

# Cost Management and Cost Control of Photovoltaic Projects

Weimin Lv\*

Southwest Oil and Gas Field Cost Center, Suining 629000, Sichuan, China

\*Corresponding author: Weimin Lv, lwml@petrochina.com.cn

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**Abstract:** With the rapid development of the photovoltaic (PV) industry and policy support, photovoltaic engineering has attracted much attention as a clean energy project. However, the complexity and huge investment scale of photovoltaic projects make cost management and cost control the key to project success. The purpose of this paper is to discuss the cost management and cost control strategies of photovoltaic projects, analyze their importance and challenges in the process of project implementation, and discuss the common cost control methods and techniques in photovoltaic projects, to improve cost management and cost control in photovoltaic projects, and to provide a reference for the sustainable development of the industry.

**Keywords:** Photovoltaic engineering; Cost management; Cost control

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## 1. Introduction

Photovoltaic engineering project investment is characterized by a shorter construction period and a larger total investment compared with other engineering construction, which needs to be rapidly constructed and put into use within a limited time <sup>[1]</sup>. The whole process of cost management has become an important way of cost control in modern engineering construction, and effective measures must be taken in the decision-making, designing, bidding and purchasing, construction, and completion stages of the project to strengthen the control of key factors affecting the investment to achieve the coordination and unity of organizational management, technical management, and economic management. Therefore, in photovoltaic engineering projects, it is crucial to manage costs and control investment risks in a timely and effective manner to improve the efficiency of project execution and management levels. As a clean, safe, and sustainable energy source, photovoltaic power generation has been rapidly developed in recent years. However, the high cost of PV projects has been one of the main bottlenecks restricting its large-scale application. Therefore, strengthening the cost management and cost control of PV projects is of great significance in promoting the healthy development of the PV industry.

## **2. Status and background of photovoltaic power generation project**

The continuous progress of PV power generation technology and the rapid decrease of cost are the main driving force for the development of PV market. With the continuous maturity and large-scale application of PV power generation technology, the cost of PV power generation will be further reduced, and the future development potential is huge. Photovoltaic engineering is a technology that utilizes photovoltaic cells to directly convert solar energy into electricity. Currently, a variety of high-efficiency PV materials and technologies, such as monocrystalline silicon, polycrystalline silicon, copper-zinc-tin-sulfur, and chalcogenide, are being developed and utilized, which significantly enhance the efficiency of PV power generation. The application areas of PV engineering cover a wide range of residential, commercial, and industrial applications. Driven by policy encouragement and market demand, more PV power plant construction projects have been launched globally, especially in countries such as China, the United States, and Germany. For example, China, as a large country in the PV industry, is not only experiencing a rapid increase in installed PV capacity in its domestic market but also exporting the PV products it produces to all parts of the world. Although PV technology has great potential for development, it still faces challenges such as cost, technology storage, and weather dependence. Future research is likely to focus on reducing costs, improving conversion efficiency, and developing more reliable energy storage systems. In addition, with the global pursuit of reducing carbon emissions and alienating fossil energy sources, PV engineering is expected to be promoted and applied on a larger scale.

## **3. Whole process cost management of PV engineering**

The costs of a photovoltaic project mainly include equipment costs, installation costs, other costs of engineering and construction, and financial costs. Among them, equipment cost is the main component of PV project cost, accounting for more than 70%. Installation costs include PV module installation, inverter installation, racking system installation, electrical equipment installation, and so on. Other costs of project construction include land costs, design costs, supervision costs, grid connection costs, etc. The financial cost mainly refers to the interest on the project loan.

### **3.1. Cost management in the investment decision-making stage**

#### **3.1.1. Selection of plant site**

In the investment decision-making stage of the photovoltaic project, the choice of plant site is one of the important factors affecting the investment benefit of the photovoltaic project. When selecting the plant site, factors such as favorable geographic location, suitable climatic conditions, low land use costs, and convenient power supply should be fully considered to provide favorable conditions for the subsequent construction and operation of the project <sup>[2]</sup>.

#### **3.1.2. Selection of equipment and materials**

The selection of equipment and materials is directly related to the quality and performance of the project. The quality of equipment such as photovoltaic modules, inverters and transformers directly affects the project. Therefore, it is necessary to choose reliable big brands to ensure that the equipment is good and stable to improve the project quality and power generation efficiency.

#### **3.1.3. Selection of racking**

The bracket system plays an important role in supporting and fixing PV modules in PV projects, which directly

affects the stability and life of the system. When selecting the bracket, it is necessary to make comprehensive considerations according to the geographic conditions of the project, power limitation, bidding rules, and so on. It is important to select the bracket model suitable for the actual needs of the project so that the bracket system meets the engineering design requirements and can effectively support and fix the PV modules. This ensures the stability and reliability of the construction and operation of the project.

