Reconcile Safety and Reliability with Cost: A Proven Approach to Optimize Project Spending

April 17, 2015
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- Example: Full Flow Condensate Polishing Demineralizer
Alternative Analysis Approach to Project Evaluation
An alternative analysis approach to project evaluation optimizes capital investment required to achieve strategic objectives

**PROJECT EVALUATION PROCESS**

- **Cost and Reliability Targets**
  - Understand current and desired position in industry
  - Develop long-term cost and reliability targets, including the “North Star”
  - Translate long-term cost targets into current project savings targets

- **Project Approval Committee**
  - Assemble Executive Project Approval Committee
  - Provide guidelines for effective project reviews

- **Business Cases**
  - Define methodology to prepare and evaluate business cases
  - Develop business cases evaluating project alternatives, including rigorous use of risk and financial analysis techniques

- **Project Prioritization**
  - Divide the projects into “must do” and “discretionary”
  - Prioritize the discretionary projects using results of the business cases and any existing project scoring method

- **Ongoing Training and Instruction**
  - Develop desktop instruction sets
  - Provide ongoing training to engineers and business planning staff on tools and techniques for robust business case preparation

- **Lessons Learned**
  - Provide lessons learned from business case preparation and project approval meetings
  - Ensure improvements will “stick”

**Improvements in project evaluation processes have historically provided a 20-30% reduction in annual project spending.**
Enhancing the project evaluation process inherently improves the “bottom line” of utilities.

“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.”
–Utility Vice President

- Utilities nearly always have more projects than they have budget

- Producing robust project evaluations optimizes project spending, which in turn frees funding for additional high-value projects
  - More effective project evaluation process frees funds for contingency purposes during the year … giving utility executives more confidence they will meet financial and reliability targets
  - For state regulators and other stakeholders, robust project evaluations for capital and O&M projects ensure prudent project spending
A robust project evaluation process should be viewed in the context of the long range strategy of the company.

**Step 1**
- Develop long-term cost and reliability targets, including the “North Star” cost target

**Approach**
- Use industry data to formulate long-term cost and reliability targets; gain alignment on the “North Star”
- Analyze the data; develop long-term cost curves, which are directionally correct and reasonably supported by available data
- Access available reliability data
- Establish the strategic purpose of project evaluations; translate long-term cost targets into current project savings targets

**Deliverables**
Quantifiable cost and reliability targets, considering client’s peer groups, technology and rate circumstances
Documented support for long-term chosen targets (e.g., industry data) and implications for project savings targets

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Achieving the North Star

<table>
<thead>
<tr>
<th>Year</th>
<th>Base Case</th>
<th>North Star</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
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<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Gap**

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The long-term cost and reliability targets provide the link to the short-term savings targets.

“We have to discipline ourselves to differentiate between needs and wants.”
—Senior Vice President

- Executive management must communicate both savings and reliability targets when business case objectives are developed
  - Both reliability and savings bring focus to the process
  - Short-term cost savings targets ensure fiscal responsibility

- Requiring achievement of savings targets motivates engineers to develop cost effective alternatives for each project

- One CEO motivated his engineers to find the most cost-effective projects by setting a minimum total savings target for project evaluations
  - The target was 15% savings against the existing current year project budget with a stretch target of 20%
  - The target was reached primarily by first developing additional alternatives for each project that otherwise would not have been considered and then comparing the alternatives with risk-adjusted metrics
  - In addition, the utility also achieved equipment reliability gains from the projects
Once targets are set, the project lead presents to an approval committee, resulting in significant improvements in quality of project evaluations.

Step 2

- Establish an involved Executive Project Approval Committee

Approach

- Outline the role of the Executive Project Approval Committee and other mid-management project approval committees
- Establish success criteria for each meeting, including progress against targeted savings
- Define expectations of a successful project presentation
  - Ensures a robust analysis
  - Fosters insightful discussion about the project rather than a simple “check the box” evaluation

Deliverables

- Documented charter with committee role
- Expectations of project presenter
Executive involvement provides oversight and leadership in sharing the responsibility of risk with the engineers.

“Rigorous project evaluations give me a comfort level we are spending our funds wisely and any risks we are taking are done with full knowledge of the executives.”

