

AACE
INTERNATIONAL
RECOMMENDED
PRACTICE

96R-18

**COST ESTIMATE CLASSIFICATION
SYSTEM – AS APPLIED IN
ENGINEERING, PROCUREMENT,
AND CONSTRUCTION FOR THE
POWER TRANSMISSION
LINE INFRASTRUCTURE
INDUSTRIES**

SAMPLE

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AAACE® International Recommended Practice No. 96R-18

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE POWER TRANSMISSION LINE INFRASTRUCTURE INDUSTRIES

TCM Framework: 105 – Cost Estimating and Budgeting

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1. PURPOSE

As a recommended practice (RP) of AACE International, the *Cost Estimate Classification System* provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The *Cost Estimate Classification System* maps the phases and stages of project cost estimating together with a generic project scope definition maturity and quality matrix, which can be applied across a wide variety of industries and scope content.

This recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for electrical power transmission lines infrastructure facilities. This document supplements the generic cost estimate classification RP (17R-97 [1]) by providing:

- A section that further defines classification concepts as they apply to the power transmission line infrastructure industries.
- A chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic RP, the intent of this document is to improve communications among all the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the power transmission line infrastructure industries.

The overall purpose of this recommended practice is to provide the power transmission line infrastructure industries with a project definition deliverable maturity matrix that is not provided in 17R-97. It also provides an approximate

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representation of the relationship of specific design input data and design deliverable maturity to the estimate accuracy and methodology used to produce the cost estimate. The estimate accuracy range is driven by many other variables and risks, so the maturity and quality of the scope definition available at the time of the estimate is not the sole determinate of accuracy; risk analysis is required for that purpose.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes, terminology, and may classify estimates in other ways. This guideline provides a generic and generally acceptable classification system for the power transmission line infrastructure industries that can be used as a basis to compare against. This recommended practice should allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

2. INTRODUCTION

For the purposes of this document, the term *power transmission line infrastructure industries* is assumed to include greenfield or brownfield sites for overhead, buried and submarine transmission of electrical power in the infrastructure industries. High voltage is typically >100kV but may be less (e.g., 3 or 60 kV) if long distance with light electrical loads. This excludes power supply and distribution scope within a process plant, mining facility, building complex or other facility site. It also excludes power generation facilities and substations. The defining deliverables of those excluded project scopes are covered in other RPs (e.g., 187-97 for process plants [2]).

Power transmission is considered an element of the infrastructure industry. The Construction Industry Institute has provided a good definition of infrastructure in its Project Definition Rating Index for Infrastructure Projects as follows [3]:

“A capital project that provides transportation, transmission, distribution, collection or other capabilities supporting commerce or interaction of goods, services, or people. Infrastructure projects generally impact multiple jurisdictions, stakeholder groups and/or a wide area. They are characterized as projects with a primary purpose that is integral to the effective operation of a system. These collective capabilities provide a service that is made up of nodes and vectors into a grid or system.”

Using this definition, power transmission lines are a vector or linear scope element that connects substation or other facility nodes at its terminations. The substation nodes may be part of or associated with a generation, consuming or interconnection facility. As such, transmission projects are often executed as part of a program that also involves node project scope or facility operational changes (or at least considerations for integrated system commissioning and startup). As the definition states, a distinguishing feature of these projects is that they often traverse wide areas, cross country or subsea, which puts an emphasis on the definition of routing, land ownership and conditions, and establishing right-of-way (ROW). Associated scope definition challenges include defining stakeholder, permitting and regulatory requirements. Buried and submarine installations increase the focus on the protection philosophy and strategies affecting cable selection, armoring and joint considerations. While many distinguish power transmission (higher voltage, long distances) from power distribution (short distance, lower voltage connections to retail customers), the principles of estimating these elements are similar; i.e., the RP applies to both.