### **3.2. Cost management in the design stage**

The whole process of cost management in the design stage is critical to the successful implementation of the project. In the design stage, the following three points are key cost management measures.

#### **3.2.1. Design bidding by introducing a competitive mechanism**

In the design bidding stage, through the introduction of a competitive mechanism, can prompt the design schemes to compete with each other and finally select the best design scheme. During the bidding process, the design solutions will be comprehensively evaluated in terms of safety, practicality, aesthetics, and economic rationality to ensure that the final selected design solution meets the needs of the project and has a high cost-effectiveness.

#### **3.2.2. Introduction of design supervision**

The introduction of design supervision is crucial to the construction drawing design process, and its main responsibilities include: reviewing whether the design is consistent with the preliminary scheme and norms and standards, providing rationalization suggestions on equipment selection, new materials, and new techniques, and coordinating multi-departmental cooperation to prevent changes in demand to ensure the consistency and quality level of the design scheme.

#### **3.2.3. Implement limit optimization design and strictly control design changes**

The project design stage should focus on cost control, strive to optimize the design scheme under the premise of meeting the functional requirements, and strictly control the design changes, especially the major changes that may increase the project cost. Avoid unreasonable changes, keep the investment strictly within the budget, and ensure the economic benefits and financial sustainability of the project.

### **3.3. Cost management in the evaluation stage of the feasibility study report**

In the feasibility study report evaluation stage, cost management is a key link to ensure the economic feasibility of the project and investment efficiency. The following are the key points of cost management that need to be paid attention to at this stage:

#### **3.3.1. Attention to rate standards**

The importance of reviewing the rate system is self-evident in the review of the feasibility study. Rates, as the pillar of comprehensive cost accounting of the project, comprehensively cover many areas including the cost of measures, incidental expenditures, profit expectations, and tax expenditures, and are customarily presented in the form of a percentage <sup>[3]</sup>. During the evaluation process, it is important to focus on and review the reasonableness and accuracy of the rate standards to ensure that the rates are set following the actual situation and to avoid deviations and risks in the cost estimation. Only by confirming the accuracy and reasonableness of the rates can the uncertainty of the cost be effectively reduced, providing a more reliable guarantee for the successful implementation of the project and investment benefits.

### **3.3.2. Attention to related cost items**

In the evaluation stage of the feasibility study report, special attention should be paid to related cost items, including equipment cost, equipment supervision cost, and production preparation cost. Equipment costs cover transportation and miscellaneous fees, transportation insurance fees, procurement and storage fees, and many more which must be verified in detail during the evaluation to ensure the accuracy of the calculation and avoid cost estimation errors. Equipment supervision costs are usually calculated together with the construction supervision costs, which should not be double-calculated, and its reasonableness needs to be confirmed. The calculation standard of production preparation costs needs to be carefully reviewed and calculated according to the percentage of the equipment costs to ensure that the calculation method is justifiable, and coordinated with other related costs. Through careful review and confirmation of relevant cost items, the project cost can be effectively managed and controlled, and the economic efficiency and return on investment of the project can be improved under the premise of ensuring the accuracy of the cost calculation, to lay a solid foundation for the smooth implementation and successful operation of the project.

### **3.3.3. Pay attention to the quantity and price of major equipment and materials**

The evaluation should make a detailed assessment of the quantity and price of equipment and materials to ensure the accuracy and reasonableness of the estimate. When the feasibility study and general contracting are both handled by the same company for Engineering, Procurement, and Construction (EPC), special attention should be paid to the reliability of the data and prices to avoid bias and overblown costs. Only by carefully assessing and checking the volume and price of major equipment and materials can we ensure the truthfulness and reliability of the project cost estimation and avoid additional costs and risks caused by distorted data <sup>[4]</sup>.

## **3.4. Cost management in the implementation stage**

### **3.4.1. Reasonable control of material dosage and material price**

In the cost composition of the photovoltaic power plant, the proportion of equipment and material expenditures is quite high, most of the time it will occupy the range of 60% to 80%. The price of PV modules, more conspicuously occupies at least half of this huge cost. This high proportion of material and equipment prices has a decisive impact on the overall cost of the project. Because the core of the photovoltaic power generation project lies in the utilization of solar modules, the cost of these components accounts for a large proportion of the overall project cost, directly affecting the project's economy and profitability.

