

PARETO'S LAW APPLIED TO PROJECT PLANNING

Paul J. De Martini, PMP
Pacific Gas & Electric Co.

Introduction

An analysis of electric transmission and substation retro-fit projects concluded that within the first 20% of a project's schedule, 80% of the costs are accrued, reflecting Pareto's 80/20 Law. The result is that soon after engineering and design starts a project manager has effective control on only the remaining 20% of the total project budget. Unfortunately, project planning usually focuses on the construction activities. A retro-fit project, to be successful, needs a thorough project plan that includes a well-defined project scope, a WIN, and a control system to track total accrued and actual costs and scope changes prior to starting the execution phase.

The traditional approach to project planning and control at PG&E was developed for large, new engineering and construction projects that entailed long project schedules and substantial expenditures during construction. The typical electric transmission and substation project today is relatively short in duration and substantial costs are committed very early. The focus on construction should be replaced with an emphasis on the engineering decisions during project development and early into the execution phase.

BACKGROUND

Pareto's 80/20 Law

The 17th Century economist Wilfredo Pareto observed that 20% of the population controls 80% of the wealth. So too, major material and the associated engineering and procurement effort account for 80% of a retro-fit project's budget.

Instead of spending most of the planning effort on defining construction activities that account for only 20% of the budget, project managers should focus their attention on defining design scope, especially major material.

Project planning and controls at PG&E for greenfields projects focused on the construction phase which typically accounts for only 20%. These projects included new substations and transmission lines and are construction

intensive. Specifically, making sure construction received materials and design in a timely manner to start construction and then monitoring and controlling each construction activity closely until completion. Unfortunately, the majority of capital projects today are retro-fit projects. Retro-fit projects are major material intensive and relatively short in duration, 6 to 12 months. These projects typically involve replacing high voltage circuit breakers or relay protective schemes, or reconductoring transmission lines.

The high level of planning effort usually directed at the construction phase appears misplaced. *Within a few months after engineering starts a project manager has effective control only on the remaining 20% of the budget.* Therefore, planning effort is most effective if expended on developing and defining the project scope, including the likely vendors and prices for the major material. To wait until after project authorization to identify material and vendors for such electrical equipment, as transformers, circuit breakers and specialized conductor can prove disastrous to a project budget.

Transmission & Substation Study

In 1992, PG&E conducted an internal analysis of thirty electric transmission and substation projects to identify unit costs for electrical construction. The study revealed interesting statistics: Within two months after project authorization approximately 80% of the total project costs on a typical retro-fit project are committed. The committed costs represent both major material purchase orders and initial engineering and material procurement labor. Major material accounted for nearly 70% of total project costs. Also, construction typically spent less than 20% of the total budget. The breakdown is as follows:

- Material - 70%
- Construction & Test Labor - 20%
- Engineering & Project Mgmt - 10%

The study revealed that overall on retro-fit projects that construction labor, including testing accounted for 20% of the project costs. Material purchases represented about 70% of total costs. Field purchased material was less than 10% of total material costs. As a result, after construction has begun a project manager has effective control over less than 30% of a project's total direct costs.

However, most clients and project participants were not fully aware of the implications that continuing to develop scope during initial engineering had on an approved project budget especially after only a few months. Too often a client requested a cost estimate be prepared before resolving the substantive scope issues. The result was a project plan; cost estimate, schedule, and scope document, that became a moving target. The projects that suffered this fate ended unsuccessfully. The project study was under taken as a result of several failed projects. The intent was to determine unit costs and how to improve the probability of success for retro-fit projects.

Included in the study was a comparative analysis of greenfields projects versus retro-fit projects. The differences are notable for the management approach to one is not necessarily appropriate for the other. The following is a summary of the significant characteristics from a project planning and control perspective:

Greenfields

- a. Emphasis on construction activities for project controls
- b. Casual scope definition during conceptual and development phases (not detailed)
- c. Long project life-cycle 2-3 yrs
- d. Large project team (50-200 people)

Retro-fit

- a. Emphasis on major material and committed costs for project controls
- b. Need specific scope definition
- c. Short life-cycle 6-12 mos.
- d. Small project team (10-50 people)

Often, on a greenfields project it is possible to overcome a negative impact from one activity by producing a positive impact from another. A series of trade-offs during the project by the project manager can result in a successful completion. The project manager can actually manage activities and resources during the execution phase to achieve the project objectives. Another attribute of large greenfields projects is the effect of "skills averaging" that results from a large project team. Skills averaging is the blending effect that occurs when combining workers of varied levels of labor skills, so that a relative uniform labor

productivity is achieved. As a project team the overall labor productivity is rather uniform.

