# Reconcile Safety and Reliability with Cost

## A Proven Approach to Optimize Project Spending at Nuclear Power Plants

**Tim Schlimpert**

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**Most nuclear plants require some form of business case before a significant project is approved. These business cases, however, often *just go through the motions*, resulting in higher than necessary budgets and crowding out other important projects in the portfolio. Sometimes, business cases are an exercise of justifying the desired project. A successful business case and project review process requires an active Executive Review Team and robust business cases to quantify alternatives and structure evaluation of cost-risk tradeoffs. This process helps ensure power plants meet their reliability goals in the most cost-effective manner. Moreover, when led by senior plant management, this approach can produce cost savings of 20-60%, thereby reducing the strain on power plant capital and operating budgets.**

### Robust Business Cases Save Money

MCR assists nuclear plants by teaching techniques to prepare robust business cases with creative alternatives, quantifying reliability and financial risk. With this information, the Executive Review Team is empowered with previously unavailable insights to confidently make the best decisions.

Over the course of the most recent 50 plus business cases developed by MCR and our utility clients, we were able to identify over $200 million in savings from more than $700 million of originally proposed spending. On average each business case resulted in savings of 30%. (See Exhibit 1.)

**Producing robust business cases within a well managed process typically produce capital budget savings of more than 30%.**

**Exhibit 1** ***Results: MCR Project Evaluation Process***

| Utility | Total value of Projects Reviewed ($M)[1] | Total Value of Savings from Projects Reviewed ($M)[1] | % Savings |
|---|---|---|---|
| A | $42 | $10 | 22.6% |
| B | $8 | $2 | 23.2% |
| C | $51 | $26 | 49.8% |
| D | $115 | $27 | 23.5% |
| E | $405 | $103 | 25.4% |
| F | $84 | $48 | 57.3% |
| ***Total*** | ***$705*** | ***$216*** | ***30.6%*** |

[1] Total proposed spending was latest estimate prior to MCR arrival

*Source: Actual MCR client results.*

## The Case for Business Cases

Nuclear plants often have more projects than they have budget. As one Site Vice President said, “I have no shortage of high net present value projects I can do … I do, however, have a shortage of money to accommodate those projects and still make my business plan goals.” Producing robust business cases within a well thought out process allows plants to spend their project budget more wisely and to provide funds for additional high value projects. In addition, producing more effective business cases can free-up funds for contingency purposes during the year, giving power plant executives more comfort in making their financial and reliability targets, even if unforeseen projects emerge. Lastly, robust business cases for capital and O&M projects give state regulators and other stakeholders comfort that project spending is being optimized.

**Problems in the development of business cases leading to unimpressive results:**

- **Lack of strategic context**
- **Lack of direct executive involvement**
- **Lack of rigor**
- **Lack of risk quantification**

Eighty percent of U.S. nuclear plants are at least 30 years old (see Exhibit 2). As these plants continue to age, there will be additional pressure on capital and O&M spending to maintain reliability. To address this increasing pressure, it is imperative to produce robust business cases with quantitative comparisons of alternatives. Doing so will ensure management plans projects to increase reliability in the most cost-effective manner possible.

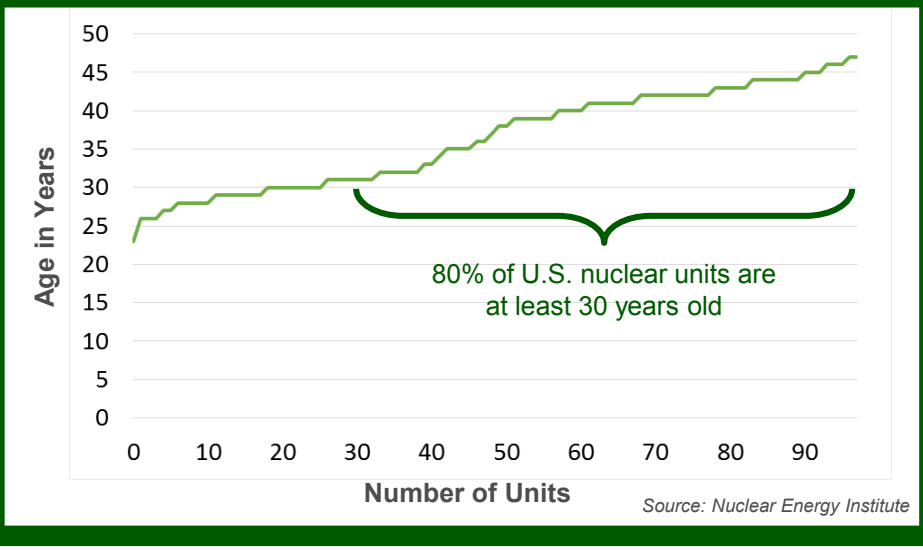
## Current State—Going Through the Motions

