RESEARCH ON APPLICATION OF LIFE CYCLE ASSET MANAGEMENT IN MATERIAL PROCUREMENT

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ABSTRACT

To lower the equipment operation cost, malfunction level and enhance the comprehensive equipment efficiency, State Grid Corporation of China (SGCC) puts forward the method of Life Cycle Cost (LCC) to engage in tender and procurement, which transforms the original program of paying attention to the initial equipment procuring cost and achieves a better actual result. This paper introduces the LCC tender model from SGCC, including purchase expense, operational cost, maintenance cost, repair cost and disposal cost. Then, it goes on to discuss the specific procedure of LCC in the tender, including selecting equipment, establishing model, preparing tender document, pre-appraising supplier's qualification, holding meetings before tender, evaluating tender deciding, concluding contract and making post-appraisal. At the end of paper, the 500kV transformer substation for Shanghai World Expo is taken as example to introduce the LCC tender process of 220kV transformer.

INTRODUCTION

The life cycle cost (LCC) refers to the total cost needed to procure the equipment and maintain its normal operation in the life cycle of the system or equipment, that is, the total sum of direct, indirect, repeating, one-time and other related cost from design, research, development, manufacturing, operation, maintenance, guarantee, and scrap in the life cycle of equipment[1]. The LCC is originated in the railway of Sweden in 1904. The application of the concept into technical analysis can be traced back to value analysis in America in 1947. After the 80s of the 20th century, the widespread application of LCC in the electric power industry became mature and internationalized. For example, in November, 1987, International Electrotechnical Commission (IEC) promulgated LCC Evaluation---Concept, Procedure and Application, which is suggested to put into use internationally in January, 1993. In the year of 1996, IEC issued the international standard IEC60300-3-3, and released the revised version in July 2004. Besides, the International Council on Large Electric Systems (CIGRE) proposed the concept of LCC application in the management of equipment, and encouraged the manufacturer to offer the reports on LCC [2].

Currently, the LCC is widely researched and applied in the electric power industry all over the world. Major international manufacturers of power equipment like ABB and Siemens are conducting related LCC research for their products. Power corporations attach great importance to the LCC management and make the life cycle management strategies through assets management plan, including NG of Britain, Ashburton of New Zealand, and etc [3].

With the rapid development of power grid, there exist many problems in the assets management in SGCC, covering the short life cycle of equipment, low service efficiency, large investment for technical innovation and high maintenance cost [4]. All these problems prompts the corporation to transform the management concept, co-ordinate the relation of safety, efficiency and life cycle cost, realize the overall precise management of assets. Under this background, in order to lower the equipment operation cost and malfunction level and enhance the comprehensive equipment efficiency, SGCC puts forward the method of LCC to conduct tender and procurement, which transforms the original program of paying attention to the initial equipment procuring cost. SGCC's LCC tender model and tender procedure is now introduced, exemplified with the tender for 500kV transformer substation for Shanghai World Expo.

RESEARCH ON LCC TENDER MODEL

SGCC believes that life cycle cost (LCC) management of power system is to achieve the lowest life cycle cost of equipment or system on the basis of reliability. In the process of equipment procurement, except the price of equipment is taken into consideration, the support cost of whole process shall be taken into account. The core is to make the analytical calculation of equipment or system, making decision based on quantification value and choosing the supplier with the lowest LCC in the bid [5]. According to this theory, SGCC builds the LCC tender model, as shown in Figure 1 below:

LCC=CI+CO+CM+CF+CD

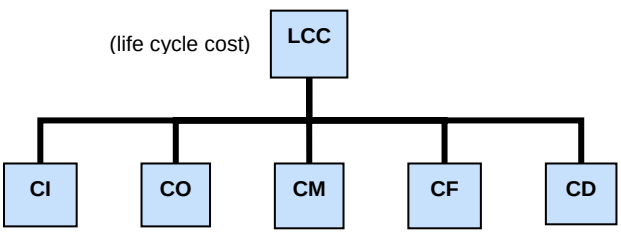

Figure 1 LCC Tender model of SGCC

Investment Cost (CI)

It mainly includes the equipment procuring cost, installation and adjustment cost and miscellaneous costs. The procuring cost consists of the equipment price, the special-use tool cost, the cost of initial spare part, the on-site service cost and transport charge of supplier; the installation and adjustment cost comprises transport charge of owner, the construction and installation cost for the equipment and the adjustment cost before the equipment being put into operation; the miscellaneous cost includes the special test cost.

Operation Cost (CO)

It mainly includes the equipment energy consumption cost, routine inspection cost and environment protection cost. The equipment energy consumption cost comprises the energy consumption cost of equipment proper and auxiliary equipments(such as fan); the routine inspection cost consists of inspection equipment and material cost required in the routine inspection and inspection personnel cost; the environment protection cost includes the cost which is needed to satisfy the requirement of environment protection in the operation process.

Maintenance Cost (CM)

It mainly includes the periodical disassembly check cost and periodical check and maintenance cost. The cost of each check and maintenance item comprises the equipment and material cost and service fee which are provided by the supplier for this activity; it also consists of the equipment and material cost and labor cost on the part of owner.

