List Group Price Analysis of the Grid Engineering Quantity in Grid International EPC Bidding

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Abstract: In the international EPC bidding, company’s own business objectives are used to determine the expected profit level of the power grid project. Therefore, the composition and calculation on the bidding price and sub-items of the power grid engineering fees, measure project fees, other project fees and regulations fees as well as taxes are introduced in the paper under the grid project quantity list pricing model. Moreover, in terms of the problem on the cost allocation in the bidding price of the grid project quantity list, a nonlinear cost allocation model is established to obtain the optimal solution with the help of Kuhn-Tucker condition. Then the nature of the optimal solution is analyzed, which proves that the optimal solution can be used as the cost sharing standard or reference basis in the grid project quantity list.

1. Introduction
In recent years, the domestic power industry has begun to implement the EPC general contracting construction model. Especially in power projects with short construction periods and large amounts of coordination, and the EPC general contracting model fully reflects its advantages. However, at present, EPC general contracting in the power industry is still in its early stages, where no unified management norms and standards have been formed. What is more, in the bidding mode of grid project quantity list, it is necessary not only to acquaint and understand the grid project quantity list bidding system and bid quotation theory, but also adopt some effective bidding strategies and bidding techniques in conjunction with the company's own technical and management levels. Therefore, it is of necessity to study the bid quotation model in the bidding mode of the grid project quantity list to help bidding companies determine the bid quotation and increase the bidding probability of bidding companies.

The introduction of EPC general contracting model for power grid projects has unparalleled advantages over other contracting models, which can effectively reduce the cost of power grid projects. Meanwhile, a cost control system for power grid projects under EPC mode is constructed. Moreover, on the basis of the international EPC power grid bidding project, the research content of this paper determines the bidding price of the grid project quantity list and establishes a cost-sharing model based on utility maximization and rationality to analyze and verify the research content feasibility of the paper.

2. Determination of the Bidding Price in the Grid Project Quantity List

2.1 Grid Engineering Quantity List
The cost of the bidding price in the grid project quantity list includes sub-item grid project fees, measure project fees, other project fees, regulation fees and taxes, as shown in Figure 1.
Besides the power grid project quantity list project costs, \( A \) refers to the necessary costs that must be accomplished to complete the power grid project to ensure the smooth implementation of the construction in the power grid project according to the relevant national regulations and regulations in the power grid project quantity list. Moreover, entity measure fee refers to the expenses that must be completed to ensure the smooth progress of a certain type of power grid engineering entity project in the grid engineering quantity list, and supporting measure fee refers to the cost required to complete the supporting power grid project, so that the smooth implementation of the entire power grid project can be guaranteed.

2.2 Engineering Project Fees of Partial Power Grid

The Grid Engineering Quantity List Valuation Specification stipulates that grid project quantity list pricing in China mainly adopts the comprehensive unit price method, and the cost of each coding project includes the labor cost, material cost, machinery cost, management cost and profit required to complete a specified unit of measure project in the grid project quantity list. Meanwhile, the increased costs of risk factors is considered.

Labor cost: The calculation method has the following two modes, and the current pricing model of the estimated budget is applied.

\[
F = \sum (S \times J)
\]  \hspace{1cm} (1)

In formula (1), \( F \) stands for labor cost, \( S \) refers to the fixed number of labor days, and \( J \) is comprehensive wage unit price.

The dynamic calculation mode is as follows.

\[
F = \sum (H \times R)
\]  \hspace{1cm} (2)

In formula (1), \( F \) stands for labor cost, \( S \) refers to the fixed number of labor days, and \( J \) is comprehensive wage unit price.

The dynamic calculation mode is as follows.
In formula (3), \( G \) represents the use fee of construction machinery, \( B \) refers to the amount of construction machinery desks consumed in power grid construction, and \( Y \) indicates the comprehensive unit price of machinery desks. Additionally, \( C \) stands for construction machinery entry and exit fees and installation and removal fees.

Profit: Profit is what a construction enterprise can obtain after completing the contracted power grid project, which is generally calculated as follows:

\[
G = \sum (B \times Y) + C
\]

In the formula (4), \( G \) represents the use fee of construction machinery, \( B \) refers to the amount of construction machinery desks consumed in power grid construction, and \( Y \) is the comprehensive unit price of machinery desks.

\[
L = V \times N
\]

In formula (5), \( L \) represents profit, \( V \) is calculation base, and \( N \) refers to profit rate.

Comprehensive unit price of part of the grid project quantity list: The content of the project is separately priced according to the five expenses mentioned above, and the total unit price of the power grid project quantity list is formed after being summed up. In addition, there are coefficient calculation method and scheme analysis method two kinds of calculation methods for entity measures fee and supporting measures fee.

