BEFORE THE MINNESOTA OFFICE OF ADMINISTRATIVE HEARINGS
600 North Robert Street
St. Paul, MN 55101

FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION
121 7th Place East, Suite 350
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IN THE MATTER OF A COMMISSION INVESTIGATION INTO XCEL ENERGY'S MONTICELLO LIFE CYCLE MANAGEMENT/EXTENDED POWER UPRATE PROJECT AND REQUEST FOR RECOVERY OF COST OVERRUNS	MPUC Docket No. E002/CI-13-754 OAH Docket No. 48-2500-31139

SURREBUTTAL TESTIMONY AND ATTACHMENT OF MARK W. CRISP, P.E.

ON BEHALF OF

THE DIVISON OF ENERGY RESOURCES OF
THE MINNESOTA DEPARTMENT OF COMMERCE

SEPTEMBER 19, 2014

SURREBUTTAL TESTIMONY OF MARK W. CRISP, P.E.
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I. INTRODUCTION AND PURPOSE

Q. Please state your name, titles and business address.

A. My name is Mark W. Crisp. I am the Managing Consultant of Global Energy & Water Consulting, LLC. My business address is 4539 Woodvalley Drive, Suite 100, Acworth, Georgia (Suburban Atlanta) 30101.

Q. Are you the same Mark W. Crisp that provided direct testimony on July 2, 2014 in this case?

A. Yes I am.

Q. What is the purpose of your Surrebuttal Testimony?

A. The purpose of my Surrebuttal Testimony is to address issues, statements, and conclusions offered in Xcel Energy's (Xcel or the Company) Rebuttal Testimony filed August 26, 2014, in the Company's Life-cycle Management (LCM) and the Extended Power Uprate (EPU) project at Monticello Nuclear (MPUC DOCKET NO. E002/CI-13-754).

II. RESPONSE TO XCEL'S REBUTTAL TESTIMONY

A. XCEL'S CHOICES INCREASED THE COSTS OF MONTICELLO

Q. Do you have any opening remarks to offer that would add clarity to the Company's Rebuttal and your Direct Testimony?

A. Yes, while my Direct Testimony specifically addresses Xcel's Project Management decisions and project management execution, I did not offer an opinion, either affirmative or non-affirmative, on prudence of the LCM/EPU project overall. The purpose of my direct testimony on behalf of the Minnesota Department of Commerce (DOC or the Department) was specifically to bring to the attention of the Minnesota Public Utilities Commission (Commission) areas that, in my opinion and supported by information supplied by Xcel, raised substantial questions about the reasonableness of Xcel's management and execution of the LCM/EPU project that added costs and delays to the project.

The testimonies of DOC Witnesses Ms. Campbell and Mr. Shaw discuss the Department's overall approach to assessing whether Xcel met its burden of proof to show that it is reasonable for the Company's ratepayers to pay for the extensive cost overruns for Monticello.

Q. Did any Xcel Witness claim that you had provided an opinion on the prudence of their decisions?

A. Yes, Mr. O'Connor's rebuttal testimony stated that in his opinion I did not "determine that Xcel Energy's actions were imprudent." Xcel Ex. ___ at 2 (O'Connor Public Rebuttal). In fact and included in Mr. O'Connor's own Rebuttal Testimony, my assignment was to "identify the causes and reasons for the cost overruns that have occurred since the project was first approved." DOC Ex. ___ at 3 (Crisp Public Direct) and Xcel Ex. __ at TJO-2 Schedule 1).

Q. Did any other Xcel witness claim that you did not determine that Xcel's more than doubling the costs of the total of the LCM and EPU projects was imprudent?

A. Yes. Mr. Sparby stated that my "opinion" regarding Xcel's decision to proceed "on parallel tracks and pursu[e] a 2009/11 implementation …does not render the

Company's decision imprudent or wrong." Xcel Ex. ___ at 15 (Sparby Rebuttal). However, Mr. Sparby's testimony misses the point completely and does not address the concerns I raised regarding the effects of Xcel's choices, such as pursuing the project design, construction and license activities in parallel, on costs. As I stated in my direct testimony regarding the challenges of using the parallel approach that Xcel chose to use:

> In a parallel effort, the design team along with the plant operational team must be physically evaluating the logistics required to dismantle any retired existing equipment and remove those components from their specific installation sites within the plant while determining the physical size and installation requirements of the new equipment. Failing to follow these steps in the planning and design process almost guarantees schedule delays and cost overruns during the actual process of constructing the project.
> DOC Ex. ___ at 7-8 (Crisp Public Direct)

My direct testimony pointed out that Xcel's performance in the parallel path did not manage the project appropriately:

> Given the focus on my testimony on the reasonableness of Xcel's management of the project, I note that the program design and scope changes would have been minimized with proper initial scoping of the project. That is the function of a well thought-out scoping process. It may not have corrected all of the issues with scoping but it certainly would have minimized the issues.
>
> For example, Xcel should have anticipated the upgrade to the distribution system at the plant early on in designing the system, rather than the ad-hoc approach Xcel used. Xcel also should have known the size specifications of the new equipment early in the process. Not having that basic information in the initial estimates indicates that Xcel wasn't thinking through the process adequately to ensure that the design and scope were reasonably worked out at that time.
> DOC Ex. ___ at 7-8 and 10-11 (Crisp Public Direct)

Q. Did any Xcel witness agree with you that Xcel's choice to use a parallel path led to costs increasing for the construction at Monticello?

A. Yes. Mr. Sieracki did so in at least two places in his rebuttal testimony, even as he, too, claimed that I did not assert that Xcel's actions were imprudent. First, he stated:

> Xcel Energy has acknowledged that its initial cost estimates for the LCM/EPU Program were not accurate. This was in large part because "controlling factors" could not be completely assessed until the design was complete, the Plant could be walked down, and the existing conditions assessed. In my professional opinion, this is not an indication of imprudence but is rather a normal part of the design and implementation of a project that is being pursued on multiple tracks in order to capture the benefits of the project as quickly as reasonably possible.
> Xcel Ex. ___ at 5-6 (Sieracki Rebuttal)

Second, he stated:

> Mr. Crisp's testimony apparently ignores the need for Xcel Energy to approach the LCM/EPU Program on multiple, simultaneous tracks based on the need for additional generating capacity. As I discuss in further detail below, Mr. Crisp's criticism would be more appropriate if the LCM/EPU Program were a traditional design/bid/build project, in which a more detailed design is completed prior to the start of construction. When comparing the timing of Xcel Energy's need for additional generating capacity with the timing of completing the overall LCM/EPU Program, it was a reasonable decision for Xcel Energy to not take that other approach. Under the circumstances, it was appropriate for Xcel Energy to decide to move forward on multiple tracks to increase the chances of successful and timely completion.
> Xcel Ex. ___ at 10-11 (Sieracki Rebuttal)

While Mr. Sieracki also ignored several points I raised as to Xcel's poor performance in using the parallel approach (such as Xcel not even having the size of the new equipment scoped out before filing a certificate-of-need petition with the

Commission), I appreciate that he agreed that my criticism would be "more appropriate if the LCM/EPU Program were a traditional design/bid/build project, in which a more detailed design is completed prior to the start of construction."

