Power Plant Construction Management

Contents

Preface

This book, the second edition of the original *Power Plant Construction Management: A Survival Guide* has been written to update and upgrade its predecessor. Almost a decade has passed since the first edition. A lot has transpired, and sometimes re-transpired, during those years. As discussed in more detail in the introduction, since the first edition was published the construction industry in general, and the power plant construction industry in particular, have had several ups and several downs. The construction industry went through major shifts in the availability and cost of labor, supervision, equipment, and materials. It has started to embrace advanced technology, tools, and processes made available with the exponential advance of computers (especially their downsizing) and computing power, intelligent cell phones, and the Internet. And during this same period, the power plant industry has seen shifts to and from coal-fired generation, gas-fired generation, solar, wind, nuclear, and other renewables. In other words, the only constant during this intervening decade has been change.

As was the case for this book's first edition, this second edition has also been written to provide economic guidance and support to those involved in the management of power plant construction activities, whether these activities are the building of a new plant or the rebuilding, repowering, or modification of existing components. This book is not intended to be a technical "how to" manual on performing construction work, on selecting the mechanical tools and equipment for executing the construction activities, or on directing the day-to-day activities of the work. Instead, this edition, just like its predecessor, is intended to provide a stimulus to perform these tasks in a cost effective manner—to think outside of the box—to think about the financial stakeholders of the project/s at hand. In other words, this book will not help the reader to select the right crane for a particular lifting task, but it will offer the reader support in deciding whether using a crane in the first place is the most economic thing to do.

Although the book title and its supporting examples are specifically power plant oriented, the fundamental theories and practices discussed within are applicable to any construction endeavor, from power plant construction to road building, from refinery construction to chemical

process plant expansions, and for commercial and municipal projects. The underlying premise is that the construction activities being undertaken are being performed for the ultimate benefit of the owner/stakeholder, and this owner/stakeholder expects a return for investing in this endeavor.

Still today, too many projects, within and outside of the power plant industry, do not meet the expectations of their stakeholders from an economic perspective. Some of the reasons for this can be traced back to events that preceded the start of site activities, and for this reason this second edition includes information and provides examples of what to do, and not to do, early in the project cycle. It goes into the initial decision-making process of whether a project should even be undertaken from a construction risk point of view. It covers the development and understanding of construction specifications. And it drives deep into the budgeting and estimating phase of preparing for a construction project. The first edition only covered this material from a 30,000-foot level.

As pointed out by many of the contributors to this book, maintaining awareness of the finances of the site construction activities is extremely important, but being able to predict—and correspondingly impact—the outcome, early during the project, is even more crucial. As one contributor, John Long, who is now retired from Constellation Energy, put it, "Surprises are not acceptable." In other words, the outcome may be inevitable, but it is crucial to be able to predict this early on; the owner/stakeholder must be afforded the opportunity to mitigate.

The first edition was written to provide support for several different circles. First, it was a treatise on managing the economics of power plant construction, intended to be useful for the site superintendent to get from today to tomorrow. Second, it was intended for the site general manager to direct his staff in performing their duties in a coordinated and focused manner. But third, it was also written to provide the management of all site personnel a primer on what to expect from their charges and how to offer them ideas and support. The first edition book provides detailed formats for accomplishing many of the tasks of performing construction management, and it offers examples of how to use these formats in various settings. This second edition does the same, even using some of the same language and examples, but it also enhances the information in the first edition by extending the circles to include much more of the pre-site work. Both are designed to be useful in teaching environments. In fact, the

first edition has been used as the foundation for many one- and two-day construction management workshops ever since it hit the bookshelves in 2005. It is intended that this new revision will be the foundation for many more workshops, both in academia and in industrial settings.