Nearly all plants require a business case for projects over a certain threshold amount. They also have a series of procedures, financial models and forms to guide the business case development and project review process. Yet, with all the time and effort spent on developing and following procedures, senior management is nearly universal in their frustration over the lack of results. A Chief Nuclear Officer of a large fleet of plants sums it up pretty well: “We have smart people working on business cases, and our processes and procedures are well-documented. Why can’t we produce business cases for our projects that enable us to identify and select the most cost effective solutions?”

In our experience, the process of developing and reviewing business cases typically encounters four problems leading to unimpressive results: lack of strategic context, lack of direct executive involvement, lack of rigor and lack of risk quantification.

**Lack of Strategic Context.** Although most nuclear plants produce business cases, it is often a process with little executive visibility and no direct linkage to the financial goals or project spending targets of the plant or company. Personnel who write business cases often lack the context for how their projects fit into the plant and fleet’s overall spending strategy. Without the guidance of strategic context, they often go through the motions of developing business cases to satisfy the procedure and prove the project has acceptable economics. As one Finance Director for several plants

**Exhibit 2** ***U.S. Nuclear Units Cumulative Age***




*Source: Nuclear Energy Institute*

lamented, "I've had engineers say, 'just tell us the required return to meet the cut line—we'll fill in the rest.'"

**Lack of Direct Executive Involvement.** Many plants rely primarily on mid-management project review committees to evaluate the merits of a project. The Executive Review Team only gets involved as a business case is *routed around for comments and signatures* or during annual reviews of the project list. This indirect involvement results in an unnecessarily long review cycle and only a surface-level understanding from the Executive Review Team of approved projects.

**The lack of *scrubbing* at the executive level can lead to suboptimal implementation of project alternatives.**

The Executive Review Team also has little or no meaningful interactions and deliberations among themselves (or with the system and project engineers) to identify and evaluate alternative approaches to projects. This lack of *scrubbing* at the executive level can lead to sub-optimal implementation of project alternatives from a technical and financial perspective.

The lack of interaction and deliberation at the executive level can also result in a dysfunctional *reverse pyramid* risk structure for the organization. Without executive interaction, the engineers often perceive they bear the risk of their decisions, which leads them to devise and support the alternative with the least risk … which is almost always the most expensive.

**Lack of Rigor.** Many business cases do not rigorously employ quantitative measures nor do they have adequate data to back up the request for funding. For example, business cases often lack historical failure rates of equipment or even any evidence of industry experience with the equipment. This omission can result in suspect NPV and IRR calculations and prevents an accurate evaluation of cost and reliability. In addition to insufficient data, the cost-benefit analysis for business cases often does not incorporate creative alternatives to explicitly lay out cost and risk tradeoffs or compare

NPVs. Oftentimes, the business case becomes a *check the box* exercise, simply looking for a positive NPV, regardless of the validity of the assumptions behind it or whether more cost-effective solutions exist. A symptom of an ineffective and *tired* business case process is one that repeatedly accepts the base case and produces insignificant cost savings compared to the budget or long range plan.