Outage or Failure Cost (CF)

It mainly includes the failure check cost, financial loss of failure. The failure check cost comprises on-site failure check cost and miscellaneous cost in case of repair in the factory. The on-site failure check cost consists of the equipment and material cost of supplier and the service fee; it also includes the equipment and material cost and labor cost on the part of owner. Financial loss of failure includes the power-cut loss, the equipment performance and life loss and indirect loss.

Disposal Cost(CD)

It includes the labor, equipment and transport cost in the time of equipment disposal and cost of environment protection in the time of equipment disposal treatment, with the deduction of recovery value of the equipment.

RESEARCH ON LCC TENDER PROCEDURE

The research in this paper stresses LCC management in the equipment procurement, which can be applied in the process from equipment tender to formal commercial operation after inspection. After the establishment of LCC tender model, SGCC sets up the standard procedure in which LCC method is used to conduct the equipment tender and procurement, offering a route diagram for the actual tender (see Figure 2). The following is introduction to eight phases in the procedure.

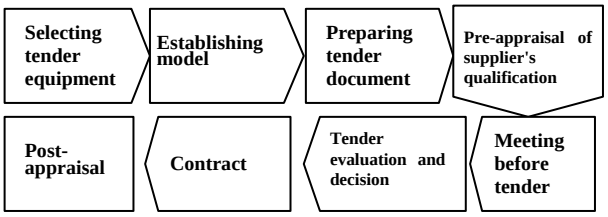

Figure 2 LCC Tender Procedure of State Grid

Equipment Tender Range

The equipment selected by SGCC for tender should meet the following conditions: low cost of the equipment operation or maintenance; low financial loss of failure in the key parts in the equipment system; the manufacturer has the opportunity or condition to provide diverse programs to improve the design to reduce LCC; LCC can be inspected and verified within a certain period of time after the equipment is put into operation.

Establishing Tender Model

After selecting the tender equipment, LCC tender model of related equipments should be established in order to confirm the cost and specific parameters in the model in accordance with LCC model theory. The tender model can be referred to Research on LCC Tender Model in the second section. After establishing the model, the sensitivity analysis is conducted on the specific parameters in the model. Because scores of parameters involved in the LCC model, if put entirely into computation, require lots of calculation, bringing along unnecessary data interference, it is necessary to sift through all these parameters and choose parameters with significant influence on the LCC computation result in the method of sensitivity analysis. The equation of sensitivity analysis is shown below:

$$LCC = f(P_1, P_2, \ldots P_m) = a_1 P_1 + a_2 P_2 + \ldots + a_m P_m$$

Among, P1, P2⋯⋯Pm are the specific numerical value affecting various factors of cost, which can be numerical value, capacity, unit price, tenure of use, average failure interval time, average repair time and the like; a1，a2，⋯am are cost coefficients after linear or non-linear transformation, which can be a constant, or function of P1, P2……Pm in most cases. The sensitivity analysis is aimed to find out the Pi which has a larger influence on LCC value through calculation.

Preparing Tender Document

When preparing the tender document, the tenderee should combine technology and economy. LCC

standard should be first set up in the tender document. Besides making clear such technical parameters as the functional specification and the layout mode, it also should require the bidder to provide data involved in the LCC computation, mainly including the following: the designed life of equipment, operational condition, maintenance mode and cost, reliability analysis and failure rate. In addition, LCC theoretical validation condition, validation method and guarantee data should be clarified in the tender document.

Pre-Appraisal of Supplier's Qualification

Before LCC tender, pre-appraisal of supplier's qualification can be conducted in order to select qualified suppliers from all the registered suppliers, for whom the tender is held. The pre-appraisal includes the evaluation of new supplier and re-interview of old supplier. For one thing, the pre-appraisal can prevent unqualified supplier from participation and increase the progress and efficiency of selection in the later stage; for another, it can efficiently find out the potential supplier.

Meeting before Tender

After confirming their qualification, a meeting should be held with the participation of the qualified suppliers, with the aim of handing out the tender document to suppliers and informing them to provide related data and specific requirements. In the meeting, suppliers can be taught knowledge about LCC, including the concept of LCC including five kinds of cost, the data collection method and the requirement of related parameters, the data provided by supplier in the tender document, the inspection mode and method and the penalty clause.

Tender Evaluation and Decision

This phase is the most important in the LCC tender procedure. When evaluating the tender, after comparing the major design difference of various proposals and combining operational data of similar equipments, the tenderee can conduct reliability analysis on the above mentioned data provided by the bidder. Then adding cost of various parts which is predicted to occur by the tenderee, sensitivity analysis can be carried out with some reasonable hypothesis and mathematical computing formula. Then LCC value of various proposals can be obtained and LCC evaluation report can be written. When deciding the tender, taking LCC computing result as commercial bid and related technical bid as tender evaluation standard, we can choose the final supplier.