– Senior Vice President

- The Executive Project Approval Committee should be composed of senior executives who must be significantly involved in the project evaluation process
  - Mid-management can participate in the project review, but executive oversight is critical
  - Executive involvement ensures projects will be in line with the overall utility strategy

- Project evaluations lacking continuous executive involvement cause a dysfunctional “inverted risk pyramid” structure
  - Engineers often perceive they solely bear the risk of their decisions
  - “Cadillac Alternatives” with the least risk tend to be developed … these projects are almost always the most expensive

- Direct executive involvement in project evaluations provide necessary discovery transparency for informed decisions
  - Executive involvement turns the inverted risk pyramid right side up, making it clear to engineers the executives are assuming risk
  - Engineers may now focus on complete discovery of facts and development of creative alternatives with cost and risk trade-offs
Robust business cases allow the approval committee to meaningfully discuss, interact and deliberate project alternatives.

- **Step 3**
- **Approach**

  - Develop rigorous business cases
  - Select which projects will be evaluated and establish a single point of accountability from Engineering who has knowledge to answer questions, gather information and ensure timely completion of each business case
  - Document the problem statement, background and current established cost for each project, serving as a baseline for project savings
  - Identify project alternatives; quantify alternatives using risk techniques and financial tools; identify cost-risk tradeoffs
  - Mentor engineers, project leads and business planning staff through:
    - Participation in the business case development process
    - Presentations for the Executive Project Approval Committee

- **Deliverables**

  - Business cases in Microsoft Word and associated summary presentations in PowerPoint, presented before the Executive Project Approval Committee
  - Savings or value added from the initial estimate for the projects
  - Demonstrated capability to develop business cases; a change in culture
Rigorous business cases must be built into the culture.

“If I go ahead and lay out alternatives that save money, I want assurance from the Project Approval Committee that all the plant’s projects will be subjected to this same expectation and scrutiny.”

–Plant System Engineer

Rigorous business cases share the following:

- Clear distinction between “do nothing,” base case and alternatives
- Clear documentation and associated timetable of regulatory commitments
- Creative alternatives explicitly discussing tradeoffs between cost and risk and providing supporting data
- Clear distinction between hard labor savings versus productivity savings to determine incremental cash flows
- Basis of all key assumptions, including failure rates, backed up by historical equipment failure rate data and documented industry or vendor experience
- Quantitative financial analysis of alternatives with sensitivity analysis and breakeven analysis, comparing the net present value (NPV) of alternatives
- Quantitative risk analysis of alternatives, including Monte Carlo analysis, to quantify risk and calculate the confidence of reaching point estimates
Once the chosen projects have been evaluated and optimized, the committee can more easily prioritize the projects.

**Step 4**

- Prioritize the projects using the results of the business cases
  - Executive Project Approval Committee prioritizes the projects in a project prioritization meeting (commonly held quarterly)
  - Any existing project scoring methods adding to the understanding of the relative value of the projects are also used by the Committee

- Divide the projects into “must do” and “discretionary” using the results of the business cases and the utility’s scoring method, if one exists

- Rank the discretionary projects above and below the budget cut-line (“go” and “no-go”) in the project prioritization meeting
  - Lower the budget cut-lines to reflect the savings found in the business case evaluations to permit discretionary projects to move “above the line”
  - In fleet applications, lower or raise individual budget cut-lines to reflect “trading” between business units during the prioritization meeting

**Approach**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Mandatory/Discretionary</th>
<th>Title</th>
<th>PROJECT COST</th>
<th>CUM TOTAL PROJECT COST</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>AST/SC/MSLC Deaeritiation</td>
<td>5,500</td>
<td>5,500</td>
<td>Above the line</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>Control Room Habitability</td>
<td>1,000</td>
<td>6,500</td>
<td>Above the line</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>Emergency Diesel Generator Rebuild</td>
<td>1,500</td>
<td>8,000</td>
<td>Above the line</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>HCU Replacement</td>
<td>3,500</td>
<td>11,500</td>
<td>Above the line</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>MOV Replacement</td>
<td>1,000</td>
<td>12,500</td>
<td>Above the line</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Check Valve Replacement Program</td>
<td>3,100</td>
<td>15,600</td>
<td>Below the line</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>Upgrade Feedwater Hrs</td>
<td>5,500</td>
<td>21,100</td>
<td>Below the line</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>Information Technology Infrastructure</td>
<td>2,000</td>
<td>23,100</td>
<td>Below the line</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>PDIS Historical Engine</td>
<td>1,000</td>
<td>24,100</td>
<td>Below the line</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Replace Narrowband Radio</td>
<td>1,500</td>
<td>25,600</td>
<td>Below the line</td>
</tr>
</tbody>
</table>

**Deliverables**

Prioritized list of approved projects providing input into the long range plan
Prioritized list of discretionary projects not approved but on a “waiting list”
Business cases with quantitative rigor allow the Executive Project Approval Committee to prioritize projects aligned with short- and long-term financial goals.