I note that DOC Witness Mr. Shaw discusses the "need for additional generating capacity" that Mr. Sieracki references above, along with options that were available to meet that need at that time.

Q. Did Mr. O'Connor's testimony specifically address the basis for his assertion that you provided a finding of prudence in your testimony?

A. Yes, Mr. O'Connor made specific reference to Utility Information Request No. 8 which I provide below for clarity and completeness of the answer.

a. Is it your contention that it was imprudent of Xcel Energy to:

1) begin project design in parallel with licensing and construction activities in 2006?
2) contract with GE for design work?
3) select Day Zimmerman/Sargent Lundy in 2007?
4) transfer some work scope to other contractors in 2010? or,
5) retain Bechtel in 2011?

<u>Response</u>

The question does not accurately reflect the role of Global Water & Energy in this proceeding. As stated on page 3 of my Direct Testimony:

> Global's assignment is to work with the Minnesota Department of Commerce (Department or DOC) to investigate whether Xcel's actions were prudent. We are to evaluate, from an engineering perspective, whether Xcel's decisions in response to NRC directives, lessons

> learned from Fukushima, and any other relevant factors in the time since the Commission issued a Certificate of Need (CN) for Monticello were necessary and reasonable. My assignment was to "identify the causes and reasons for the cost overruns that have occurred since the project was first approved." I do not determine that items 1-5 were imprudent; instead I indicate that they contributed to cost increases from the amount the Company first estimated. I concluded on pages 28-29 of my testimony as follows:

Q. Please explain how the scheduling issues impacted the schedule and budget.

A. "Fast track" refers to the project management effort requirement to engineer, procure, and construct a project in an abnormally short period of time. In the LCM/EPU project at Monticello, the schedule was to be completed in a single [refueling outage] RFO scheduled for 2011.

> Unfortunately at the time this schedule was approved by the Xcel Board of Directors, licensing had not begun, design was not started, little if any actual project definition had been accomplished and certainly the overall Project Management Team was not in a position to be responsible for such a project undertaking in this short of a timeframe. An expedited project is successful in meeting schedule, budget and constructability only if all components are completed ahead of the actual implementation.
>
> Projects such as Monticello with (as the Company indicates) a "small footprint" benefit from the time and effort to build a 3-dimensional model on the computer of the activities required to construct the design. Had Xcel not been so aggressive with schedules a 3-D design model would have been invaluable to point out conflicts and construction interferences. It is simply not wise to expedite a project without the benefit of proper project planning on the front end.
>
> Undoubtedly, the expedited approach caused delays and budget increases that could have been avoided with proper preplanning, project management and proper design sequencing. Proper Project Management and

> management strategy could have actually supported the 2011 or 2013 refueling outage. Unfortunately, neither of these occurred satisfactorily. The position of the Department of Commerce on the prudency of Xcel's decisions is addressed in the testimony [of] Department Witnesses.

Mr. O'Connor took out of context the favorable portion of the sentence but failed to include the complete subject of the sentence or of the answer. I did not conclude that the five actions taken by Xcel were imprudent, but neither did I conclude that they were prudent. However, I did conclude that these five (5) actions "did contribute to cost increases from the amount the Company first estimated."

In addition, I noted that the "position of the Department of Commerce on the prudency of Xcel's decisions is addressed in the testimony [of] Department Witnesses." As I noted above, Ms. Campbell and Mr. Shaw discuss the overall approach of the Department.

Q. Do you have anything further to note about Mr. O'Connor's statement about the five actions above?

A. Mr. O'Connor's question implies that a finding of prudence regarding the five individual actions listed above by Xcel would result in an overall conclusion that the LCM and EPU projects at Monticello were prudent. However, these five individual actions were only small pieces of a much larger kaleidoscope of actions that led to cost overruns and project management failures.

Q. Could a finding of prudence or imprudence be determined solely on the basis of these five individual actions taken by Xcel, as Mr. O'Connor has presented in his Rebuttal Testimony? (Cite: Page 2, lines 8-10 and Footnote 1)

A. Absolutely not. As I described in my direct testimony, there are numerous steps in planning for and executing a successful project:

> As with every major project and most minor projects the overall execution of the project is directly attributed to thorough and exhaustive project management. Success is defined by the schedule, cost, and operational benefits the project is able to accrue to the plant and to the ratepayers. Each attribute of overall project management, including proper staffing, scope definition, scheduling, budgeting, design, procurement, and construction is linked together to form a synergistic approach to the overall execution of the project. A project cannot expect to be completely successful if any one or more of the attributes fails to meet its goal.
>
> Each of these attributes must be addressed as thoroughly as possible in the initial project definition and the expectations defined for the schedule, scope, design, construction, start-up, operation, and final cost. The project management for the Monticello project suffered from failure of several of these activities to be adequately defined and for responsibility to be assigned to fully able and skilled personnel at each step in the process.
>
> DOC Ex. ___ at 6 (Crisp Public Direct).

Q. Do you have other comments about Mr. Sparby's testimony regarding planning?

A. Yes. First, Mr. Sparby stated:

> Department consultant Mr. Mark W. Crisp suggests that "'complexity issues' should not have been the cause of such high cost overruns of installation." I am concerned that this statement undervalues nuclear safety.
>
> Xcel Ex. ___ at 7 (Sparby Rebuttal)

Again, Mr. Sparby chose not to respond to my testimony regarding the need for appropriate planning of and timing for complex projects and instead misconstrued my testimony as suggesting that the Company should skimp on safety issue for a nuclear power plant. It's unfortunate that the Company both misconstrued my testimony and failed to address the legitimate concerns I raised about the difficulties Xcel had in planning for and implementing the construction projects at Monticello, especially given that Xcel was well aware of the small footprint, levels of radiation in various places in the plant, etc.

B. BENEFITS OF MONTICELLO ARE REFLECTED IN DOC'S TESTIMONY

Q. Mr. O'Connor was critical of Department Witnesses, particularly you and Dr. Jacobs, for not referencing the benefits accruing to the Plant as a result of the LCM/EPU. Is this criticism appropriate?

A. No it is not. Our specific charge did not include a review and determination of operating benefits of the either the LCM or the EPU. For discussion of the positive attributes of the LCM and the EPU, I point to Mr. Shaw's testimonies in this proceeding.

