RECONCILE SAFETY AND RELIABILITY WITH COST: A PROVEN APPROACH TO OPTIMIZE PROJECT SPENDING AT NUCLEAR POWER PLANTS

Most nuclear plants require a business case before a significant project is approved. However, these business cases often just go through the motions to justify the desired project, resulting in higher-than-necessary budgets and displacement of other important projects.

A successful project review process requires an active executive team and robust business cases to quantify alternatives and evaluate cost-risk trade-offs. This process helps ensure power plants meet their reliability goals in cost-effective ways. Moreover, when led by senior plant management, this approach can produce cost savings of over 50%, reducing the strain on power plant capital and operating budgets.

MCR assists nuclear plants by teaching techniques to prepare robust business cases with creative alternatives that quantify reliability and financial risk. These previously unavailable insights empower the executive team to confidently make the best decisions.

The Case for Business Cases

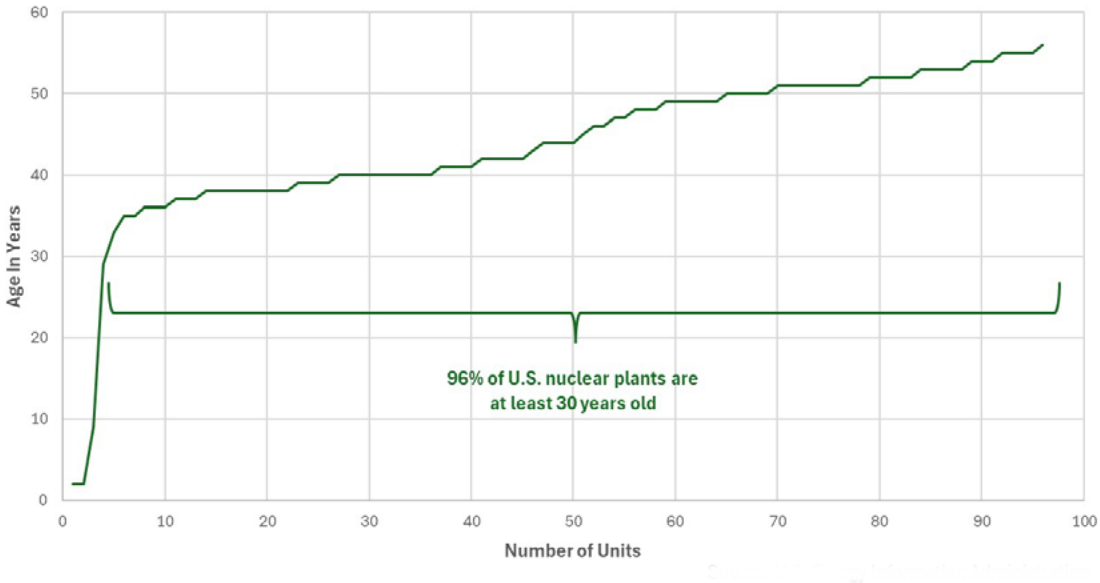
Nuclear plants often have more projects than budget. As one Site Vice President said, “I have no shortage of high net present value projects I can do. … I do, however, have a shortage of money to accommodate those projects and still make my business plan goals.”

Ninety-six percent of U.S. nuclear plants are at least 30 years old (see Exhibit 1). As these plants continue to age, capital and O&M budgets will face additional pressure to maintain reliability. To address this increasing pressure, management needs to plan projects to increase reliability in the most cost-effective manner possible. Robust business cases with quantitative comparisons of alternatives, considered in a well-thought-out process, provide the following benefits to utilities:

- Wise project budget spending.

- Funds made available in the annual budget for additional high-value projects and contingency purposes.
- Available margin for executives to meet financial and reliability targets even if unforeseen projects emerge.
- Assurance to state regulators and other stakeholders that project spending is responsibly allocated and optimized.