As a final note, this second edition does not specifically address working outside of North America. The first edition did. That is not to say that the information in this second edition is not applicable to working elsewhere in the world. It is. But when planning and managing construction projects beyond our borders, a lot more is required. There are cultural impacts. There are different legal implications. There are skill level challenges. There are distances, terrain, and seasonal hurdles to overcome. The list goes on and on. Therefore, if one is seriously considering a project outside of North America, the first edition of this book is still a must-read.

As the author, I hope you, the reader, benefit from the contents of the book you are now holding. I hope you will share the contents with your peers. As a former coworker Gary "Red" Wilcoxon once said about the first edition: "Many can bid and win, but few can track and execute. If you find the problems fast you have time to react, even if the work is fast-paced. The tools are in this book—Read it and use them." I look forward to meeting some of you as time marches forward, and I look forward to hearing from you—to hear how some parts of this book made your jobs successful as well as where things did not work out so well. Please let me know at PGHessler@ConstrBiz.com.

Introduction

When the first edition of this book was written nearly a decade ago, the power plant construction industry had just undergone a major transformation. It had gone from long-term, large-scale, coal-fired power plant build-outs to fast-track, smaller-sized, gas-fired, combined-cycle plant builds, mostly due to low gas prices at the time.

But after the first edition was published, the price of gas went through the roof, and these gas-fired projects came to a screeching halt. The industry actually reversed itself and started looking at major coal-fired projects again. For example, in 2007, the U.S. Department of Energy's National Energy Technology Laboratory (NETL) published a study suggesting that about 100 GW (gigawatts) of additional power capacity would be needed by the year 2020, and almost 50% of that was to be coal-fired.[1] These coal-fired plants alone amounted to nearly 150 new projects. The increase in the economic activity of the country and the increase in population growth at that time was creating an insatiable demand for more power, a demand that seemed to be opening up one of the busiest times ever in the power plant construction business. That was then.

But, wow, what a change just one year later, let alone two, three, and more! That pending construction boom had everyone extremely busy getting ready for it. Even I, while working on this second edition book, was forced to postpone its completion while working with owners and contractors to move forward for this unprecedented, impending boom. But then, suddenly, the U.S. power plant construction world turned upside-down again. The political landscape went into a state of flux, no longer providing a clear view of where power plant owners could prudently take risks. Climate control legislation was unpredictable, leaving many owners in the dark as to what pollution control technologies would be required. They could have spent hundreds of millions of dollars, only to find out that the newly installed pollution control equipment did not remove the pollutants that might be legislated out in the future. So owners stopped planning for large, new coal-fired plants.

Then, starting in 2008, power plant project cancellations became endemic. Costs for the construction of these planned or in-progress plants, especially the coal-fired plants, had started escalating at an out-of-control pace. According to the February 14, 2008, edition of the electronic version of *Power Engineering*, "the cost of new power plant construction in North America increased 27 percent in 12 months, and 19 percent in the most recent six months."[2] This led to a change in the business model for constructing power plants. Construction firms were no longer willing to commit to fixed-price contracts. Instead, they were attempting to shift the risks of these higher material and construction prices to the plant owners. And on top of this, the "Great Recession" hit, so regardless of the cost of building power plants, money was suddenly just not available. The result is that of the 150 coal-fired power plant projects reported in the 2007 NETL study, a lot fewer were or will be built. Instead, in their place will be more gas-fired plants, along with various renewable power generation projects.

According to a follow-on NETL study published in 2012, the additional power capacity build-out between now and 2020 will have a fuel mix that has shifted dramatically from essentially a 50/50 coal-fired/gas-fired combination to a 30/70 ratio, with gas-fired generation expected to be the plant of choice.[3] There are two specific reasons for this. The first is the dramatic increase of available shale gas, heretofore inaccessible, through the use of a technology called fracking; this has driven the price of gas so low that the economics dictate gas over coal. The second reason is the high cost of additional equipment that will be required for new coal-fired plants to capture CO_2 in the future, thereby eliminating them from consideration for many future projects.