C. MONTICELLO LCM AND EPU AS TWO DISTINCT AND RELATED PROJECTS

Q. Xcel referred throughout its rebuttal testimony to the LCM and EPU projects as if they were a single effort or project. Were the LCM and EPU two separate and distinct projects?

A. Yes, in the overall purposes of the two projects, in the licenses Xcel filed with the Nuclear Regulatory Commission (NRC), and with the approvals from the Minnesota

Public Utilities Commission. The LCM project was defined to provide the necessary equipment renewals and upgrades necessary to bring the Plant up to standards, allowing Xcel to apply for and to obtain an extended operating license from the NRC. The EPU was designed to increase the power output of the Plant. Of course, implementation of the two projects can be done in tandem, but given that Xcel sought and received two separate approvals based on different goals and cost estimates, and given the extensive cost overruns, it is important to consider these two projects appropriately, as I discussed in my direct testimony and below.

Q. When was the Application for License Renewal for the LCM submitted to the NRC?

A. The LCM was submitted to the NRC on March 24, 2005.

Q. When did the NRC issue the License Renewal?

A. The NRC issued the License Renewal for the LCM on November 8, 2006.

Q. When did Xcel submit its application to the NRC for the Extended Power Uprate?

A. Xcel submitted the EPU application to the NRC on November 5, 2008.

Q. When did Xcel receive NRC approval of the Extended Power Uprate?

A. Xcel received NRC approval of the EPU on December 9, 2013. However, as of the date of this testimony, Xcel has not yet received authorization from the NRC to operate the Plant at the full 671 MWe that would reflect authorization to operate the EPU fully.

Q. Is it fair to say that based on the application dates to the NRC and the NRC approval dates that these two projects were, from a regulatory perspective, separate and distinguishable?

A. Yes.

Q. From a project management perspective, why is it important for these two separate projects to be viewed as two distinguishable projects, if they were undertaken during a similar timeframe?

A. These two projects require significant definition, scoping, design engineering and construction engineering for each project individually, to assess the reasonableness to pursue both the LCM and the EPU or the LCM alone. Combining the two efforts (without also keeping the details of each effort separate) only exacerbates the difficulty of making such assessments, let alone scoping, designing and constructing the projects. This fact does not mean that the two projects could not or should not have been designed and constructed in parallel with each other. However, cost management should have remained independent and distinguishable to support the underlying definition established in each independent and distinguishable CN, to help ensure that the projects remain within budgets, and to address issues that arise as soon as possible.

As I stated in my direct testimony, pursuing an LCM with an EPU requires coordination in planning, designing and constructing the combined project:

> Establishing the scope for the LCM/EPU project requires considerable coordination among all of the involved departments of Xcel, internal management of Xcel, the original designer of Monticello, the current responsible designer, in this case GE, and all sub-designers

> supporting the original design and the scope of the LCM/EPU. These entities need to accomplish the following tasks at the beginning of the project.
>
> In an established and functioning plant the first step in developing the scope of any project is to define the final outcome; that is, what is the project to accomplish, how will the project be accomplished, and what is the scheduled completion or operational date the project is to be completed.
>
> Secondly, before any design is initiated, a fully integrated team representing operations and designers must be assembled for the purpose of determining the existing condition of plant equipment, whether the existing equipment has adequate capacity to be used in the future plans or whether the existing equipment does not have the remaining life or capacity to work within the new scheme.
>
> At this point in the scoping process the goals of the project must be specifically identified in order for the design team to begin the process of establishing the requirements for new and replacement equipment.
> In a parallel effort, the design team along with the plant operational team must be physically evaluating the logistics required to dismantle any retired existing equipment and remove those components from their specific installation sites within the plant while determining the physical size and installation requirements of the new equipment. Failing to follow these steps in the planning and design process almost guarantees schedule delays and cost overruns during the actual process of constructing the project.
> DOC Ex. ___ at 7-8 (Crisp Public Direct)

Q. Understanding the difficulty of the two separate projects, did Xcel assign the proper management to the projects in order to accomplish the design and construction within budget and schedule?

A. In my opinion, no. The record of cost overruns and schedule delays supports my opinion. In fact, Mr. O'Connor admitted that "this Program was more costly and difficult than we anticipated." Xcel Ex. ___ at 2 (O'Connor Rebuttal). Further, he acknowledged that "we do not dispute that the overall costs of the LCM/EPU Program were higher than we expected…" Xcel Ex. ___ at 6 (O'Connor Rebuttal). While some cost overruns may happen, just as cost decreases may occur, there should not have been a case of the project being materially "more difficult than we anticipated" or "costs…higher than we expected" to the extent that occurred with Monticello. I pointed out numerous flaws in Xcel's approach, such as failing to consider the small footprint, especially in light of the "fast track" that Xcel chose to use.

Proper definition of a project scope would have protected against these two situations of unanticipated difficulties and costs by requiring Xcel to plan for the specifics of the LCM only and the LCM in tandem with the EPU. Of course, Xcel knew that Monticello had a small footprint and knew, or certainly should have known, at that time, about the layout of Monticello. Taking that knowledge into account with proper scoping of the equipment needed and logistics of installing the equipment would have anticipated many of the difficulties Xcel has pointed to as causing the cost overruns. Of course, that is not to say that unanticipated issues won't arise; however, as discussed further by Ms. Campbell, it is the Company's responsibility to alert the Commission when significant deviations occur at the time of discovery or very shortly thereafter.

Q. If the projects had remained separate and distinguishable with respect to the Company's documentation would the costs have been easier to track and therefore easier to determine when the costs were exceeding the budget?

A. There is no question that detailed and separate record keeping as part of the management of the projects would have enhanced not only planning but also monitoring the costs of the projects as separate and distinguishable, and would have made it easier to identify when there were or were likely to be significant cost overruns. Having each project managed within its individual scope, even while the projects were coordinated, would have presented the Company with a much easier task of tracking costs and schedules.

Q. Would tracking the costs separately provide the Company with other benefits?

A. Absolutely. As Ms. Campbell discusses, Minnesota regulations require the Company to return to the Commission whenever there is a substantial change in a Commission-approved project. Had Xcel tracked the costs at the individual project level, the cost overruns would have been easier to track and subsequently would have been more easily identifiable for notification to the Commission. Separate and independent cost tracking would have provided the Company with specific knowledge not only as to when the cost increases were occurring, but also where the cost increases were occurring, and to what degree each project was increasing. Tracking the costs and responses to the costs also would have provided for clear accounting of the costs along with a decision tree for how the Company addressed each cost increase. Given that the Company insists that its decisions were reasonable, tracking the costs separately for each project would have increased the transparency of those decisions for later Commission review.

D. USE OF AS-BUILT DRAWINGS AS APPROPRIATE PLANNING TOOLS

Q. Mr. O'Connor stated that your "statement that as-built summaries or conditions should have been prepared… is not a reasonable conclusion." (O'Connor Rebuttal Testimony, Page 17). Is Mr. O'Connor's conclusion consistent with industry practice, in your opinion?