Exhibit 1: The Age of the U.S. Nuclear Fleet



Source: U.S. Energy Information Administration

Current State—Going Through the Motions

Nearly all plants require a business case for projects over a certain threshold dollar amount. They also have procedures, financial models, and forms to guide the business case development and project review process. Yet the results often lead to frustration among senior management. In MCR's experience, utilities typically encounter four problems in the process of developing and reviewing business cases, leading to unimpressive results:

1. Lack of strategic context

The business case process often takes place out of executives' view, with no direct linkage to financial goals or spending targets. Personnel who write business cases often lack understanding of the wider capital strategy and simply develop them to satisfy procedure, shoehorning acceptable costs into the plan. As one Finance Director for several plants

> *"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?"*
>
> *—Chief Nuclear Officer*

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

2. Lack of direct executive involvement

Many plants rely on middle management committees to evaluate projects, reserving the executive team for final approval or annual portfolio reviews that lack sufficient deliberation to identify and evaluate alternatives to projects. This results in a long review cycle, a surface-level understanding from executives, and suboptimal project alternatives. This can also result in a dysfunctional reverse-pyramid risk culture, in which engineers perceive they alone bear the risk of their decisions, leading to overly conservative project alternatives.

3. Lack of rigor

Many business cases do not support funding requests with adequate quantitative data. For example, historical equipment failure rates or industry experience may be missing, resulting in suspect NPV calculations. Without this foundation, cost-benefit analyses cannot incorporate creative alternatives to compare cost-risk trade-offs. Business cases can become a box-checking exercise, seeking a positive NPV and leaving more cost-effective solutions on the table.

4. Lack of risk quantification

Most business cases do not quantify risks. If there is a risk calculation, such as potential reduction of equipment failure rates, the financial analysis relies on overly optimistic estimates of investments, savings, and reductions in forced outages. This provides middle management and the executive team with a false sense of security, neglects uncertainties, and prevents rigorous cost-risk evaluations.

Is Your Business Case Robust?

This checklist provides the key elements of successful business cases:

- ✓ The proposed project and alternatives are clearly distinguished.
- ✓ Creative alternatives address ways to save costs and improve reliability.
- ✓ The costs of the alternatives clearly tie back to the existing budget or business plan.
- ✓ Hard labor savings are clearly distinguished from productivity savings when determining incremental cash flows.
- ✓ There is a clear discussion of cost-risk trade-offs based on the financial and risk analyses.
- ✓ All key assumptions are documented.
- ✓ Failure rate assumptions are backed up by historical equipment failure rate data and documented industry or vendor experience.
- ✓ The financial analysis includes sensitivity and breakeven analyses and compares the net present value (NPV) of alternatives.
- ✓ The business case includes a Monte Carlo risk analysis to quantify risk and calculate the confidence of reaching the point estimates.
- ✓ Regulatory commitments and timetables are clearly documented.

Breathing New Life into Business Cases and the Project Review Process

A successful project review process requires an active executive team, a clear link to overall spending targets, robust business cases to better evaluate alternatives and cost-risk trade-offs, and measurement of results for continuous improvement.

Establish an Active Executive Review Team

Direct executive involvement in the business case review provides essential oversight and drives discovery. An engaged executive team should strive for healthy conversation and debate rather than rubber-stamping. This involvement flips the inverted risk pyramid into its proper position, where engineers are confident in the executives addressing risk. Thus, engineers can focus on discovering the facts and developing creative alternatives.

One nuclear power plant saw a remarkable improvement in the quality of business cases when the executive team asked engineers to present directly to them. Formerly, executives at the plant only signed off on project approvals without firsthand discussion of the alternatives. The new process cut the review cycle by a month and resulted in a 35% reduction in spending for the projects reviewed, without an expected loss in reliability.

Link the Business Case to Overall Project Spending Targets

Executive management must communicate clear objectives for developing business cases to support reliability and fiscal responsibility goals. Having a clear financial target for overall project spending provides motivation for engineers to find the most cost-effective solution.

One nuclear CEO drove balanced decision-making by requiring business cases to target 15% savings, with a 20% stretch goal. This top-down mandate encouraged engineers and managers to surface cost-effective alternatives to be presented personally to the executive team. The executive team ensured reliability was not compromised by restoring previously reduced funding to select projects, delivering confidence in a proper cost-risk balance. From about 20 business cases, the company achieved the stretch goal of 20%, or about $10 million, in savings.