Had this book gone to press as originally scheduled, it would have been based on obsolete facts, out-of-date data, and conditions that no one ever anticipated. Now, the reader can take comfort in the knowledge of these recent, turbulent conditions. That is not to say that other, unforeseen issues will not arise in future years. Certainly, they will, so one must always be ready to adapt, that is, have a Plan B. But the need for prudent construction management will always be there, whether for new-build coal, gas, or renewables; retrofits; transmission lines for electricity and fuel; or just general maintenance outages. As Tony Licata, retired vice president at Babcock Power Environmental, Inc., put it:

> Since the first edition of this book was published, our industry has installed 100,000 MW of FGDs [flue gas desulfurization systems] and 140,000 of SCRs [selective catalytic reduction systems] in coal-fired power plants. Almost all of this work was done on brown field projects in retrofit applications. The application of these technologies in most cases was on extremely difficult construction sites in operating power plants which required a new approach to construction project management. The insights to project management in that first edition book have been a very useful tool in our approach to these projects. Managing projects in this new scenario also has forced a change to the contractual terms and conditions over this period, requiring updating our approach to the market from firm price to alliance type projects and then back to firm price projects.

In other words, the only constant is change, and therefore project and construction managers must be able to adapt to these changing conditions. That is the purpose of this second edition, to discuss how to maintain a prudent construction management process, even as the underlying forces are shifting.

Today, It's Still All About the Money

No longer do the rules of the 1960s, '70s, and '80s apply. Today's set of rules governing the power generation industry are the rules of economics. The power generation industry today has owners that place a greater emphasis on the return on their investment than owners did in the past. The industry has changed forever. Even where there is still protection through regulation, owners, including shareholders, want to see a return on their investment *now*. The former protected guarantee of blue-chip stock returns from the major utilities has gone the way of the industrial giants of yesteryear. Today, to stay in business, a company must provide a return to its shareholders that exceeds what they could earn elsewhere. In essence, any business today is only as viable as the edge its return on investment has over other options those investors may care to explore; most power companies are now viewed as expendable by their shareholders. The power plant business of today is about much more than just generating megawatt hours, it is also about generating profits for the investor.

Planning a power plant project and planning the construction activities of a power plant project in today's environment require a financial focus. Equipment, technology, and operational skills have improved since the last building boom. But now there is a shortage of skilled labor and skilled supervision to embark on major building programs. Between 1990 and 2010, a generation of power plant construction skills was lost. This will require that a different approach to the planning and execution of these new projects is used.

According to various sources within the industrial construction community, the average age of a certified pipefitter construction welder is approximately 42. The new apprentices entering the workforce are young and inexperienced, and it takes 10 years or so before they are at their peak performance. Therefore, working smarter is necessary. Preplanning in the early stages of a job has become a necessity. Preplanning just-in-time deliveries is important to facilitate smaller footprints and laydown needs, as well as for controlling the cost of inventory control and storage fees. Not only is an emphasis on safety morally correct, but it is also a major factor in the bottom-line labor costs. The list goes on and on.

Using a Managed Process

As utilities start planning, they do so with an eye on the return on their investment. They select the technology, the fuel, and the plant site with this in mind. The same applies when they select the participants and plan the process. Today, more than ever, the preplanning of the construction phase of a power project will impact the total costs of that project, whether it is building a new plant or rehabilitating an old one. Although the construction phase occurs at the end of the project process, it is really the tail that wags the dog. The project concept may start in operations, it may start in maintenance, or it may start in engineering. But then it moves into budgeting, and from there to project management and the construction preplanning phase. And when it gets to the field, the cost of change, the cost of inefficiency, and the cost of cancellation can be devastating. Therefore, the path to success is to link all of these phases by preplanning the process so it can be managed toward a successful conclusion.