A. With all due respect to Mr. O'Connor, no, his statement is not and was not consistent with industry practice. As-built drawings, summaries, conditions, procedures and policies are the life blood of an operating power plant, whether nuclear, coal, solar, etc., particularly plants that have been in operation for a number of years such as Monticello. Over the years in the due course of normal operation and maintenance and capital initiatives, "things" change; new cabling, wiring, updated instrument and controls, old equipment is removed and new equipment is added. If "as-builts" are not maintain in an updated conditions, everyone in the Plant runs the risk of making a serious mistake while carrying out normal everyday operational functions.

Q. Mr. O'Connor also stated that it was not necessary for Xcel to update the as-built drawings of the items you listed in response to the Company's Data Request No. 6 when Xcel implemented the small uprate in 1996/8 to the Monticello Plant. Will you provide context to Mr. O'Connor's discussion?

A. Yes. The original data request of the Company was:

> Reference Crisp p. 5, lines 20-22. You state: "Xcel and GE, now GE Hitachi, would have produced an 'as-built' summary of the design modifications in the first uprate in order to meet NRC requirements and to receive NRC approval." Please identify the specific NRC requirement(s) you are referring to in that sentence.

In my response to the Company, I included a list of various requirements of NRC, the American National Standards Institute (ANSI),[1] the American Society of Mechanical Engineers (ASME),[2] and cites of the Code of Federal Regulations. This list was not intended to be all inclusive nor did it imply that any one specific rule or regulation was either violated or misapplied. The list was to support the overarching concept of the "culture" that must reside within an organization responsible for the safe and efficient operation of a nuclear generating plant. These documents encourage and/or require the licensee to maintain accurate and up-to-date as-built drawings.

Q. Mr. O'Connor's testimony stated that he finds that it not unusual that as-built drawings are not readily available for all systems as Monticello. Xcel Ex.___ at 18 (O'Connor Rebuttal). Is his opinion consistent with your knowledge of the industry?

A. No not at all. As mentioned above, the updated as-built condition of a plant is the life blood of the plant. As far as my personal experience with all types of electric generating plants, the storage and maintenance of as-built drawings is a critical process with management and one that carries a very high priority. It is and has been widely understood that the as-built drawings are the first and primary source of reference during maintenance and capital project definition. I cannot over emphasize the need for properly updated as-built drawings in execution of safety or non-safety related projects.

[1] According to its website, ANSI "empowers its members and constituents to strengthen the U.S. marketplace position in the global economy while helping to assure the safety and health of consumers and the protection of the environment."

[2] According to its website, "ASME is a not-for-profit membership organization that enables collaboration, knowledge sharing, career enrichment, and skills development across all engineering disciplines, toward a goal of helping the global engineering community develop solutions to benefit lives and livelihoods."

E. COMMUNICATION WITH THE NRC

Q. Mr. O'Connor's Rebuttal Testimony (Page 21, lines 1-9) responded to your position that the Company should have notified the NRC in the Company's Application for Extended Operating License that the Company was also considering an EPU. What is your position?

A. First, I have never known the NRC to be averse to the submittal of any information concerning a license or licensee, particularly the submittal of future plans for a particular license. Second, my criticism did not surround the Company's specific plans for an uprate. Instead, my criticism was that the Company specifically informed the NRC in March of 2005 that "The current licensing basis ("CLB") **will be continued and maintained throughout the period of extended operation**." (Emphasis Added). (Monticello Nuclear Generating Plant, Application for Renewed Operating License – March 2005, Page 1-11, Section 1.3.5). However, as I stated in my direct testimony, a change in the basis for the LCM license already was under review: "contrary to this commitment to the NRC, the Company initiated studies and activities for the EPU as early as 2004." DOC Ex. ___ at 13 (Crisp Public Direct). This and similar facts led me to conclude that:

> The confusion, contradictory information to the NRC and start-stop process suggest management indecisiveness and strategic planning that, at best, was not adequately thought out. Further, these factors presented timing and schedule interruptions that caused cost increases.
> DOC Ex. ___ at 14 (Crisp Public Direct).

Q. How did Mr. O'Connor respond to your testimony concerning the Steam Dryer?

A. Mr. O'Connor stated:

> In March 2008, approximately two weeks before we submitted our initial License Amendment Request, the Advisory Committee on Reactor Safeguards ("ACRS") effectively requested an increase in the level of scrutiny for the steam dryer structural analysis by increasing the minimum acceptable stress ratio. We discussed this change with management and it was unclear whether or not the ACRS ratios would be applied by the NRC to our Plant. We made the decision to proceed with our initial License Amendment Request.
> Xcel Ex. ___ at 22 (O'Connor Rebuttal)

That is, knowing full well that neither the ACRS nor the NRC had ruled on the technical merits of the requirements for structural analysis, the Company made the unilateral decision in 2008 to proceed with the license amendment. Thus, when the NRC made changes to the steam dryer analysis, the Company had to retrace its footsteps and change its decision from modification to replacement of the existing steam dryer.

Thus, as I discussed in my direct testimony, Xcel's decision to move forward in 2008, knowing that the steam dryer issue was not resolved ultimately cost the project time and dollars from their initial effort to modify the existing dryers to a position of designing new dryers and replacing the existing dryers. Knowing that the ACRS and the NRC were not comfortable with the Company's steam dryer analysis should have been sufficient warning to the Company not to proceed until this issue was reasonably resolved.

Q. Mr. O'Connor criticized your conclusion that License Amendment Request process was not necessarily due to NRC delays and added NRC requirements. Please explain your position and response to Mr. O'Connor's rebuttal testimony. (Page 32, lines 6 – 24, O'Connor Rebuttal Testimony)

A. Mr. O'Connor concluded that my explanation is overly simplified. As I stated and as Mr. O'Connor recognized, this particular issue was "a result of the Company's reasonable decision to use the NRC guidance regarding the higher water temperatures." However, Mr. O'Connor again omitted a response to the main point of that part of my testimony that "the Company's election to use the SECY-11-6 0014 CAP guidance, which was new, resulted in a longer than normal approval process." DOC Ex. __ at 14 (Crisp Public Direct)

I think any reasonable person associated with nuclear design and licensing now or at that time would agree that when there is new guidance or rules promulgated by the NRC, it is important to fully vet the new guidance with the NRC and make certain that all issues have been resolved prior to initiating new designs or new calculations. It has been shown time and again that new procedures take an inordinate amount of time before they are fully deployable in an efficient manner. Thus, Xcel should have been aware that moving in an expedited manner without full NRC and ARCS approvals was likely to generate delays and cost increases.