The main physical power transmission line scope elements are conductors and their support structures if installed overhead. Main installation elements include land clearing if over land (including forestry if applicable), foundation and structure erection and conductor stringing if overhead, or trenching, laying and horizontal boring if subsurface or subsea. Special scope elements are involved with crossings of water, road, rail and so on and at terminations. Because conductor (e.g., aluminum) and structure (e.g., steel) material costs are usually a significant cost element, these project estimates are particularly sensitive to escalation uncertainty. In general, the more developed the route,

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the more complex the installation will be. In urban areas, visual appeal and concern for safety and health can be major issues. Installation in remote location and/or difficult or environmentally sensitive terrain creates its own challenges. Subsea installation adds the need for bathymetry¹ and metocean² studies and specialized installation equipment and vessels. Before any installation work can begin in an area, stakeholder consultation must be advanced (sometimes requiring agreements with local populations with rights), and appropriate land and ROW must be acquired which creates unique scheduling as well as cost challenges.

For the purpose of estimate classification then, the main scope definition deliverables are associated with defining the power requirements (i.e., kV), the conductors and structure, and the routing. Conductors can vary widely in content (copper, aluminum, etc.) and insulation. Overhead structures may be wood, concrete, composite or steel in various configurations with various foundation designs including pilings, concrete and so on. The route's land or subsea characteristics and the nature of developments drive the need for special design features and execution strategies. Operability and maintainability considerations may also affect ROW and access design. Brownfield and revamp projects add their own concerns for interface with existing elements, crowded working conditions, etc. For each scope definition decision, stakeholder requirements need to be considered.

Power substation projects are usually associated with transmission projects. However, substations being equipment-centric and located on a facility site have physical and defining characteristics similar to process plant projects (e.g., reliance on one-line diagrams, plot plans, etc.).

Power transmission is usually a regulated industry if not government owned. As environmental concerns increase, the design and installation becomes more complex (e.g., mitigation and management plans, construction plans with seasonality, etc.) and the regulation of projects becomes more rigorous. In respect to classification, the regulation becomes critical as the stage-gate process is increasingly driven by the regulators and not by owner economic concerns. For example, the regulator or agency with authority may dictate that final engineering cannot proceed until after the routing is finalized and the user submits a *maximum* and reasonable cost to the agency. In some cases, this gate may require design deliverables to be more or less advanced than the Classification Table 3 stages. In these situations, one should assess the governing stage-gate process and decide what class the estimate will be for each gate. For example, one may find the gate is somewhere between the RP's class; say between Class 3 and 2. If so, one would designate the estimate as "Class 2 with Exceptions" and describe which deliverables are not to full class definition at that decision gate. This is also true if the stage gate system is defined by 30/60/90 percent design reviews (or other percentages) where percent design completion may not have much relationship to the status of any particular deliverable. For example, design completion at 30% design review may not be adequate for Class 3 and hence the associated estimate would be Class 3 with Exceptions as noted).

This guideline reflects generally-accepted cost engineering practices. This recommended practice was based upon the practices of multiple major power utility companies as well as published references and standards [4]. Company and public standards were solicited and reviewed, and the practices were found to have significant commonalities. These classifications are also supported by empirical industry research of systemic risks and their correlation with cost growth and schedule slip [5].

This RP applies to a variety of project delivery methods such as traditional design-bid-build (DBB), design-build (DB), construction management for fee (CM-fee), construction management at risk (CM-at risk), and private-public partnerships (PPP) contracting methods.

¹ The study of underwater depth of lake or ocean floors.

² A combination of meteorology and oceanography.

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3. COST ESTIMATE CLASSIFICATION MATRIX FOR THE POWER TRANSMISSION LINE INFRASTRUCTURE INDUSTRIES

A purpose of cost estimate classification is to align the estimating process with project stage-gate scope development and decision-making processes.

Table 1 provides a summary of the characteristics of the five estimate classes. The maturity level of project definition is the sole determining (i.e., primary) characteristic of class. In Table 1, the maturity is roughly indicated by a percentage of complete definition; however, it is the maturity of the defining deliverables that is the determinant, not the percent. The specific deliverables, and their maturity or status are provided in Table 3. The other characteristics are secondary and are generally correlated with the maturity level of project definition deliverables, as discussed in the generic RP.[1] The characteristics are typical but may vary depending on the circumstances.