However, a retro-fit project does not benefit from skills averaging. The project team is too small for the blending of skill levels to create an acceptable average productivity y . The small team's productivity can be influenced by just one individual. The labor skills and experience needed for a specific retro-fit project should be considered during project planning.

PROJECT PLANNING & CONTROL

Statement of Scope

Planning for a retro-fit project requires a greater level of detail than may be used for much larger projects. The overall level of effort required for a retro-fit project may encompass only one or more WBS activities on a large project. Therefore, a different approach is needed to effectively plan for a retro-fit project. The level of detail that should be used in planning is what is typically defined as a "Work Plan". A work plan is a detailed plan for one or more WBS activities, usually no more than six weeks in duration. Work plans are typically used to plan small segments of a project in a rolling wave method as the project progresses. In this application, the work plan method is applied to the entire retro-fit project. The purpose of this level of project planning is to identify the "sub-WBS" so that the work activities can be sufficiently defined and managed.

An important aspect of planning is defining the project scope. The scope statement is the critical element for retro-fit project planning. Scope becomes the foundation for the cost estimate and the schedule. As stated earlier, limited flexibility exists for changes in scope after a project has been authorized and the execution phase begins. Typically, project cost and schedule contingencies are sufficient to accommodate only minor changes in the original scope. Failed retro-fit projects tend to suffer from the same problems: a poorly defined scope of work, failure to recognize the impacts of potential scope changes during planning and execution, and insufficient buy-in from project sponsor on scope.

A quality improvement team at PG&E studied these problems and developed a set of recommended actions for project planning:

- Client involvement
- Job walk-downs using a checklist

- Field review of facility drawings prior to start of engineering
- Detailed scope document

It is crucial to get the project sponsor/client to buy-in on the project scope. The best approach is to solicit their input continually during the development phase. A retro-fit project budget is not able to accommodate a client that changes the scope after the execution phase has begun, for 80% of the project costs are likely to have already been committed.

A job walkdown is an investigation of the work planned at the proposed job site. The purpose of a job walkdown is to determine the constructability of the project and uncover additional work to include in the project scope. It is a method to refine the conceptual project scope. A job site visit by engineering, design and construction personnel is recommended to identify the engineering and design work required as well. Too often the existing drawings for a facility are not current which leads to problems during construction. This problem can be minimized by a job site walkdown by the project team. At the same time constructability issues can be addressed. These two aspects of a job site walkdown can significantly reduce the unique problems associated with retro-fit projects. The results of the job walkdown include: 1) a list of constructability items that form the assumptions used in developing the estimate for construction; 2) an itemized list of modifications to the scope so that a definitive written statement of work can be prepared; 3) a WBS for the construction phase of the project that includes all the work is required.

After the job walkdown has occurred, a detailed statement of scope and a list of estimate assumptions are prepared. It is important to see the linkage between the scope document, cost estimate and schedule and engineering, material procurement and construction activities.

During the planning phase a project manager needs to emphasize identifying the design scope including major material. A design criteria memorandum (scope document) describes rather well the engineering and procurement activity that will take place after project authorization and the start of the execution phase. Taking additional time during planning to develop this document and getting the project stakeholders buy-in is critical. Once the design criteria memorandum (DCM) has been accepted it will serve the project manager well as a basis for project estimates and a benchmark for controlling changes and project costs.

Time & Cost Estimates

Generally, a project estimate is viewed as the estimated (predicted) cost to complete a project. This view usually does not tie design scope absolutely to the estimated cost. As a result, during the project when design changes occur they are not always recognized for their influence on costs within the project estimate. An alternative view is to consider a cost estimate to be a prediction of the final design. This is often a different perspective for people involved with estimating and cost control. By considering the job estimate to be a prediction of the final design and the costs associated with engineering and constructing that design, it is very apparent the affect design has on project costs. It is for this reason that the level of engineering applied to project scope development determines the type of estimate: Conceptual, Budget, or Construction.