Given their charter of achieving reliability, engineers typically are reluctant to assume more risk—they will naturally err on the side of reliability and ensure full funding for their project to minimize any risk of an abnormal event or even a shutdown. Adding rigor to business cases and managing this risk-averse behavior is not something that can be influenced through a simple training course. A charter and culture accepting the Executive Review Team as part of the cost-risk tradeoff decisions must guide this process. Additionally, the charter and culture must drive the aggressive review of alternatives and must stretch thinking beyond the first option coming to mind. The new charter must be consistently applied and the culture constantly reinforced to avoid the concerns reflected by one system engineer: "If I go ahead and lay out alternatives that save money, I want assurance from the Executive Review Team that all the plant's projects will be subjected to this same expectation and scrutiny."

**A symptom of an ineffective and *tired* business case process is one that repeatedly accepts the base case and produces insignificant cost savings as compared to the budget or long range plan.**

**Lack of Risk Quantification.** Most business cases identify and discuss risks, but do not quantify risks, such as incorporating the potential reduction of equipment failure rates into the benefits of a project. In addition, the financial analysis of a typical business case relies on overly optimistic point estimates of investments, cost savings and assumed reductions in forced outage rates. A single point estimate provides the mid-management project review committee and Executive Review Team a false sense of security; they assume the project will produce the promised returns. This failure to systematically quantify risk makes it difficult for the Executive Review Team to succeed in its most important role—properly evaluating the cost-risk tradeoffs of a particular project.

## Breathing New Life into Business Cases and the Project Review Process

To ensure the most cost-effective use of project spending, business case development must be elevated. Business cases must include complete financial and risk analysis, and must be given executive visibility within the plant, the nuclear business unit and even the parent utility. A successful project review process requires an active Executive Review Team, a clear link to overall spending targets, robust business cases to better evaluate alternatives and cost-risk tradeoffs, and measurement of the results to continuously improve the process for the future.

**1) Establish an Active Executive Review Team.** Project evaluation and review is critical to the health of a power plant. The Executive Review Team must have significant involvement in the process; project reviews cannot be delegated to a mid-management project review committee without executive oversight.

For example, one nuclear power plant saw a remarkable improvement in the quality of the business cases when the Executive Review Team asked the engineer to present directly to them. Formerly, project approval at the plant level included only mid-management review combined with routing for executive signatures, without first-hand discussion of the alternatives. The new process cut the review cycle by a month and resulted in a 35% reduction in spending with no expected loss in reliability for those projects subject to the new process.

Direct executive involvement in the business case review provides essential oversight and drives the necessary discovery to provide transparency for more informed decisions. As one Senior Vice President commented, “Evaluating business cases gives me a comfort level that we are spending our funds wisely and any risks we are taking are done with full knowledge of the executives.” This involvement flips the inverted *risk pyramid* into its proper position, making it clear to engineers the executives are addressing the risk. Thus, engineers can focus on complete discovery of the facts and production of creative alternatives.

**The new process cut the review cycle by a month and resulted in a 35% reduction in spending with no expected loss in reliability.**

Another element of establishing an engaged Executive Review Team is to create a meeting environment to foster healthy conversation rather than *rubber stamping*. The executives must be given time to review the written business case well in advance of the engineer’s presentation. Solid preparation by the executives encourages a healthy debate of technical alternatives. During the project review cycle, it is common for the Executive Review Team to evaluate and make decisions on five projects every three weeks until all projects above the budget cut line are reviewed and agreed upon. Prior to the executive review, it is important for the mid-management project review team to evaluate the business cases to ensure the best thinking of the company is included in the alternatives.

**2) Link the Business Case to Overall Project Spending Targets.** Executive management must communicate clear objectives regarding the purpose of developing business cases. These objectives often include project spending targets that must link to the business plan. The purpose of developing business cases for proposed projects is to identify the most cost-effective alternative for meeting a project’s intended goal. Behaviors must be demonstrated and reinforced to seek out the desired reliability targets while still ensuring fiscal responsibility. As one Senior Vice President of a nuclear business unit said, “We have to discipline ourselves to differentiate between needs versus wants.” Having a clear financial target for overall project spending is a critical ingredient to ensuring fiscal balance. Achieving financial targets provide the extra motivation for engineers to find the most cost-effective solution. Similarly, at the individual project level, each project must tie directly to a known starting point for costs, such as the existing budget or latest business plan. This link ensures each alternative for a project is evaluated based on a common

**Exhibit 3** ***Is Your Business Case Robust?***

This checklist provides the key elements of successful business cases.