“I’ve had engineers say, ‘just tell us the required return to meet the cut-line—we’ll fill in the rest.’”

–Finance Director for utility business unit

- Rigorous, quantitative business cases provide supporting analysis for projects, allowing the Executive Project Approval Committee to more easily decide whether a project fits within the overall spending strategy … and makes the cut-line
  - Allows senior executives to determine if the project belongs in a future budget and/or in the long range plan

- Rigorous analysis avoids the undesirable alternative approach … staff simply going through the motions of developing business cases to satisfy procedures and meet a hurdle rate
Robust business cases quantify risk through use of the binomial distribution.

### Simplified Risk Analysis—Binomial Distribution

<table>
<thead>
<tr>
<th>Probability</th>
<th>Probability</th>
<th>Shutdown Consequence Days of Forced Outage</th>
<th>Total Shutdown Consequence $</th>
<th>Expected Shutdown Consequence $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor 1A fails = 10%</td>
<td>0.005</td>
<td>56</td>
<td>$48.7M</td>
<td>$0.2M</td>
</tr>
<tr>
<td>Motor 1B does not fail = 90%</td>
<td>0.045</td>
<td>28</td>
<td>$24.4M</td>
<td>$1.1M</td>
</tr>
<tr>
<td>Motor 1B fails = 10%</td>
<td>0.095</td>
<td>28</td>
<td>$24.4M</td>
<td>$2.3M</td>
</tr>
<tr>
<td>Motor 1B does not fail = 90%</td>
<td>0.855</td>
<td>0</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

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.
Breakeven analysis provides critical information when a failure rate is unknown.

**Simplified Risk Analysis—Breakeven Analysis**

At the breakeven point, the value of the component failure risk 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 project evaluation analysis for the NPV point estimate.

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**Breakeven Value of $500K Spare Pump and Motor**

Single Year Recovery of Investment

- $000
- 1.0% 2.0% 3.0% 4.0%

($500K spare is financially justified)

($500K spare is not financially justified)
Monte Carlo analysis determines the probability of achieving the net present value … and quantifies the level of confidence.

- Traditional project evaluation calculates a single-point estimate NPV
- The Monte Carlo analysis plot above shows there is a 70% confidence the point estimate will be exceeded
- This analysis provides insight to the Executive Project Approval Committee on the expected costs of the project

Only 30% confidence the PV of the base case costs will be less than the point estimate of $27.9M
Adding tools and training ensures rigorous and consistent project evaluation into the future.

**Step 5**

- Develop desktop guide for sustaining robust project evaluation
- Update/produce a new desktop guide reflecting the new, rigorous project evaluation approach
- Enhance the ongoing risk and financial tools used in project evaluation to sustain a new culture of quantitative project evaluation and development of alternatives
- Identify gaps and initiate governance changes to sustain more robust project evaluation development process

**Approach**

**Deliverables**

Project evaluation desktop guide consistent with company’s governance and the new project evaluation instructions
Recommended improvements to the existing project evaluation analysis tools
Training with these risk analysis tools provides the means to build rigorous business cases.

“Quantifying risk has created an entirely new and more objective way for us to evaluate benefits and the cost-risk tradeoffs in projects.”
–Chairman of Executive Project Approval Committee for a large utility

- Training is necessary to better understand the analytical tools
  - To conduct sensitivity and breakeven analysis
  - To translate failure rates into expected NPV results
  - To conduct Monte Carlo risk analysis on key input assumptions

- Since complete business cases are developed by a team, including staff from Engineering, Business Planning and Finance, all three organizations benefit from the training
  - Engineers and project leads often have the lead to independently develop the background and cost estimates of the business case
  - Engineers and project leads receive input from Business Planning and Finance staff to ensure development of solid financial analysis and a well-rounded business case
Tracking lessons learned is the key to continuous process improvement.