Conceptual (order-of-magnitude) estimates are those estimates that are prepared during the conceptual phase of the project. Minimal engineering effort is usually directed at defining the final project design scope and for preparing these estimates. Project scope ranges from concepts to some basic engineering design in definition.

At PG&E project authorizations for electric transmission and substation work are sought using budget estimates. Budget estimates are also called detailed conceptual estimates or owner's estimates. Detailed conceptual estimates are those in which material quantities are predicted category by category (e.g. structures, bus, insulators, breakers, relays, etc.) and then priced. These estimates are prepared after the project team and the internal client have developed the project design criteria memorandum (predicted final design scope).

Construction estimates are those estimates prepared after all substantial engineering and most design is complete. These estimates provide the greatest level of estimating detail since the project design scope is nearly complete. Unfortunately, while this may be ideal and standard practice to use these estimates for most industrial engineering and construction projects that are contracted, most utilities rely on budget estimates for project authorization and as the project control estimate.

Risk Assessment

Retro-fit projects are relatively short in duration, material cost intensive, and based on a prediction of final design scope. That does not afford a project manager much leeway to manage a project. The project's success is a result of the planning effort. The final consideration during planning is an assessment of the project's risk. This is particularly important for retro-fit projects since most of the

project resources are committed soon after the execution phase begins. The principle areas of risk are:

- Major Material - Prices, Delivery Schedules & Quality
- Engineering Labor - Experience, Expertise & Quality
- Construction Labor - Experience, Expertise & Quality
- External & Internal - Economic, Business, Environment, Etc.

Identification and assessment of the risk elements in a retro-fit project is essential to understanding the pitfalls that may occur. The early recognition of risks allows for the development of action that can be taken to mitigate, deflect, or assume (through contingency planning). It is almost always too late to wait until the risk has been realized on a retro-fit project to address the issue.

For example, a 500 kV SF₆ circuit breaker for a breaker replacement project is ordered from a manufacturer that has no previous experience building a circuit breaker for that voltage. The manufacturer does have experience building circuit breakers for lower voltages and has substantially discounted the price of the 500 kV breaker to gain entry into the extra high voltage market. What are the risks? A few are: Can the delivery schedule be met? Will the product meet quality specs? Does the discounted price offset the associated risks of this decision? What can be done to mitigate or deflect the risks? These and other issues should be addressed by the project team and client. A risk plan should be developed as a result of the risk assessment by the project team and client. It is important for the project manager and project team to be pro-active.

Perceived Control vs. Actual Control

The problem with focusing on the construction phase is that it can create the false impression that a project manager has the opportunity to manage costs by following the traditional S-Curve of project expenditures. Unfortunately, what they do not realize is that:

They have a tiger by the tail and no control of the tiger - in fact, they may be eaten by the tiger.

Project managers have often tracked project costs using a system based on only recording costs on a cash basis, i.e. when an invoice is received and paid. This approach to cost management will lead to trouble in a material intensive project. By not accruing committed costs along with the out-of-pocket costs a true picture of the overall project expenditures is not visible. This leads to problems when the inevitable scope changes start. Committed costs are those costs that are accrued but not yet booked. For example, issuing a purchase order with a vendor for material.

The purchase order commits the project to the cost of material when it is ordered, despite the fact that the material invoice will not be booked and paid until the material is delivered to the jobsite weeks or months later. Too often the committed costs are not considered. For example, when a change in design occurs the true impact of that change is not known until the actual costs have cleared several months later. Usually too late for any corrective action to mitigate a negative impact.

Without the whole cost picture (committed costs plus actual costs) a project manager cannot determine the effect a scope change will make on project cost. This is particularly true for electric transmission and substation projects because of the early material procurement activity due to long lead times for delivery. Tracking only actual costs understates the real financial position at any given time during a project. The perceived ability to manage the remaining costs to within the project budget is overstated. For example, two months into a circuit breaker replacement project only 10% of the project budget has been expended, but nearly 80% of the budget has been committed.

This figure is actually larger if the associated installation labor is considered along with the material when the purchase order is issued. Including the installation labor costs with material costs can lead to the conclusion that most project costs are committed when the material is ordered. This conclusion is important to effective control of a retro-fit project.