F. BENCHMARKING AND CONTINGENCIES

Q. Mr. O'Connor described in his Rebuttal Testimony how the Company worked with the Boling Water Reactor Owner's Group and with General Electric, attended benchmarking trips and reviewed reports from other plants about issues that had been experienced at other EPU projects. Xcel Ex. ___ at 37 (O'Connor Rebuttal). He also presented Exhibit TJO-1, Table 3 "Cost Increases and Schedule Changes" as evidence that the Monticello EPU was commensurate with other similar projects in

the US Nuclear Fleet. Xcel Ex. ___ at 38 (O'Connor Rebuttal). What is your assessment of this position?

A. Mr. O'Connor and other Company witnesses who refer to this Table 3 claim that, since the Monticello example is similar to these identified projects, the cost overruns are somehow justified. I disagree. My response is two-fold. First, projects need to be addressed on a case-by-case basis, given circumstances involving each project, along with state requirements and other circumstances. Second, since the Company engaged in the benchmarking, review of the Owner's Group documentation and other reports, the Company should have understood that there were problems associated with schedules and cost containment with EPU projects.

Q. How did Mr. O'Connor respond to your discussion about use of contingency dollars?

A. Mr. O'Connor stated that:

> …contingencies were used throughout the Program… However, while I believe our effort to estimate contingency dollars was reasonable, it is possible we could have included additional contingency in our estimates. But the presence or absence of contingency does not make the overall cost of a project higher or lower.
> Xcel Ex. ___ at 40 (O'Connor Rebuttal).

Q. Is Mr. O'Connor's response reasonably supported?

A. No, for several reasons. First, Mr. O'Connor's statement that "contingencies were used throughout the Program" appears to contradict the statement by Mr. Sparby that the Company management decided not to use contingencies:

> …the $362.5 million figure cited in the 2011 Cost History document was the high-end of the $299-362.5

> million range that was also developed in 2006 to include additional contingency in the estimate. Recognizing that the study work supporting the initial rollout of the Program was preliminary, management requested funding at the lower level because there was not substantial cost support at that time for other estimates. Xcel Ex. ___ at 27-28 (Sparby Rebuttal).

Second, Mr. O'Connor is absolutely correct that the inclusion of contingencies does not directly affect the final cost of the project. However, if the estimated project cost plus contingencies does not produce a Benefit / Cost ratio greater than 1.0 then the project is not economically justified. As Mr. Shaw stated in his direct testimony:

> **Q. Do your conclusions mean that if the actual costs of the EPU were accurately estimated at the time of the 2008 EPU CN, the Department would have recommended that the CN for the EPU not be granted?**
>
> A. Yes. If the actual costs and timing of the EPU had been known, other alternatives would have been more cost-effective. DOC Ex. ___ at 32 (Shaw Direct)

Mr. Shaw and Ms. Campbell discuss the Department's overall approach in more detail, but the point I am making is that the use of contingency dollars is appropriate and should have been included in this project from the initial cost estimate until project completion, particularly given the Company's statements in this proceeding regarding the inadequacies of the cost estimates at the time Xcel filed for CNs. As Mr. O'Connor points out throughout his Direct Testimony and Rebuttal Testimony, and as Mr. Sieracki confirms as discussed above, the Company initiated the project well before the final design was complete. The Commission relied on those cost estimates in reaching its decisions without knowing how under-developed the cost estimates were.

Mr. O'Connor also pointed out that during construction situations were encountered that required design modification as well as structural modifications simply to provide work-around access. This example of Xcel's lack of adequate planning for all of these "unknowns" is precisely why contingency dollars are important in a reasonable budget estimate. Otherwise, cost estimates of projects are inadequate and could give a utility project an unreasonable competitive advantage that competing projects might not have.

Q. Was any other Company Witness critical of your testimony regarding Xcel's use of contingencies?

A. Yes, Mr. Sieracki also criticized my testimony regarding the use of contingencies. Mr. Sieracki testified that I was wrong in my assessment that contingencies were not used in the LCM/EPU cost estimates. Mr. Sieracki stated that $7.7 million was included in the LCM/EPU Program, and that $2.5 million was included in the cost estimate for the 13.8 kV Distribution System. He stated that all of these contingencies were in the 2007 nuclear project authorization for the LCM/EPU. Xcel Ex. ___ at 54 (Sieracki Rebuttal). Based on this information, Mr. Sieracki concluded that "Xcel Energy used contingencies on the LCM/EPU Program in the initial NPA and continued to use contingencies through to January 2013 estimate." *Id*. At 55.

Q. How do you respond?

A. First, I note that this discussion of the use of contingencies presented by Mr. Sieracki is not consistent with documentation supplied by Xcel Energy. Specifically, the DOC

Ex. 171 NAC-30 (Campbell Direct) in Docket E002-GR-12-961[3] showed no contingencies in the January 2008 estimate, December 2010 estimate, or October 2012 estimate. It is not until the January 2013 estimate, years after the Commission approved Xcel's CN for the EPU, when Xcel indicated the use of any contingencies. Moreover, the level of contingencies in 2013 was $20.0 Million (3.05% of the Total Direct Cost of the Major Projects).

Second, this information only makes it more clear that Xcel's limited use of contingencies was and is inconsistent with industry practice using the industry standard AACE International[4] Recommended Practice No. 18R-97, "Cost Classification System-As Applied in Engineering, Procurement, and Construction ('EPC')."

Q. Would you please explain?

A. Certainly. Mr. Sieracki's statement that a contingency of $7.7 million was applied to the 2007 LCM/EPU Project indicates that Xcel's use of contingencies was significantly inadequate. Given what Xcel represents in this proceeding as the stage of this project in January 2008, AACE International standards would apply a contingency of + or – 50%-100% to the direct costs:

> In addition to the degree of project definition, estimate accuracy is also driven by other systemic risks such as:
>
> - Level of non-familiar technology in the project.
> - Complexity of the project.
> - Quality of reference cost estimating data.

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[3] NAC-30 is the Company's initial response to Department Information Request 160, which is attached to Mr. O'Conner's Direct Testimony as Exhibit___(TJO-1), Schedule 8. Mr. O'Conner's Schedule 8 provides both the initial response to Information Request 160 and the Supplemental Response that the Company provided for the first time in this proceeding.

[4] Originally chartered in 1956 as the American Association of Cost Engineers.

- 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.

> Systemic risks such as these are often the primary driver of accuracy; however, project-specific risks (e.g. risk events) also drive the accuracy range.
>
> Another way to look at the variability associated with estimate accuracy ranges is shown in Figure 1. 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 a process industry project may have an accuracy range as broad as -50% to +100%, or as narrow as -20% to +30%.
>
> DOC Ex. ___ at MWC-S-1, page 3 (Crisp Surrebuttal).[5]

Instead of following AACE International's recommendations, the $7.7 Million stated by Mr. Sieracki's is a mere 2.4% of the Direct Costs of the Major Projects. Thus, Xcel far underestimated the contingency dollars that would have been applied to the total cost estimate had Xcel appropriately applied proper estimating technique.