### **3.4.2. Strengthen project budget audit and settlement according to the quota**

In addition to the common EPC general contracting mode, some of the fragmented projects in the photovoltaic power generation project will also use comprehensive unit pricing. Through the strict audit and review of the quota, the cost of the project can be effectively controlled to ensure the accuracy and reasonableness of the project investment. Projects using the comprehensive unit pricing mode can more accurately control the cost of each construction element and ensure the accuracy of the project budget.

## **4. Cost control program for the whole process of photovoltaic project**

### **4.1. Cost management in the project establishment stage**

In the bidding process of the design unit, the owner needs to carefully prepare the bidding documents to clarify the project requirements and technical principles, such as the project scale and access voltage level, to provide

clear guidelines for the design unit to carry out its work. This helps ensure that the design unit understands the specific requirements of the project and improves the quality and efficiency of the design <sup>[5]</sup>. At the same time, clear requirements and technical guidance help reduce the risk of changes and additional costs in the later design phase. Additionally, investment estimation is an integral part of the project establishment phase. Through investment estimation, the owner can better understand the overall cost of the project, laying a foundation for subsequent budget control and cost management. This not only helps to plan capital expenditure but also provides important reference information for the project's financial plan and investment strategy. Based on determining the scale of project investment, the owner can better grasp the economic feasibility of the project and provide a basis for subsequent project promotion and management.

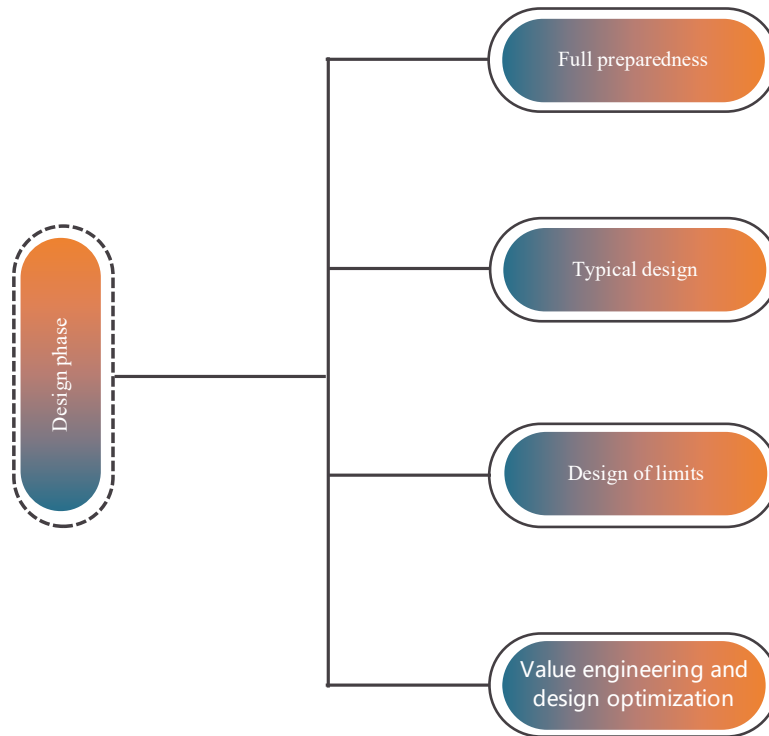
## **4.2. Cost Management in project design and bidding stage**

### **4.2.1. Bidding process of EPC enterprises**

Cost management is extremely important in the project bidding process and needs to follow the “one center, two basic points” principle. Among them, “one center” is to focus on the preparation of bidding documents to ensure the project needs and requirements. The “two basic points” are the key operation in the bid evaluation process where one aspect focuses on the total price to ensure that the overall cost of the project is controllable while the other aspect focuses on the unit price, carefully analyzing the cost of each element of the construction to ensure that the cost of each specification is reasonable <sup>[6]</sup>. By strictly controlling these two basic points, project costs can be effectively managed to ensure the economic feasibility and sustainability of the project.

### **4.2.2. Design phase**

- (1) Full preparedness: Insufficient design or inadequate preparation is a common problem in many projects. Therefore, in the initial stage of project initiation, the owner should abandon the tendency to prioritize speed and shorten the construction cycle, and should instead reserve sufficient time for the design phase to ensure the depth and quality of the design, thereby laying a solid foundation for the project's success.
- (2) Typical design: Typical design is based on the rich experience of designers and scientific research results, and combined with the design model that has been proven effective in practice. This design method can significantly improve the quality and efficiency, and provide a solid foundation for the smooth implementation of the project.
- (3) Design of limits: In the control design phase, the focus is on managing the cost of specific engineering components, such as the inverter room, booster room, comprehensive building, distribution room, and other individual structures, to ensure that the planning is completed within the budget constraints. By setting separate limits for each part, the cost of each project can be effectively managed and controlled to guarantee that the project operates stably within the budget. This fine-limit design method can help the project team better monitor and manage the cost of each building, thus securing the project's economy and sustainability.
- (4) Value engineering and optimized design: Through value engineering, costs can be reduced and efficiency improved without compromising the quality of the project. Optimization design, on the other hand, is to continuously optimize the solution during the design process to achieve the best design effect and economy. All these methods help to improve the design level of the project and guarantee that the project runs smoothly and achieves the expected results. The organizational chart of the design phase is shown in **Figure 1**.