3. Cost Sharing Model Based on Utility Maximization and Rationality

The cost-sharing decision-making model of the grid project quantity list with the main objective of maximizing utility and the rationality which are treated as the objective is as follows.

\[
\begin{align*}
\text{max} & \quad \sum_{i=1}^{n} (h_r x_i) \\
(x_i - \bar{x}_i)^2 & \leq (h_r)^2, \quad i = 1, 2, \ldots, n \\
\sum_{i=1}^{n} x_i & \leq C^* \\
x_i & \geq 0, \quad i = 1, 2, \ldots, n \\
\end{align*}
\]

\((x_i - \bar{x}_i)^2 \leq (h_r)^2\) is \( n \) reaction and rational constraints in the model where \( r_i \) is the amount of income that can be brought by sub-item \( i \) in the grid engineering quantity list, and \( h \in (0, 1) \) refers to the rationality correction coefficient. Moreover, a standard form of nonlinear programming needs to be modeled into, \( n \) rationality constraints that are added can be expressed as \( \phi_i(X) = (h_r)^2 - (x_i - \bar{x}_i)^2 \geq 0 \), and \( \phi_i(X) \) is a concave function. Therefore, matrix 1 is also a convex programming, so that the sufficient and necessary condition for matrix 1 to have a global optimal solution \( X^* = (X_1^*, X_2^*, \ldots, X_n^*) \) is the co-existence of generalized Lagrange multiplier \( \delta_1^*, \delta_2^*, \ldots, \delta_n^* \) and the Kuhn-Tucker condition.
4. Model and Solution Analysis

According to the matrix 1 and K-T conditions, following conclusions can be obtained:

(1) If the error between the initial cost apportionment amount and the reasonable cost apportionment amount of sub-item $i$ in the grid project quantity list is controlled within a predetermined range, that is $|x_i^* - \bar{x}_i| < h r_i$, Lagrange multiplier $\delta_i = 0$ will be obtained according to K-T, so that $\mu_i x_i = \frac{\lambda_0^* - \lambda_i^*}{\epsilon_i}$ and $\lambda_0^* - \lambda_i^* \leq 0$ can be gained as well. Moreover, from K-T, $C^* = \sum_{i=1}^{n} x_i^*$ will be clear, namely the optimal solution of matrix 1 will allocate the cost to be shared by the grid project quantity list.

(2) $\mu_i x_i = \frac{\lambda_0^* - \lambda_i^*}{\epsilon_i} < 0$ is the marginal utility of the cost allocation function of sub-item $i$ in the grid engineering quantity list, so $X^* = (X_1^*, X_2^*, \ldots, X_n^*)$ is the ideal apportionment amount of sub item $i$ in the grid engineering quantity list. The ideal cost-sharing amount is inversely proportional to the bidder's preference for the list item $i$, and appropriate reduction of the cost-sharing amount of these list items is not only beneficial to increase the efficiency of allocation, but also conducive to rationality.

(3) Under the condition where the total amortized expenses are to be determined, according to the KT condition, the optimal solution for the allocation of the list items is $X^* = (X_1^*, X_2^*, \ldots, X_n^*)$, whose corresponding optimal objective function value is A, and the optimal objective function value B is a function of $C$, which is

$$\mu(C^*) = \mu x^* = \sum_{i=1}^{n} \epsilon_i \mu_i (x_i)$$

(6)

If an increment is given to $C^*$, the second constraint of matrix 1 will be $\sum_{i=1}^{n} x_i \leq C^* + \Delta C$, which is equivalent to give an increment to the apportionment $x_i$ of one or certain several sub-items in the grid engineering quantity list. Due to $\mu_i x_i < 0$, the marginal utility of all the list items decreases at this time.

When the optimal scheme for the allocation of the list items is A, that is, the total utility based on rationality is $C^*$ when the total cost of assessment is $\sum_{i=1}^{n} \epsilon_i \mu_i (x_i^*)$, and it is less than 0. In other words,
the objective function of matrix 1 is unchanged, but the feasible region extends outward on the original basis. Therefore, the corresponding optimal objective function value can be seen from the monotonous reduction function of the cost-sharing utility function \( \mu(C^*) \).

\[
\mu(C^*) \geq \lim_{\varepsilon \to 0} \frac{\mu(C) - \mu(C^*)}{\Delta C}
\]

is the optimal marginal utility under the condition where the total cost distribution is \( C^* \). At this time, \( X^* = (X_1^*, X_2^*, \cdots, X_n^*) \) is the ideal distribution amount of each list item, which can be used as the basis for amortizing the grid project volume list cost distribution.

5. Conclusion

1) The project cost can be controlled. When the preliminary design budget is reviewed and approved, the settlement price will be basically determined. What is more, the increase in engineering volume caused by general contractor is not included in the settlement, that is, the general contractor bears the risk.

2) Project cost is saved. Due to the design optimization division method, the general contractor has the motivation for design optimization, which can effectively save the project cost.

3) The settlement project volume is large and the settlement period is long. Since the preliminary design and the actual amount of the project have to be compared during the settlement, the preparation and review of the project amount will require a large amount of manpower and long time for the owner.

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