1. A clear distinction exists between the base case and alternatives
2. Alternatives are creative and address saving costs and improving reliability
3. The costs of the alternatives clearly tie back to the existing budget or business plan
4. A clear distinction exists between hard labor savings versus productivity savings when determining incremental cash flows
5. There is a clear discussion of cost-risk tradeoffs based on the financial and risk analyses
6. All key assumptions are documented
7. Failure rate assumptions are backed up by historical equipment failure rate data and documented industry or vendor experience
8. The financial analysis provides sensitivity analysis, includes breakeven analysis and compares the NPV of alternatives
9. The business case includes a Monte Carlo risk analysis to quantify risk and calculate the confidence of reaching the point estimates
10. Regulatory commitments are clearly documented with an associated timetable

language and well-known yardstick.

One nuclear CEO strongly encouraged this balanced behavior by setting a minimum savings target for business cases of 15% against the existing current year project budget with a stretch of 20% savings. This top-down communication motivated the engineers and mid-management project review committee to identify cost-saving alternatives in business cases. The responsibility associated with personally presenting their business cases to the Executive Review Team gave the engineers additional incentive for identifying the most cost effective alternatives. After developing and presenting about 20 business cases, the company achieved the stretch goal of saving 20%, or about $10 million, against the existing budget. This accomplishment allowed them to reach their financial targets and provide a cushion for unplanned projects. Progress against the targets was reinforced after each executive review meeting by showing a *tally sheet* comparing each project's original budget against the new budget. The Executive Review Team ensured high reliability goals were not compromised by circling back to restore funding to select projects initially reduced in the early executive review meetings. Revisiting some earlier decisions gave the Executive Review Team comfort they had achieved the proper cost-risk balance.

**3) Develop Robust Business Cases.** In analyzing the effectiveness of a plant's project review process, rarely is the question asked: Are the current business cases producing the most cost-effective solution and consequently, could we be paying too much for our desired reliability? Exhibit 3—*Is Your Business Case Robust?*—provides the key elements of successful business cases.

In many cases, engineers do not have the financial depth necessary to identify, quantify and analyze alternative project solutions. As a result, engineers should be

teamed up with Finance or Business Planning personnel who possess technical and financial skills to develop business cases. Engineers develop the background and cost estimates, while the Business Planning and Finance personnel use financial and risk analysis techniques. Business Planning and Finance personnel with a technical background create additional value as they talk the engineer's language, challenge the alternatives and consistently structure the financial analysis for each alternative.

Financial and risk analytic tools, combined with financial and engineering knowledge, can breathe new life into business cases. These tools are used to conduct sensitivity and breakeven analysis, translate failure rates into expected NPV results and conduct Monte Carlo risk analysis on key input assumptions. Successfully integrating probability and risk analysis into business cases was a giant leap forward for one large utility, which was reflected by the Chairman of the Executive Review Team: "Quantifying risk has created an entirely new and more objective way for us to evaluate benefits and the cost-risk tradeoffs in projects."

Engineers must be trained on these financial and risk analysis techniques to increase their comfort in evaluating alternatives and presenting a business case to the mid-management project review team and the Executive Review Team (see Exhibits 4, 5 and 6). Because engineers typically do not develop enough business cases to

**Exhibit 4** ***Simplified Risk Analysis—Binomial Distribution***

The binomial distribution (used here for a dual motor set) is useful in quantifying the financial risk from power plant equipment failures.

