risk and probability of risk occurrence, establishing a risk score reference table, in which UHV project construction cost growth risk is divided into “Ideal to promote construction, Can continue to build, Cautiously promote construction, Suspend construction” four intervals. The research results of the thesis have strong practical application value, and can provide decision support for UHV construction and actual work of cost control in the future.

References
[1] YANG H., JI P., MIAO M.(2018) Analysis on Interrelationship Between Future UHV Power Grid Structural Form and Power Source Composition in China. Automation of Electric Power Systems, 42: 9-17.
[2] CHEN G., LI M., XU T.(2018) System Protection and its Key Technologies of UHV AC and DC Power Grid. Automation of Electric Power Systems, 42: 2-10.
[3] ZHAO L., YI H., WU Y.(2016) Timing Optimization Evaluation Index System of UHVAC and UHVDC Project Construction. Electric Power Construction, 37: 56-63.
[4] LIU L., ZHAO W., WANG Z.(2013) Research on Economic Evaluation Contents and Indices for Large Power Grid Construction. ELECTRIC POWER CONSTRUCTION, 34: 22-26.
[5] LIU X., WANG B., LI W.(2016) Environmental Risk Assessment of Pipeline Crossing River Based on Risk Assessment Matrix. Environmental Science and Management, 41: 186-189.
[6] MA Q., WANG C., LI Y.(2017) Investment Risk Analysis of Power Grid Enterprises Under Incremental Distribution Businesses Opening. Electric Power Construction, 38: 139-145.