Q. What is the significance of this misleading testimony with regards to the LCM/EPU Program?

A. Had Xcel applied proper cost estimating standards to this project when they applied for a CN for the EPU in January 2008, the cost would have been $480 million - $640 million[6] without consideration of allowance for funds used during construction (AFUDC). This level is much closer to the actual final costs per Xcel's latest estimate

[5] Also see Table 1 on page 4 of "Cost Estimate Classification Matrix" AACE International Recommended Practice No. 18R-97," Revision: November 29, 2011.
[6] Calculated as $320 million times 1.5 and 2.0, respectively.

and would have provided better information for the Commission to use in deciding whether to grant a CN for the uprate or simply to allow Xcel to continue to use Monticello at the 600 MWe level. However, as Department Witness Shaw points out in his testimony it is highly probable that the EPU portion of the project would not have been cost justified at this level.

Q. Is it necessary for construction contingency dollars actually to be spent?

A. No. Construction contingency dollars are not necessarily dollars that will actually be spent during construction. They are dollars that are incorporated into an estimate that are appropriately identified as contingencies should any one or more unanticipated situations occur. Contingencies are incorporated into the economic "benefit / cost" analysis to establish the upper boundary to a decision of whether to proceed with a project and whether to continue with a project if costs increase materially.

In the instant case of Monticello, if the LCM costs, including proper contingencies, independent of the EPU, produced a Benefit / Cost Ratio greater than 1.0 then it would be economically feasible to proceed with the LCM with all of the regulatory approvals. If the EPU costs, including proper contingences, independent of the LCM were greater than 1.0 then the EPU project would be economically feasible. Unfortunately, Xcel apparently did not use proper contingences in either case when it performed the economic analysis. Therefore, as costs escalated, the economic analyses justifying the projects were no longer accurate under the cost scenario. Mr. Shaw's and Ms. Campbell's testimonies discuss how to remedy this fact on behalf of Xcel's ratepayers.

G. 2011 COST HISTORY DOCUMENT

Q. Mr. O'Connor took exception to your use of a document developed by Company employee Mr. Hammer at the direct request of then Chief Nuclear Officer Mr. Denis Koehl. Is his criticism of the use of this document warranted?

A. No, for several reasons. First, Xcel does not refute any of the facts stated in that document. No Xcel witness contradicted, criticized, or showed that any of the points in the document were incorrect, inaccurate, or in some form biased. If it had contained inaccuracies, then it was incumbent on Xcel to provide evidence showing that any of those statements were false. Xcel did not do so.

Second, Mr. O'Connor assumed that this single document formed the basis for most of my analysis. In fact this document was merely the basis for formal criticism and direction to investigate further into Company actions through the use of Data Requests served on the Company and a visit to the Monticello Plant.

Nonetheless, this document provided a substantial record due to its thoroughness. It was also important in that it was requested by the then Chief Nuclear Officer (Mr. Koehl) to be prepared to help him (Mr. Koehl) understand the twists and turns of the project. This is the one and only document provided through data requests that clearly and succinctly articulates the project in a chronological order.

Q. Do you have any other comment about this document?

A. Yes. While Mr. O'Connor criticized me for the use of this document and he attempted to trivialize the document by claiming it was developed by "one employee," this document was prepared for the highest ranking and most responsible person within the organization responsible for Monticello.

I find it disturbing that Mr. O'Connor acknowledged the following in his criticism of the use of this document, "the 2011 Cost History was prepared at a time when the Program was under substantial pressure for missing cost and timing targets. During that period, tensions were running high and some attempts to assign blame naturally occurred." This statement elevates my concerns as to the culture at Xcel during that time and the credibility of Xcel's statements that the Company's actions for which "attempts to assign blame" occurred were reasonable under the circumstances then existing.

Finally, Mr. Sparby's testimony did not accurately reflect either what is in the 2011 Cost History document or what is in my testimony, so it is important to correct the record. Mr. Sparby's testimony stated:

> Q. MR. CRISP OBSERVES THAT THE BOARD DID NOT ADOPT THE $362.5 MILLION ESTIMATE DESCRIBED IN THE 2011 COST HISTORY DOCUMENT. WHY WAS THAT?
>
> A. **Mr. Crisp makes it seem that the recommendations by one employee contained in the 2011 Cost History document should have dictated the Company's actions in 2006.** This is not the case.
>
> First, in the Company's corporate structure, capital projects are generally developed by the affected business unit, which is responsible to assess options, vet differing opinions, and provide its recommendations to corporate decision-makers for consideration. Management presented and the Board approved the initial LCM/EPU Program authorization and scope **based on the overall Program team's recommendation, which in 2006 was $274 million**. (Emphasis added)
>
> Xcel Ex. ___ at 27 (Sparby Rebuttal)

However, the 2011 Cost History document stated the following:

> Following consideration of the GE study, the site projects group in July of 2006 recommended a budget of $362.5M with final implementation in the 2013 RFO. The higher cost was to recognize the uncertainty associated with work scope and estimate quality. The Xcel Board of Directors approved a $273M budget with a 2011 project completion in August of 2006.
> DOC Ex. ___ at MWC-2 (Crisp Public Direct)

That is, the document described exactly what Mr. Sparby said should occur – the site projects group – not a single employee – made a recommendation to the Board for a higher proposed cost and more time for the EPU, but the Board rejected the site project group's recommendation. As a result, I noted the following in my direct testimony:

> …without explanation, the Xcel Board disregarded the Monticello Site Projects Group, approving a budget that was substantially (33 percent) lower than the amount recommended by the "boots-on-the-ground" Team. Further, the Board of Directors required the installation to occur in 2011, 2 years earlier than recommended by the Monticello Site Projects Group, thus requiring a "fast track approach." … The discussion also points to a concern about communication between the Board of Directors and the Monticello Site Projects Group since the Monticello Site Projects Group's recommendation was overruled by the Board.
> DOC Ex. ___ at 24-25 (Crisp Public Direct)

Q. Do you have any final comments about Xcel's rebuttal testimony regarding project management?

A. Yes. While in some cases Mr. O'Connor and Mr. Sparby admitted to problems and issues with project management, in many cases they tried to portray those problems as being reasonable even though they acknowledge the problems prevented appropriate planning, design and construction of the projects. For example, Mr.

Sparby testified "In short, this job was very hard and that fact more than anything drove our costs." (Page 8, lines 22 & 23, Sparby Rebuttal Testimony). That the job was very hard is neither an excuse nor a justification for cost overruns; it is an amplification of the need for better project management in order to ensure reasonable project costs.