"We have to discipline ourselves to differentiate between needs versus wants."

—Nuclear Business Unit Senior Vice President

"Quantifying risk has created an entirely new and more objective way for us to evaluate benefits and the cost-risk trade-offs in projects."

—Chairman of the Executive Review Team

Develop Robust Business Cases

Engineers often lack the financial expertise to fully evaluate alternatives, so they should be paired with finance or business planning staff to develop business cases. This collaboration strengthens cost estimates with financial and risk analysis, leveraging tools such as sensitivity and breakeven analysis, NPV modeling using failure rates, and Monte Carlo simulations to enhance decisionmaking and quantify uncertainties. Exhibits 2, 3, and 4 illustrate these analytical methods.

The binomial distribution (used in Exhibit 2 for a dual motor set) is useful in quantifying the financial risk from power plant equipment failures.

Exhibit 2: Simplified Risk Analysis—Binomial Distribution

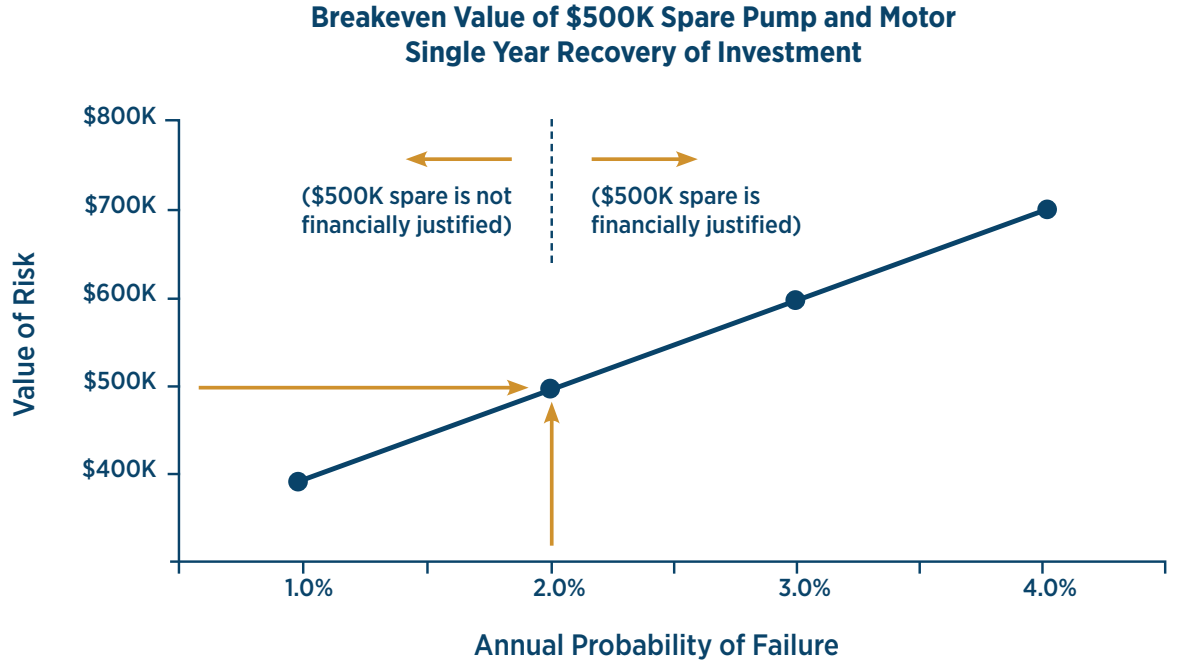
Probability	Probability	Shutdown Consequence: Days of Forced Outage	Total Shutdown Consequence	Expected Shutdown Consequence
Motor 1A fails=5% → 0.05 → Motor 1B fails=10%	0.005	56	$48.7M	$0.2M
Motor 1A fails=5% → 0.05 → Motor 1B does not fail=90%	0 .045	28	$24.4M	$1.1M
Motor 1A does not fail=95% → 0.95 → Motor 1B fails=10%	0.095	28	$24.4M	$2.3M
Motor 1A does not fail=95% → 0.95 → Motor 1B does not fail=90%	0.855	0	$0	$0
1.00	1.00			$3.6M

The sum of the probabilities always totals 1.00.