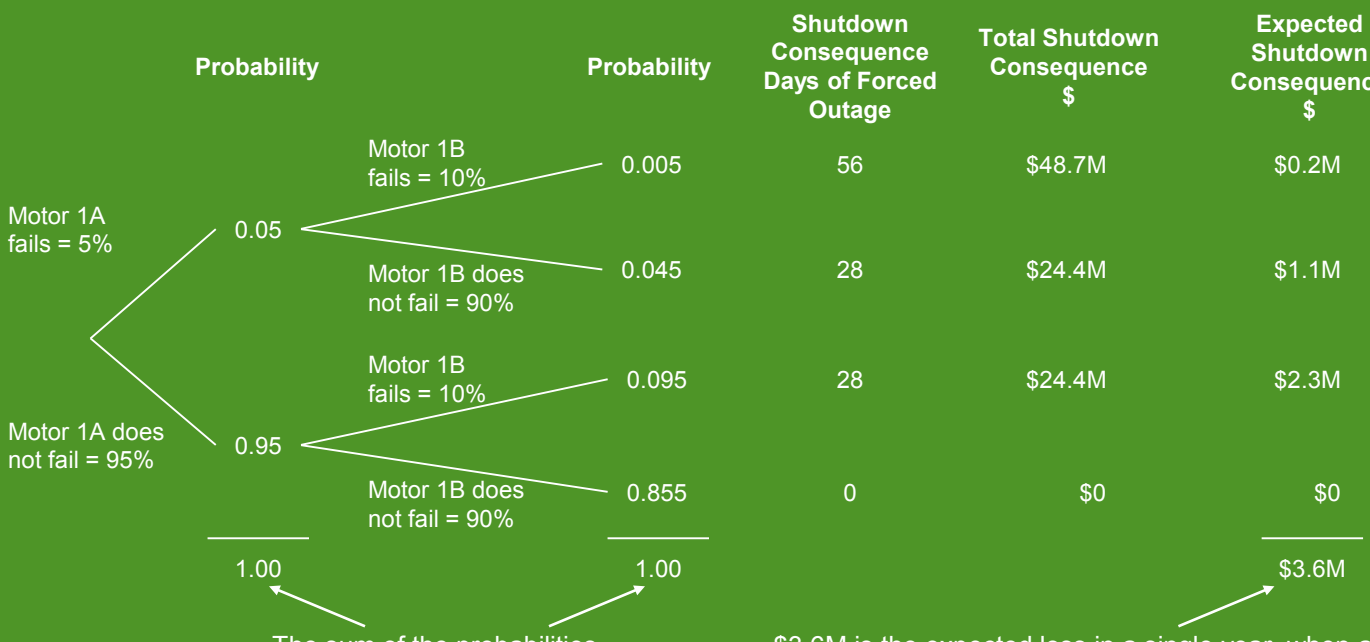
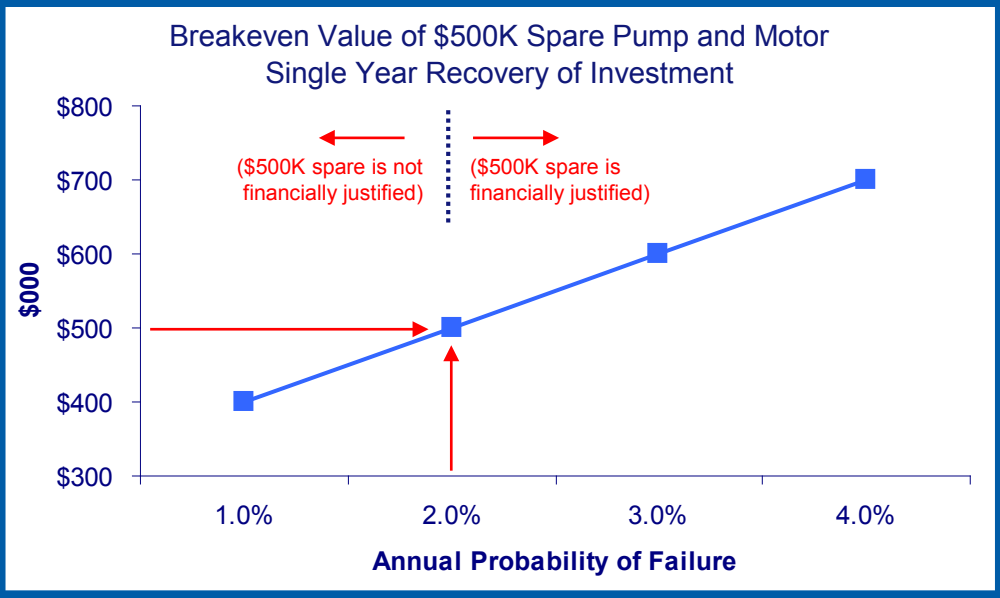


**Exhibit 5** ***Simplified Risk Analysis—Breakeven Analysis***

The breakeven analysis (used here in a pump and motor set) is an important tool when a failure rate of a component is not known.