To manage a power plant construction project, one must look at three basic elements:

- Pursuing and ensuring a manageable contract (or contractor)
- Structuring the contract correctly
- Managing the contract to a successful conclusion

The first edition of this book only addressed the latter of these three elements. This second edition addresses all three. It uses examples that are more in line with tomorrow's expected power mix, such as a heavier emphasis on gas-fired generation. The data have been updated to reflect current-day numbers and the trend toward more technology. Preplanning for a construction project requires a dedicated and managed process; this book covers how to achieve that. The need for adequate resources to preplan is addressed. Contingency planning is covered from a view of factually determining how much, if any, contingency should really be included.

The budgeting, bidding, and estimating phases are introduced. The concept of managing this stage of the project, as if it were the site work itself, is discussed. Developing and writing, as well as reading and understanding, the specifications come next. There are many different thoughts on how this should be done, and these are compared. Designing the work scope and reviewing its logic is explored, and developing the resultant schedule and constraints is explained with examples of what can happen if not properly done.

Time is spent discussing how to develop price requests, how to develop pricing based on these requests, and how to structure the contract so pricing can be changed, if necessary, as the project goes forward. This is then translated into payment requirements. Taxes are addressed, and the pros and cons of penalties and bonuses are shown, with examples. Also, there is a detailed discussion of the importance of cash flow.

The estimating process is looked at from both the owner's perspective and the contractor's viewpoint. The importance of a site visit is highlighted with checklists. Labor, tools, and supervision are reviewed from a perspective of current-day costs and availability, and then there is some discussion about how to extrapolate these costs into the future. Additionally, the cost savings of proper quality control and safety planning are put into perspective, and finally, the methods of arriving at the total budget, or price offering, are described.

Next, planning the delivery structure of the site works is addressed. Things change during the overall project timeline, and even though the delivery structure may have been envisioned one way during the preplanning stages, it needs to be reviewed in light of actual conditions that exist as the work begins. As an example, resources such as labor, supervision, and tools and equipment may no longer be as available as was once thought. This is addressed, along with training.

Commercial terms and conditions are explored. Examples are given to show what can happen, or not, if the people in the field do not understand these requirements. This then leads into a chapter on risk management. Preparing for thorough risk management at the job site is addressed by discussing the risk management stool and how it is supported by its three legs: the insurance coverage, the claims management process, and the contract wording. This book explores all three.

Next, there is a chapter on setting up the site itself, followed by a chapter on managing quality and safety from a financial perspective. In fact, the central theme of this second edition is identical to the successful original edition, managing the financials of building a power plant (or any other heavy industrial project, for that matter). In the next three chapters tools are provided to assist in setting up and managing the finances of the site works. There are checklists, guidelines, photos, and examples that can be used immediately for managing the work activities and reporting results, up and down the line. By using these tools, the decision making process can be greatly enhanced.

Finally, there is a chapter on how to use current-day technology to make the work of managing the process at the job site much easier. Since this technology is constantly evolving, suggestions are offered as to how to stay on top of it.

It is the author's hope that the reader will find the topics herein to be of use in his or her own daily practice. As stated in the original edition of this book:

> I've taken all the body of knowledge that I've come across over the years, combined that with the observations of how things seem to really work out on the street, and the result of that is what I've come up with in this book.[4]

Read on and enjoy.

Preplanning to Planning 1

(with content from Mark Bridgers)

As discussed in the Introduction, preplanning cannot be overemphasized. Many instances of project failure can be traced directly to the lack of project preplanning. When an owner ponders the pros and cons of embarking on a project, or when a contractor looks for projects to bid on, some fundamental criteria should be in place, both technical and economic. If the project does not meet these criteria, the owner needs to rethink the plans and the contractor needs to be willing to say "no" to the opportunity. This is the start of the preplanning process.

However, the preplanning process needs a preplanning team. The team members must be knowledgeable about the purpose of the project, and they need to understand the impact the project can have on the organization. In the course of their work, they will develop an understanding of the project's risks and rewards, and they will assist management in deciding whether this project should be undertaken, and if so, why and how (for both the owner and the contractor).