Mr. Sparby went further to testify that "we encountered many installation challenges for which no amount of advance preparation could have prepared us. (Page 8, lines 22 & 23, Sparby Rebuttal Testimony). I absolutely do not agree with Mr. Sparby on this point. Proper advance planning, design and project management should have identified the potential for these installation challenges. It may have been impossible to determine the exact cause of a particular installation challenge or impossible to identify every one of the challenges but the installation challenges should have been identified as potential problems and extra time should have been built into the schedule to complete the installation, scope out costs and even to consider alternatives to meeting the needs of Xcel's ratepayers if cost estimates (including costs of externalities, as Mr. Shaw discusses) became too high.

Q. There is a consistent theme through all Company's rebuttal testimony that "All program work needed to be completed during the periodic refueling outage." Is this an accurate statement?

A. No. While it is desirable to complete work during a scheduled outage it is not absolutely necessary to do so. A scheduled refueling outage is established and plans are made within the Company to use generating reserves or purchase replacement energy to meet the demands of the Company while the unit is off-line during the outage. The Company also establishes operating goals based on outage times and subsequently unit availability, ultimately used to develop performance bonuses. However, under conditions such as these projects, it may be reasonable to extend an outage or reschedule a refueling outage for a longer period of time, particularly if the demand for energy is relatively low. Based on my review of the performance information provided by the Company, it would appear that the Company Project Management team should have reviewed this option as a possibility to support the project and limit cost increases.

III. CONCLUSIONS

Q. Based on your in-depth review of Company provided documentation, Company Direct Testimony and Company Rebuttal Testimony, what is your conclusion with regards to project management?

A. First, I concur with Company witnesses that safety appears to have always and appropriately been a focus of Xcel, regardless of any other finding.

However, I am also just as convinced from my review that more reasonable project management would have saved the Company, and ultimately the ratepayers, significant costs by clearer project definition on the frontend, more efficient and coordinated execution throughout the LCM and EPU projects, and improved communications within the Company and with regulators.

I am also convinced the LCM and EPU projects were separate and distinguishable projects complying with the definitions stated in their separate and distinguishable CN approved by the Commission and licenses with the NRC. This fact does not mean the two projects should not have been constructed in parallel.

Regarding the overall conclusions of the Department, I point to the testimonies of Department witnesses Ms. Campbell and Mr. Shaw.

The project management issues were responsible for increased costs of the LCM and EPU projects substantially above what reasonably should have been incurred. Company Witnesses admit this fact.

Q. Does this complete your Surrebuttal Testimony?

A. Yes it does.

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

Rev. November 29, 2011

Note: As AACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

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COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

November 29, 2011

PURPOSE

As a recommended practice 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 process industries.

This addendum to the generic recommended practice (17R-97) provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice by providing:

- a section that further defines classification concepts as they apply to the process industries; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic recommended practice, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

The overall purpose of this recommended practice is to provide the process industry definition deliverable maturity matrix which is not provided in 17R-97. It also provides an approximate 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 and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. This addendum should allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the degree of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions

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of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in non-process industries such as commercial building construction, environmental remediation, transportation infrastructure, hydropower, "dry" processes such as assembly and manufacturing, "soft asset" production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the significant building construction that may be a part of process plants.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed, and the practices were found to have significant commonalities. These classifications are also supported by empirical process industry research of systemic risks and their correlation with cost growth and schedule slip[8].

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**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 [a]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-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 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Notes: [a] The state of process technology, availability of applicable reference cost data, and many other risks affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

Table 1 – Cost Estimate Classification Matrix for Process Industries

Table 1 provides a summary of the characteristics of the five estimate classes. The maturity level of definition is the sole determining (i.e., primary) characteristic of Class. In Table 1, the maturity is roughly indicated by a % 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 for the process industries but may vary from application to application.

This matrix and guideline outline an estimate classification system that is specific to the process industries. Refer to the generic estimate classification RP[1] for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will provide additional information, particularly the project definition deliverable maturity matrix which determines the class in those particular industries.

Table 1 illustrates typical ranges of accuracy ranges that are associated with the process industries. 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 into the ranges identified (although extreme risks can lead to wider ranges).

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

- Level of non-familiar technology in the project.
- Complexity of the project.
- 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.

Systemic risks such as these are often the primary driver of accuracy; however, project-specific risks (e.g. risk events) also drive the accuracy range[3].

Another way to look at the variability associated with estimate accuracy ranges is shown in Figure 1. 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 a process industry project may have an accuracy range as broad as -50% to +100%, or as narrow as -20% to +30%.

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 the Class 5 estimate of one project that is based on a repeat project with good cost history and data and the Class 3 estimate for another project involving new technology. It is for this reason that Table 1 provides ranges of accuracy range values. The accuracy range is determined through risk analysis of the specific project.