ESTIMATE CLASS	Primary Characteristic	Secondary Characteristic		
	MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Cost/length factors, parametric models, judgment, analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Cost/length, factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Some detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 99%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Table 1 – Cost Estimate Classification Matrix for the Power Transmission Line Infrastructure Industries

This matrix and guideline outline an estimate classification system that is specific to electrical power transmission lines in the infrastructure industry. Refer to Recommended Practice 17R-97 [1] for a general matrix that is non-industry specific, or to other cost estimate classification RPs for guidelines that will provide more detailed information for application in other specific industries (e.g., RP 18R-97 for electrical substation facilities [2]). These will provide additional information, particularly the *Estimate Input Checklist and Maturity Matrix* which determines the class in those industries. See Professional Guidance Document 01, *Guide to Cost Estimate Classification*. [6]

Table 1 illustrates typical ranges of accuracy ranges that are associated with the power transmission line infrastructure industries. The +/- value represents typical percentage variation at an 80% confidence interval of actual costs from the cost estimate after application of contingency (typically to achieve a 50% probability of project cost underrun versus overrun) for given scope. Depending on the technical and project deliverables (and other variables) and risks associated with each estimate, the accuracy range for any particular estimate is expected to fall within the ranges identified. However, this does not preclude a specific actual project result from falling outside of the indicated range of ranges identified in Table 1. In fact, research indicates that for weak project systems and complex or otherwise risky projects, the high ranges may be two to three times the high range indicated in Table 1. [7]

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In addition to the degree of project definition, estimate accuracy is also driven by other systemic risks such as:

- Level of familiarity with technology.
- Unique/remote nature of project locations and conditions and the availability of reference data for those.
- Complexity of the project and its execution.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Experience and skill level of the estimator.
- Estimating techniques employed.
- Time and level of effort budgeted to prepare the estimate.
- Market and pricing conditions.
- Currency exchange.
- Complexity and condition influence on system/grid power conditions.
- Regulatory, community, landowner, and political risks.

Systemic risks such as these are often the primary driver of accuracy, especially during the early stages of project definition. As project definition progresses, project-specific risks (e.g. risk events and conditions) become more prevalent and also drive the accuracy range.

Another concern in estimates is potential organizational pressure for a predetermined value that may result in a biased estimate. The goal should be to have an unbiased and objective estimate both for the base cost and for contingency. The stated estimate ranges are dependent on this premise and a realistic view of the project. Failure to appropriately address systemic risks (e.g. technical complexity) during the risk analysis process, impacts the resulting probability distribution of the estimated costs, and therefore the interpretation of estimate accuracy.

Figure 1 illustrates the general relationships and between estimate accuracy and the estimate classes (corresponding with the maturity level of project definition). Depending upon the technical complexity of the project, the availability of appropriate cost reference information, the degree of project definition, and the inclusion of appropriate contingency determination, a typical Class 5 estimate for an electrical transmission substation facilities project may have an accuracy range as broad as -50% to +100%, or as narrow as -20% to +30%. However, note that this is dependent upon the contingency included in the estimate appropriately quantifying the uncertainty and risks associated with the cost estimate. Research for power transmission projects has shown that industry has greatly underestimated risk and contingency for Class 5 and 4 estimates [4]. Environmental and political risk are increasing that becomes a particular concern when regulators require reporting of maximum costs or similar dictates related to accuracy. Refer to Table 1 for the accuracy ranges conceptually illustrated in Figure 1. [8]

Figure 1 also illustrates that the estimating accuracy ranges overlap the estimate classes. There are cases where a Class 5 estimate for a particular project may be as accurate as a Class 3 estimate for a different project. For example, similar accuracy ranges may occur for a Class 5 estimate of one project that is based on a repeat brownfield project with good history in an existing, approved ROW with few stakeholders, and a Class 3 estimate for a project involving new technology in a remote location, or environmentally sensitive region with stringent regulations and many stakeholders. It is for this reason that Table 1 provides ranges of accuracy values. This allows consideration of the specific circumstances inherent in a project, and an industry sector to provide realistic estimate class accuracy range percentages. While a target range may be expected for a particular estimate, the accuracy range should always be determined through risk analysis of the specific project and should never be pre-determined. AACE has recommended practices that address contingency determination and risk analysis methods. [9]

If contingency has been addressed appropriately approximately 80% of projects should fall within the ranges shown in Figure 1. However, this does not preclude a specific actual project result from falling inside or outside of the indicated range of ranges identified in Table 1. As previously mentioned, research indicates that for weak project