But, where do the resources come from to do all of this? Funding may not even be available yet. So how do you pay for a preplanning team? Where do preplanning support groups charge their time? What are the earlier mentioned fundamental criteria? Who decides? How? When?

Once the preplanning team is in place, it should consider looking at past projects—those that were successful and those that were not. Part of the preplanning process is learning from the past. Preplanning should be a process where the project specifics are investigated in enough detail to form overall execution strategies. Local conditions, resources, and impacts on the community should be reviewed. Permitting should be addressed. (See chapter 4 for more on permitting).

Then, the preplanning team should move on to considering the project delivery system. Should there be a formal alliance, a clear subtier contracting arrangement, or what some in the industry now call *coopetition*? Or does

responsibility for risk management on the project participant who can most effectively mitigate it.

The volatile nature of the power generation business often makes it difficult for project owners to plan for the most effective project delivery structure very far in advance of the start of the project's execution. Just look at the number of projects that have been planned and then cancelled or switched to a different fuel. Therefore, the preplanning team sometimes must take a leap of faith and suggest a project delivery structure even before they have all of the facts that will impact the project, if it goes ahead.

From an owner's perspective, funding also takes center stage at the outset of a project. Where does it come from? How much is required? How is it to be guaranteed (to the lender)? An important segment of the funding involves the time of construction, because the longer this work takes, the more the interest costs increase. Sometimes it may be more cost-effective to double-shift or work overtime to keep the interest costs at bay.

Finally, no matter how thorough the planning, no matter how carefully and thoughtfully the plan was developed, certain things *will not happen as planned*. There may be labor strikes or bad weather. There may be bankruptcies. There most likely will be scope creep. There may be many other unforeseen changes, all of which must be accommodated in some fashion. Therefore, contingency planning must form a part of the overall planning process. The two most disruptive issues are project delays and unforeseen parallel projects. Therefore, some type of contingency funding, and management of those funds, must be developed to address these and any other potential disruptions.

Once this preplanning phase has been traversed, the next steps will be to develop the actual costs or numbers that the contractors will require to perform the work. For the owner, this means starting the bidding process, the subject of the next chapter. For the contractor, it means looking at all of the details and risks (the subject of the next few chapters) and learning more about planning (chapter 4). Read on for ways to answer many of the questions raised in the previous pages.

limit the percentage of extra work that can be performed under the extra work rates. A typical example of this limitation is a clause stating that if the extra work exceeds 15% of the base contract value, then the contract price shall be subject to renegotiation. This is done to protect both parties. On the contractor's side, if the work significantly increases, the contractor may not have adequate supervision and site support facilities in place to handle this increase of scope and, without this limitation clause, may not have any recourse to be reimbursed for these extra costs. On the client's side, if the scope is reduced significantly, and this type of clause does not exist, then the client may be paying the contractor for establishment costs originally anticipated but now not needed.

Qualifiers

Then, there also may be a need for including qualifiers to address special circumstances and specific assumptions made when the bidder developed the price. For example, the bidder could include qualifiers, such as the following, that spell out what is expected to avoid potential problems from issues such as the delays incurred in the previous feed water pump example: "The Seller will meet the schedule guarantees *provided the Buyer grants unobstructed access to the site, with the equipment prepared, ready for use, on the date agreed in the contract schedule*."

Another qualifier that helps clarify intent is the following: "The Seller will meet the schedule guarantees *provided the Buyer provides all materials to the site, prepared ready for installation, in accordance with the installation sequence*."