Project Controls

Scope, Cost and Time management are three particularly important aspects of a retro-fit project that a project manager should consider when developing project controls. Retro-fit projects typically do not allow for significant changes in scope, budgets, or schedule duration. Contingencies sufficient to cover these changes are not usually included in the project plan or allowed by the project sponsor/client. Therefore, proper controls are necessary for the project manager to monitor and manage the project successfully.

Scope controls involve two aspects; changes in scope and changes within scope that were not included in the project plan. Scope controls for both aspects should include a formal procedure for requesting a change that includes:

- Reason for Change
- Cost & Time Estimate for the Change
- Budget & Schedule Impact of the Change
- Project Manager Approval or Recommendation
- Project Sponsor Approval (above a threshold amount)

A log of the change requests is needed to establish a record of the final project scope as-built when the project is complete. This log is an important piece of information in preparing a project analysis and critique.

Changes within the project scope are treated the same as scope changes because of the similar impact on the overall project schedule and budget. Also, it is usually difficult for most internal projects to request additional money or time for changes in scope. Management assumes that the project team did their homework when they prepared the project plan for authorization.

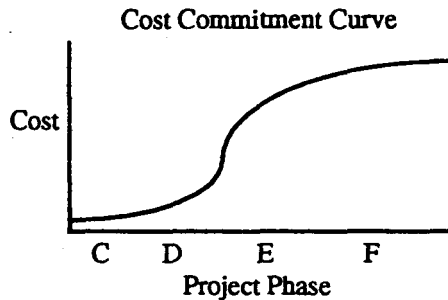
Traditional cost monitoring methods such as cash flow curves, planned costs versus actual costs, forecast to complete costs and forecast at completion cost should be used. In addition, tracking committed costs on a retro-fit project is critical if the project manager is to know the full financial status for a given period.

Committed costs represent the single largest expenditure on most retro-fit projects. When combined with the engineering and procurement effort to order the material these costs represent as much as 80% of the overall project budget. To effectively monitor and control the project costs the committed costs should be included into the project cost plan.

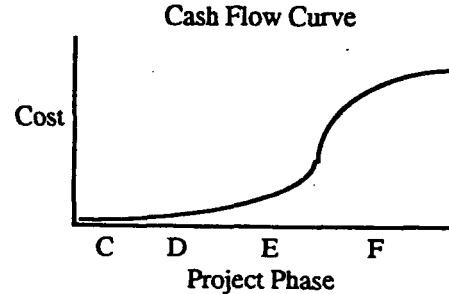
$$Ca + Cc + Ftc = Fac$$

- Ca = Actual Costs to Date
- Cc = Committed Costs to Date
- Ftc = Forecast Cost to Complete
- Fac = Forecast Cost at Completion

A separate committed cost curve should be developed, in addition to the traditional cash flow ('S') curve. This curve is developed by plotting the committed costs to date (Cc) plus the actual costs incurred to date (Ca). The cost commitment curve looks like this:



The project cash flow curve presents a much different financial picture. One that can lead a project manager to perceive that they have greater flexibility in managing the project budget than actually exists. The cash flow curve does provide valuable information to the project manager. By itself the cash flow curve does not illustrate the financial condition of the project adequately to assess current status.



Tracking committed costs and actual costs is an effective cost management tool for a retro-fit project manager. It provides a better perspective of the financial status of the project and serves as a better resource for assessing changes that occur on a project.

Summary

Project plans that include a well-defined statement of project scope are a fundamental reason for successful electric transmission and substation projects at Pacific Gas & Electric. The final accuracy of a project estimate relies solely on the definition of scope used for estimate preparation. Internal clients and project teams often overlook this during the project planning phase. Many times a client and project team expedite the planning phase to start engineering and assume that they can adjust project scope to fit within the approved budget once the project is underway. Unfortunately, about 80% of a project's total costs are committed within the first few months during project implementation. Ironically, most project planning focused on the construction phase, where construction forces expended less than 20% of the total costs. The results reflect the principle of Pareto's 80/20 Law.

Project managers need to recognize that to effectively manage project costs their planning efforts must concentrate on the 80% of a project and the relationship between well-defined project plans and successfully meeting project cost commitments. The primary end product of planning should be a well-defined statement of scope. That is the required basis for preparing accurate cost estimates and schedules.

Project control tools selected for retro-fit projects should allow the project manager a valid assessment of the project's status for a given period. Project controls need to include the element of committed costs. Otherwise, a distorted financial picture will occur that is likely to mislead a project manager.