**Figure 1.** Organizational chart for the design phase

### 4.2.3. Procurement phase

- (1) Optimize supplier relationship: Establish a win-win relationship, promote communication, and ensure a stable supply of resources.
- (2) Specialized procurement: Hire experts, formulate precise strategies, and optimize the procurement process to ensure high quality and high efficiency.
- (3) Strengthen internal audit: Establish a comprehensive audit system to monitor the procurement process, ensure compliance and efficiency, improve the quality of supplier services, reduce costs, and improve project efficiency. The establishment of a sound audit system can effectively supervise and manage the procurement activities of the project, assuring the compliance and transparency of the procurement process, and helping reduce the procurement risks and costs.

## 4.3. Cost control in the construction phase of the project

### 4.3.1. Progress control

In PV project construction management, the owner's precise management throughout the pre-construction, mid-construction, and post-construction stages is crucial. During the preparatory stage of construction, the owner has to clearly set the project progress target and specifically agree with the contractor on the construction tasks and key time points. To effectively monitor the progress of the project, it is necessary to exhaustively plan the phasing of construction and the expected completion time. During the construction process, due to the complexity of the work processes, the progress of the project should be dynamically monitored, and strategies should be adjusted on time to keep the construction running smoothly and to quickly respond to and deal with any problems that arise <sup>[7]</sup>. Simultaneously, potential risks, such as delays in the provision of design drawings, design errors, delays in supplier deliveries, inefficiency of the construction team, and the impact of inclement weather, needs to be considered in all aspects, and solutions should be formulated in advance to ensure the

smooth progress of the project. Precise management, flexible scheduling, and risk prevention are the keys to a smooth PV project. To prevent these risks, the project team needs to be prepared for possible problems in advance and formulate corresponding risk response strategies to guarantee the normal progress of the project.

#### **4.3.2. Cost control**

To control project costs, the first thing to do is to clarify the spending targets for each stage. This requires the development of a detailed cost plan, which lists the projected spending for each phase so that we can monitor and adjust it at any time. Followed by paying close attention to the gap between the actual spending and the plan. Once overspending is detected, the reasons should be analyzed immediately and measures should be taken to correct it to ensure that the project cost will not be out of control. By formulating a reasonable cost plan and taking corrective measures in time, we can effectively control the project cost and ensure that the project is carried out smoothly.

#### **4.4. Acceptance stage cost control**

In the project acceptance stage, the focus of cost management is to accurately complete the project settlement. To ensure a smooth settlement process, it is necessary to set a fair contract pricing mechanism, implement practical and effective settlement strategies, and establish a reliable dispute-handling program <sup>[8]</sup>.

- (1) Determine a reasonable contract pricing method: The contract pricing method should be able to accurately reflect the project cost and comply with the provisions of the contract. Through the reasonable pricing method, the accuracy and reasonableness of the settlement can be ensured, and the cost deviation caused by the improper pricing method can be avoided.
- (2) Implementation of practical settlement measures: When carrying out the completion of the settlement work, it is necessary to develop a detailed settlement program to clarify the basis for the calculation of the costs and the settlement provisions. This ensures that the settlement process is based on evidence to avoid confusion and loopholes.
- (3) Establish effective dispute resolution: In the settlement process, some disputes may arise, so it is necessary to develop a clear dispute resolution mechanism. Timely handling and resolution of disputes will help guarantee the smooth progress of the settlement work and ensure that the cost control objectives of the project can be realized.

### **5. Conclusion and prospects**

The cost management and cost control of photovoltaic projects is a key link to ensure the successful completion of the project. Through reasonable budgeting, strict cost accounting, and effective cost control, the cost of the project can be effectively managed to ensure that the project is balanced in terms of quality, time, and cost. In the future, with the continuous development of the PV industry and technological innovation, the cost management and cost control of PV projects will face new challenges and opportunities, and it is necessary to continuously improve the management level and introduce new cost control techniques and concepts to adapt to the changes in the market and the industry. This guarantees a future where PV projects can be implemented and completed efficiently and sustainably.

### **Disclosure statement**

The author declares no conflict of interest.

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