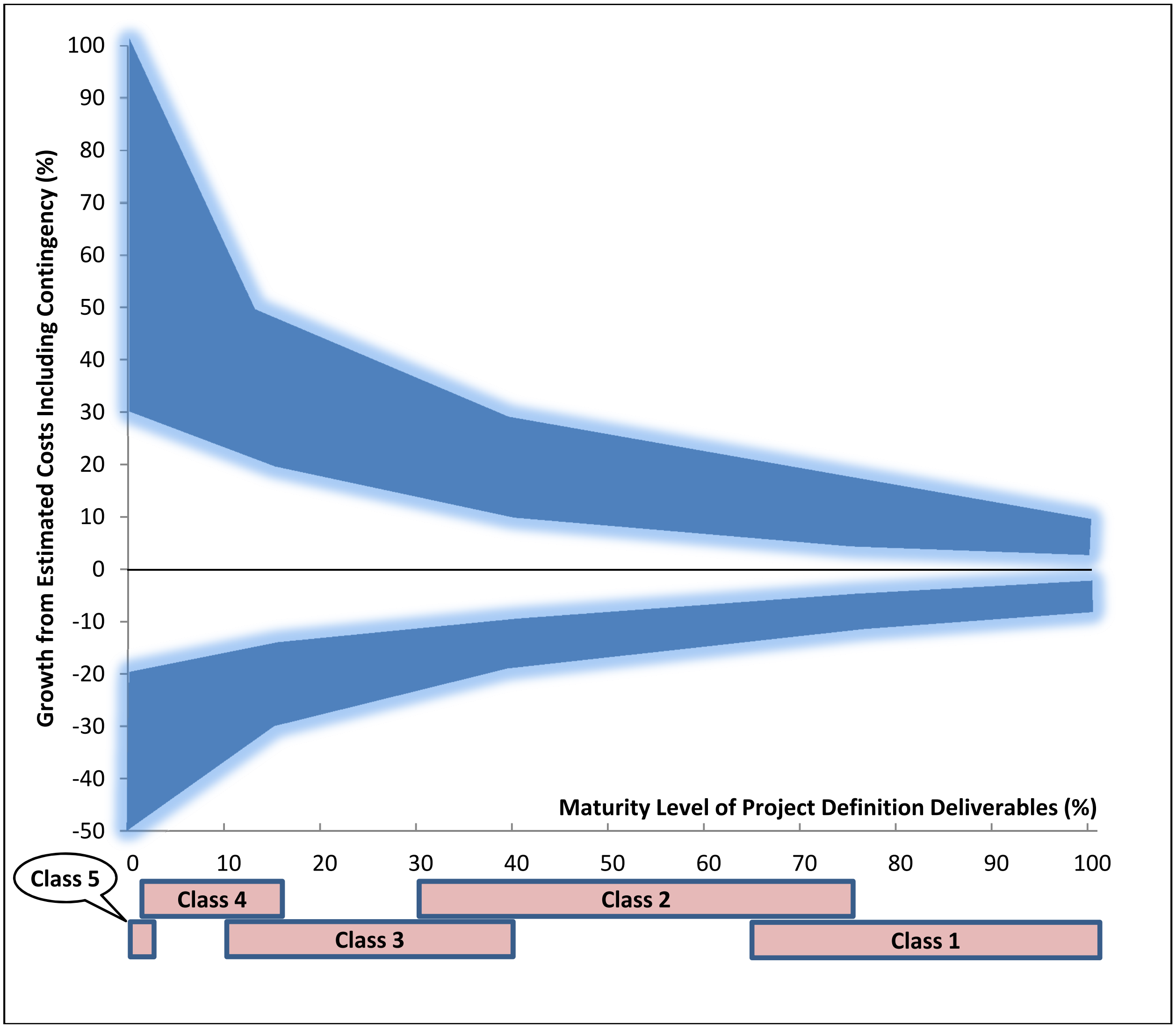

Figure 1 – Example of the Variability in Accuracy Ranges for a Process Industry Estimate

DETERMINATION OF THE COST ESTIMATE CLASS

The cost estimator makes the determination of the estimate class based upon the maturity level of project definition based on the status of specific key planning and design deliverables. The percent design completion may be correlated with the status, but the percentage should not be used as the Class determinate. While the determination of the status (and hence class) is somewhat subjective, having standards for the design input data, completeness and quality of the design deliverables will serve to make the determination more objective.

CHARACTERISTICS OF THE ESTIMATE CLASSES

The following tables (2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each table, the following information is provided:

- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the maturity level of project definition deliverables. The "minimum" inputs reflect the range of industry experience, but would not generally be recommended.
- **Maturity Level of Project Definition Deliverables (Primary Characteristic):** Describes a particularly key deliverable and a typical target status in stage-gate decision processes, plus an indication of approximate percent of full definition of project and technical deliverables. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage (Secondary Characteristic):** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methodology (Secondary Characteristic):** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range (Secondary Characteristic):** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this represents about 80% confidence that the actual cost will fall within the bounds of the low and high ranges. The estimate confidence interval or accuracy range is driven by the reliability of the scope information available at the time of the estimate in addition to the other variables and risk identified above.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in Tables 2a-2e.

CLASS 5 ESTIMATE	
Description: Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systematic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Block flow diagram agreed by key stakeholders. 0% to 2% of full project definition. **End Usage:** Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.	**Estimating Methodology:** Class 5 estimates generally use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.

Table 2a – Class 5 Estimate

CLASS 4 ESTIMATE	
Description: Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Process flow diagrams (PFDs) issued for design. 1% to 15% of full project definition. **End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	**Estimating Methodology:** Class 4 estimates generally use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility (pre-feasibility for metals processes), authorization, factored, pre-design, pre-study.

Table 2b – Class 4 Estimate

CLASS 3 ESTIMATE	
Description: Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: Piping and instrumentation diagrams (P&IDs) issued for design. 10% to 40% of full project definition. **End Usage:** Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase control estimates against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate is often the last estimate required and could very well form the only basis for cost/schedule control.	**Estimating Methodology:** Class 3 estimates generally involve more deterministic estimating methods than stochastic methods. They usually involve predominant use of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project. **Expected Accuracy Range:** Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, feasibility (for metals processes) development, basic engineering phase estimate, target estimate.

Table 2c – Class 3 Estimate

CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed contractor control baseline (and update the owner control baseline) against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the bid estimate to establish contract value. Typically, engineering is from 30% to 75% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: All specifications and datasheets complete including for instrumentation. 30% to 75% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed contractor control baseline (and update the owner control baseline) against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change management program.	**Estimating Methodology:** Class 2 estimates generally involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Table 2d – Class 2 Estimate

CLASS 1 ESTIMATE	
Description: Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, overall engineering is from 65% to 100% complete (some parts or packages may be complete and others not), and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Maturity Level of Project Definition Deliverables:** Key deliverable and target status: All deliverables in the maturity matrix complete. 65% to 100% of full project definition. **End Usage:** Generally, owners and EPC contractors use Class 1 estimates to support their change management process. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. Construction contractors may prepare Class 1 estimates to support their bidding and to act as their final control baseline against which all actual costs and resources will now be monitored for variations to their bid. During construction, Class 1 estimates may be prepared to support change management.	**Estimating Methodology:** Class 1 estimates generally involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and other risks (after inclusion of an appropriate contingency determination). Ranges could exceed those shown if there are unusual risks. **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Table 2e – Class 1 Estimate

ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Table 3 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the completion status of the deliverable. The completion is indicated by the following letters.

- **None (blank):** development of the deliverable has not begun.
- **Started (S):** work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- **Preliminary (P):** work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- **Complete (C):** the deliverable has been reviewed and approved as appropriate.

	ESTIMATE CLASSIFICATION				
	CLASS 5	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	**0% to 2%**	**1% to 15%**	**10% to 40%**	**30% to 75%**	**65% to 100%**
General Project Data:					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S/P	C	C	C
Process Flow Diagrams (PFDs)		P	C	C	C
Utility Flow Diagrams (UFDs)		S/P	C	C	C
Piping & Instrument Diagrams (P&IDs)		S/P	C	C	C
Heat & Material Balances		S/P	C	C	C
Process Equipment List		S/P	C	C	C
Utility Equipment List		S/P	C	C	C
Electrical One-Line Drawings		S/P	C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	C	C	C
Spare Parts Listings			P	P	C
Mechanical Discipline Drawings			S/P	P/C	C
Electrical Discipline Drawings			S/P	P/C	C
Instrumentation/Control System Discipline Drawings			S/P	P/C	C
Civil/Structural/Site Discipline Drawings			S/P	P/C	C

Table 3 – Estimate Input Checklist and Maturity Matrix (Primary Classification Determinate)

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