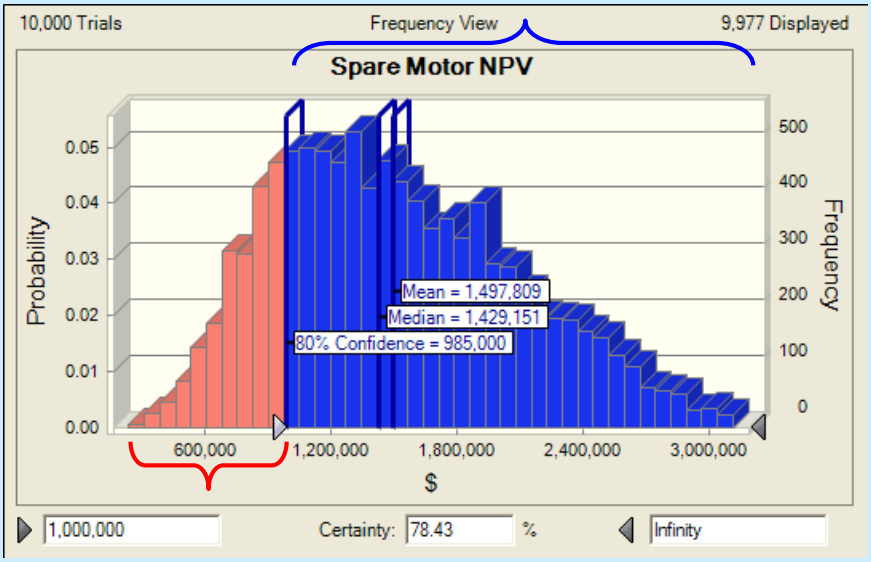
At the breakeven point, the value of the risk of the component failure is equal to the financial cost of avoiding the risk. In this example, to the right of the breakeven point, the probability of failure is high enough to justify the $500K spare. To the left of the breakeven point, the probability of failure is too low.




A breakeven analysis provides a *sanity check* regarding the failure assumptions used in the business case analysis for the NPV point estimate.

**Exhibit 6** ***Simplified Risk Analysis—Full Life NPV Frequency Chart***

78% confidence the NPV will be greater than the base case point estimate of $1.0 million




22% chance the project NPV of $1.0 million will not be met

The traditional business case would calculate a single point estimate NPV (e.g., $1.0 million) but would ignore the probability of achieving the NPV estimate.

The Monte Carlo analysis, by contrast, uses a range of values for key inputs, such as equipment failure rates, equipment cost and power costs. This provides a confidence level or probability of achieving the NPV estimate.

In this case, the confidence is 78% the point estimate of $1.0 million will be achieved … thus giving comfort to the Executive Review Team the project will achieve the stated results.

*Note: The Monte Carlo Simulation utilized Oracle's Crystal Ball 7.3.1.*

become experts in the tools or financial concepts, they should independently develop the background and cost estimates for a project and actively include knowledgeable and credible Business Planning or Finance staff early in the identification of alternative solutions. This team approach ensures alternatives are properly structured for comparative financial analysis. When all parties bring their strengths to the table, the team is positioned to offer the best recommendation considering both reliability and cost. Ultimately, however, it is the role of the Executive Review Team to decide how much risk they are willing to assume at various cost levels.

**4) Prioritize Projects.** Robust business cases reviewed by an active and engaged Executive Review Team are key to opening another door to capital and O&M savings. Utilities which are cost effective in managing nuclear plants rarely exceed the capital budgets set for their plants; often in the range of $40 million per year. To remain within the capital budget, plants cannot pursue every worthy project, therefore deferring many of them. Business case results allow the Executive Review Team to prioritize each project, typically accomplished in a periodic project prioritization meeting. Project scoring methods may enhance the Executive Review Team's understanding of the relative value of projects under review, but business case results provide the most insightful information for judging true value of projects competing for limited funds.