Signing Contract

After choosing the final supplier, the next step is to sign the contract, which clarifies the obligation and right for parties, the tenderee and the bidder. Besides original technical clauses, the contents of the contract should comprise LCC management, including the warranty clause of reliability and availability factor like failure probability; the warranty clause of maintenance like repair rate in the factory; validation mode and method of the above warranty value and its corresponding penalty clause.

Post-Appraisal

The validation usually occurs within two to five years after the operation of the equipment with such item as the availability factor, the maintenance and failure rate. In the aspect of availability, the operational cost such as load loss value and idle load loss value is appraised and compared with data provided by supplier in the time of tender evaluation; in terms of failure rate, through the failure rate in the operational period of equipment, the average failure rate of equipment is calculated and compared with the failure rate provided by the supplier; based on the evaluation result, the penalty clause in the original contract can be implemented. It should be noted that LCC validation should be completed in the guarantee period specified in the contract.

APPLICATION CASE OF LCC TENDER

Case background: to complement and meet the need of 2010 Shanghai World Expo and downtown load growth, 500kV underground transformer substation of World Expo will be set up in the downtown area. Therefore, since December, 2005, Shanghai Municipal Electric Power Company has conducted the tender for 220kV transformer, the main equipment in the transformer substation.

Finally, six suppliers enter the tender stages. In the first round of technical tender, four suppliers are ruled out because their technical standard doesn't meet the requirement of this tender. Therefore, two suppliers enter the LCC evaluation, for the sake of distinction, they are coded as A and B. The following is comparison and analysis of supplier A and B in terms of five aspects of LCC.

Investment Cost (CI)

In terms of the investment cost, two transformers are needed. The unit price of transformer of company A is 31.6414 million yuan, while that of company B is 20.009 yuan.

Operation Cost (CO)

In terms of the operation cost, Company A and B are almost the same, so it is left out of consideration.

Maintenance Cost (CM)

In terms of the maintenance cost, in the column of periodical maintenance time, it is noted that the product by company A is maintenance-free product, and it doesn't require overhaul during normal operation

without failure; while company B gives the note that three overhauls are needed within the period of 30 years, that is 5, 15, 25 years after the product being put into operation. According to calculation and quoted price by the designing institute, crane renting company and power grid construction company, the cost for one overhaul is 4.6621 million yuan, and the total cost is equal to 4.6621 million×3=13.9863 million yuan

Outage or Failure Cost (CF)

In terms of the outage or failure cost, the unplanned discontinuation rate of company A is 0.1-0.15 time/hundred sets per year, while that of company B is 1 time /hundred sets per year. The unplanned discontinuation rate of company A is 7-10 times lower than that of company B. if the loss of one unplanned discontinuation is estimated at 0.3 million yuan (electric loss and equipment repair loss), the unplanned discontinuation loss of company B is 2.10-3.00 million yuan higher than that of company A (excluding social influence).

Disposal Cost (CD)

In terms of the disposal cost, the total weight transformer of company A is 280 ton, while that of company B is 259 ton. If the average recovery value is estimated at 15.7 thousand yuan/ton in 2005, CD of company A is 0.33 million yuan lower than CD of company B.

In accordance with the data provided by the manufacturer of the original computation module, taking into account the temporal value and appreciation value of assets, the following result can be obtained after LCC calculation: LCC of company B is 67.5267 million yuan (present value), while LCC of company A is 65.654 million yuan (present value). Therefore, we can conclude from the result that LCC of company B is higher than LCC of company A by 1.8727 million yuan.

In this tender, compared with the low quoted price of company B, that of company A is far higher. However, LCC of company turns out to be higher than that of company A. The reason for this reversion is that World Expo transformer substation has a high demand on maintenance and reliability. This illustrates that it is important to lower the maintenance cost in the late stage and reduce the unplanned discontinuation rate in the tender of equipment in the underground transformer substation. According to the tender procedure, Shanghai Municipal Electric Power Company finally selects company A as the supplier.

CONCLUSION

This paper researches and forms a set of practical methods of application of LCC concept into the tender management. LCC computation module is established according to LCC concept and IEC 603002323 application guide, while taking into consideration investment cost, operation cost, maintenance cost, outage or failure cost and disposal cost for various equipments. LCC tender procedure covers the whole procedure from selecting tender equipment, establishing tender model to signing the contract and post-appraisal, and guarantees the systematicity and scientificity of the tender procedure. Practice proves that the application LCC into the tender procurement plays a significant role in optimizing the life cycle cost of the power grid equipment, increasing safety and reliability, and enhancing the assets management level in the company. Moreover, through communication and LCC announcement, the manufacturer will understand that the aim of owner to promote LCC tender is to seek a win-win situation, helping the owner select the equipment with the lowest LCC and the manufacturer enhance the market competitive strength of its product.

However, in practice, SGCC has also realized some problems awaiting to be solved, such as the collection and accumulation of operation and maintenance data, the reliability of data provided by the supplier, how to eliminate the difference between the original equipment management system and the LCC concept. All these problems await answers in the further research and application.

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