To illustrate the importance of the second case, let's look at the problems an insulation contractor can run up against. Like most projects, assume that this one has an immovable date of completion. Assume that the ultimate contract does not have the second clause referenced above, but that it does have heavy penalties for not meeting the completion dates and no other "changes" clause that addresses relief of schedule. (As already noted above, this should not happen, but sometimes it does.) The main contractor now schedules a set of work release dates for the insulation contractor to get access to the work areas. Now suppose the material arrives ahead of schedule, but as the work area release dates arrive, the mechanical contractor has not completed work sufficiently for the insulation contractor

Unfortunately, the representative decided not to visit the site himself. Instead, he telephoned the plant management and asked for answers to the questions in the guidelines. He did not go and personally look around. He did not see the labyrinth of overhead high-voltage lines, cable trays full of cables to operate the existing equipment, or the multitude of large- and small-bore pipe trains that crisscrossed the plant space, both above and below grade. Since he did not see any of this, and since the plant management did not spend much time answering the questions, these obstructions were not noted. To make matters worse, the vendor of the equipment was supplying the equipment in large, preassembled components to save on installation time in the field. This meant that large, heavy-construction equipment would be required to move the components on-site and lift them into position. The estimator, back home in the United States, therefore knew nothing about any of these conditions and proceeded to price the work in a fashion that did not include any efforts for temporary rerouting of these obstructions. Fortunately, at the very last minute, before the bid was to be submitted, the contractor found out that the representative had not visited the site. The contractor realized that his cost estimate for the work could be inadequate, and therefore he did not submit a bid.

There are other instances where things did not end so fortuitously. Take the case of the contractor who successfully bid to transport a preassembled boiler from the unloading harbor dock to the site, and then erect it in place within the plant. When the truck carrying the boiler from the harbor to the plant encountered a tunnel, it was no-go. The boiler was too large to fit through the tunnel. No one involved with estimating for this work took the time to actually travel the route that the equipment would have to traverse to get to the site; that is, no one made a thorough site visit. Unfortunately, there was no convenient bypass around this tunnel, so the boiler had to be brought to a side location, partially disassembled (i.e., cut apart), then the pieces taken through the tunnel to the site and reassembled. Quite a costly process. The contractor lost money, and the owner was not happy.

So how does one avoid such situations? The first approach is to listen to all of the horror stories such as these. Then, prepare a checklist, such as that in Appendix D to use for every site visit. Even this list is not complete. It will not guarantee that every abnormal job-site condition will be discovered. But it is a starting point.

based on material availability; realistic, proven labor productivity; and so on. It is a collaborative planning approach. As Greg Howell, one of the two cofounders of the Lean Construction Institute puts it:

> Lean construction produces rapid learning. Starting at the assignment level, understanding an assignment to my crew as a promise to the next crew drives a stake in the ground. Understanding where our preparation fell short at a detailed level makes it possible to prevent recurrence. Apply Plan-Do-Check-Act to the planning system itself. The investigation of causes can lead to improvements in logistics, operation design, and coordination across a variety of levels. In most cases, preassembly increases as workflow becomes more predictable, in part because there is no need to keep stores of smaller pieces close to the workforce to assure people can be productive when things go wrong. One unexpected consequence of this line is the significant reduction in contingencies hidden in every budget and schedule. More important is the reduction in accidents and injuries with many sites reporting a 50% reduction. We believe these results are due to the improvement in production system design rather than the motivation and training of the workforce.

Finally, Developing the Numbers

When one gets down to it, estimating is all about developing the numbers. Estimates or budgets based on estimates are used to determine if a project is viable, and they are all made up of numbers. Numbers are also the backbone of the estimates used by contractors to prepare the bids submitted for project opportunities. So it is of paramount importance that these numbers are the right numbers. These numbers must represent exactly what they are said to represent, without hidden extras. For example, the man-hours to accomplish a certain task must be exactly the man-hours that are expected to be used for that task, no more, no less. If any contingency is required due to a lack of clarity or due to unforeseen events, those contingencies should be accounted for as separate numbers. Let's say that a utility has set aside a fixed number of man-hours to open, inspect, and make repairs on a steam turbine. Then those hours should be the base estimate for that work. If this utility is unsure of the amount of work that may ultimately be required, then it could potentially add some