It is common in project prioritization meetings to divide the projects into *must do* and *discretionary* using business case results and a supplemental scoring method. The executive committee ranks discretionary projects above and below the budget cut-line (*go* and *no-go*). The savings found in business case evaluations may give cause to

**Exhibit 7** ***Project Prioritization Cut Line***

| Rank | Mandatory / Discretionary | Title | Project Cost | Cumulative Project Costs | Status |
|---|---|---|---|---|---|
| 1 | D | Generator Step Up Transformer Spare Purchase | $ 12,320,000 | $ 12,320,000 | Above the Line |
| 2 | M | Generator rewind | $ 8,045,000 | $ 20,365,000 | Above the Line |
| 3 | M | Obsolete Pneumatic Control Loop Replacement | $ 3,750,000 | $ 24,115,000 | Above the Line |
| 4 | M | Auxiliary Building Page System Replacement | $ 3,000,000 | $ 27,115,000 | Above the Line |
| 5 | M | Refueling Water Storage Tank Bladder Replacement | $ 3,000,000 | $ 30,115,000 | Above the Line |
| 6 | M | Main Turbine Valve Actuators Refurbishment | $ 2,000,000 | $ 32,115,000 | Above the Line |
| 7 | M | Purchase Replacement Reactor Head Stud Tensioners | $ 1,750,000 | $ 33,865,000 | Above the Line |
| 8 | D | Service Water Piping Replacement | $ 1,604,570 | $ 35,469,570 | Above the Line |
| 9 | D | Steam Generator Tube Supports | $ 1,500,000 | $ 36,969,570 | Above the Line |
| 10 | D | Digital Feedwater Controls Upgrade | $ 1,500,000 | $ 38,469,570 | Above the Line |
| 11 | M | Main Boiler Feedpump Replacement | $ 1,500,000 | $ 39,969,570 | Above the Line |
| 12 | D | RCP Motor Refurbishment | $ 4,308,000 | $ 44,277,570 | Above the Line |
| 13 | D | Turbine Blade Upgrade and Power Uprate | $ 7,680,000 | $ 51,957,570 | Below the Line |
| 14 | D | Alloy 600 Component Replacements | $ 12,104,000 | $ 64,061,570 | Below the Line |
| 15 | D | Digital Distributed Control System U2 | $ 3,062,400 | $ 67,123,970 | Below the Line |
| 16 | D | Pumphouse Isolation Valves | $ 3,011,694 | $ 70,135,664 | Below the Line |
| 17 | D | Reroofing Projects | $ 1,876,900 | $ 72,012,564 | Below the Line |
| 18 | D | Condenser Tube Bundle Upgrade | $ 1,794,595 | $ 73,807,159 | Below the Line |
| 19 | D | Moisture Separator Reheater Upgrade | $ 1,625,000 | $ 75,432,159 | Below the Line |

move discretionary projects *above the line*. In fleet applications, individual plant budget cut-lines can be raised or lowered to reflect *trading* between the plants during the prioritization meeting.

The project prioritization list is also used during Project Authorization meetings for executives to see what effect approving a certain project has on the portfolio of projects. A prioritized list of approved projects is then updated in the long range plan. Discretionary projects not approved are cancelled or placed in later years of the long range plan for continued monitoring.

**MCR's experience in working with several nuclear plants resulted in savings over $100 million compared to approximately $300 million budgeted.**

## Getting Back on Course

Completing business cases to evaluate proposed projects has been in place at many plants for many years. Over time, however, the process can lose its sense of purpose; today, many plants just go through the motions with business cases. Power plant executives must reinvigorate the project review process by requiring robust business cases to set the proper expectations and optimize project spending. Reinvigorating the process requires time and a commitment to changing the culture, but the returns are substantial. MCR's experience in working with several nuclear plants resulted in an **eye-popping savings of over $100 million,** compared to the approximate $300 million budget for the projects reviewed, with no degradation in safety or reliability. Achieving results of this magnitude requires a commitment by senior management to breathe new life into business cases and the project prioritization process, but the payoff can be highly rewarding.

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