$3.6M is the expected loss in a single year when a spare motor is not available; it is comparable in principle to an insurance premium.

The breakeven analysis (used in Exhibit 3 for a pump and motor set) is an important tool when a failure rate of a component is not known.

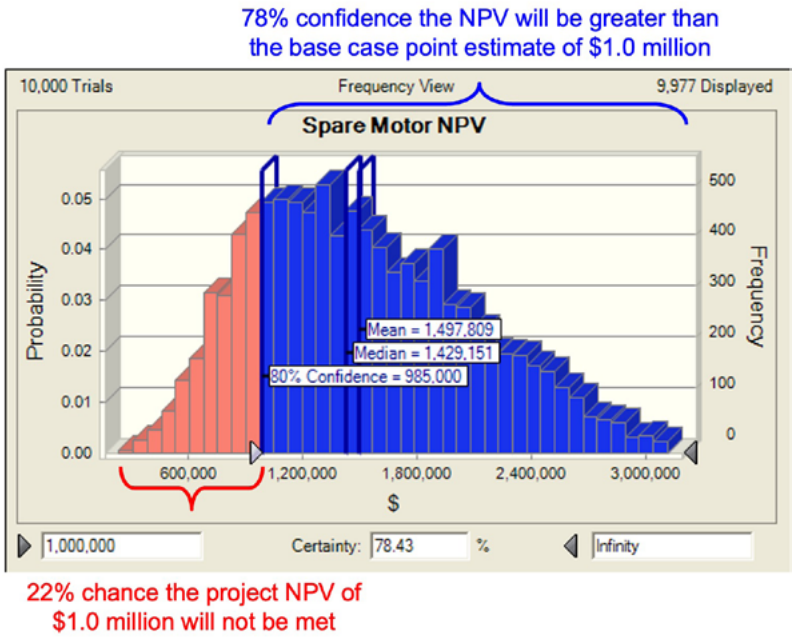
Exhibit 3: Simplified Risk Analysis—Breakeven Analysis



At the breakeven point, the value of the risk of the component failure is equal to the financial cost of avoiding the risk. In the example in Exhibit 3, 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 4: Simplified Risk Analysis—Full Life NPV Frequency Chart



A Monte Carlo analysis 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.

In the case illustrated in Exhibit 4, the confidence is 78% the point estimate of $1.0 million will be achieved, thus giving assurance to the executive team the project will achieve the stated results.

Prioritize Projects

Cost-effective nuclear utilities rarely exceed their capital budgets, often around $50 million per unit per year, which requires deferring many otherwise worthy projects. Business cases enable the executive team to prioritize within this constraint. MCR recommends combining business case results, such as NPV, with a ranking scale, separating must-do and discretionary projects and setting a clear budgetary go/no-go line. Savings identified in business cases can elevate discretionary projects above the line, while fleet prioritization allows cut lines to shift as budget is traded between plants.

Exhibit 5: The 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

Getting Back on Course

Business cases have long been used to evaluate projects, but at many plants the process has devolved into a check-the-box exercise. Executives must reset expectations by demanding rigorous business cases to optimize spending and reinforce disciplined decision-making. This requires time and cultural commitment, but the payoff is real: Over the course of more than 50 recent business cases developed by MCR with our utility clients, we were able to identify over $200 million in savings from more than $700 million of originally proposed spending, averaging savings of over 30%. (See Exhibit 6.)

MCR was able to identify **over $200 million in savings** from more than $700 million of originally proposed spending.

Exhibit 6: The Results of MCR's Project Evaluation Process

Utility	Total Value of Projects Reviewed ($M)[1]	Total Value of Savings from Projects Reviewed ($M)[1]	% Savings
A	42	10	23.8%
B	8	2	25.0%
C	51	26	51.0%
D	115	27	23.5%
E	405	103	25.4%
F	84	48	57.1%
Total	**705**	**216**	**30.6%**

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

Source: Actual MCR client results

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Contact MCR to discuss how our experts can help your plant restore certainty to capital project planning.

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