**Step 6**

- Compile lessons learned from project evaluation development and project approval and prioritization meetings throughout the project
- Incorporate lessons learned as refinements to the desktop instruction
- Develop actionable recommendations to improve project evaluations and project approval and prioritization meetings
- Use a grading sheet to evaluate the quality of business cases
- Use Executive Project Approval Committee meeting observation sheet to document meeting quality

**Approach**

**Deliverables**

Lessons learned for improvements in next cycle of project evaluations and project prioritization meetings
Project Evaluation Summary

- Project evaluation has been in place at many utilities for years
  - Completing business cases, evaluating proposed projects and more complex processes are part of the process
  - Over time, however, the process can lose its sense of purpose
  - Today, there is a tendency to merely go through the motions to complete project evaluations

- Utility executives must reinvigorate the project review process
  - Executives must require robust project evaluations to set the proper expectations and optimize project spending
  - Reinvigoration of the process requires time and a commitment to changing the culture, but the returns can be substantial
  - For typical utilities spending $500 million per year on capital and O&M projects, the annual expected savings from a reinvigorated process are between $100 million and $200 million
Example:

Full Flow Condensate Polishing Demineralizer (FFCPD)
 LCMP
FFCPD Identification and Summary Problem Statement

- The FFCPD system health is degraded, resulting in
  - reduced operational margin
  - inefficient work practices
  - loss of redundancy
  - operator workarounds
  - high level of corrective maintenance relative to preventive maintenance
- Degraded system health is due to poor material condition of the SSCs and the impact of obsolescence and aging
- Continued tolerance of the FFCPDs degraded condition is not consistent with the Equipment Reliability Improvement Plan
Strategic Fit and Risk Discussion

- This process addresses issues not easily quantified through analytics.
- Such issues are no less important and for the FFCPD include:
  - Improving personnel safety
  - Increasing effectiveness and efficiency of training
  - Improving human performance due to Human Machine Interface commonalities
  - Potential for economies of scale on spare parts
  - Cross-system equipment testing
  - Reducing operator distractions, work-arounds, plant burden
  - Improving equipment maintainability
  - Increasing operational flexibility
  - Improving system image
  - Increasing pride of ownership

- Benefits associated with these issues must be considered when selecting from among the alternatives.
## Capital Project Analysis
### Sample of four FFCPD Issues and Problem Statements

<table>
<thead>
<tr>
<th>Restoration Initiative</th>
<th>Issues</th>
<th>Problem Statement</th>
</tr>
</thead>
</table>
| Modicon Programmable Controller | - Expansion of functions is limited  
- No historical data and no process monitoring capability  
- Not consistent with main digital control upgrade project  
- Control room analog instrumentation is unreliable; needs extensive PM program  
- No operator troubleshooting capability | Expansion of Programmable Controller is limited, thereby constraining system improvements that would increase operations and maintenance efficiency |
| Reline Polisher Vessel Internal Liner | ~ 30% of internal lining of each vessel is blistered  
- Broken-off pieces could challenge regeneration  
- Linings are 15 years past vendor-recommended lifespan  
- Overall, not an immediate threat to power production | Material condition of polisher vessels' linings is degraded |
| Polishers' Boundary Valves # 1, 2 & 4 | - Valves no longer supported by vendor (Jamesbury)  
- Leak-by prevents establishment of boundaries for mntc work  
- Leak-by results in excessive water usage and high chloride levels  
- Valve leak-by continues despite replacement or refurbishment | Excessive leakage past valve seats increases plant burden, i.e., mntc, operations, engineering, chemistry |
| Regeneration Subsytem Diaphragm Valves | - Diaphragms approaching end of life  
- Position indicators inoperable  
- Numerous manual actuators not maintained and are inoperable  
- Seat leak-by is intolerable for operations | Degraded material condition of regen valves hinders efficient regeneration operations and maintenance on equipment |
### Focusing on Initiative 3,
Polisher Boundary Valves, 1, 2 & 4 – Alternatives

<table>
<thead>
<tr>
<th>Issues</th>
<th>Problem Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Valves no longer supported by vendor (Jamesbury)</td>
<td>Excessive leakage past valve seats increases plant burden, i.e.,</td>
</tr>
<tr>
<td>- Leak-by prevents establishment of boundaries for mntc work</td>
<td>mntc, operations, engineering, chemistry</td>
</tr>
<tr>
<td>- Leak-by results in excessive water usage and high chloride levels</td>
<td></td>
</tr>
<tr>
<td>- Valve leak-by continues despite replacement or refurbishment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>Proactively replace Polisher Boundary Valves, 1, 2 &amp; 4 with a new design for all 12 beds – 36 total valves</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>Proactively replace Polisher Boundary Valves, 1, 2 &amp; 4 with like-for-like for all 12 beds – 36 total valves</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>Proactively refurbish Polisher Boundary Valves, 1, 2 &amp; 4 for all 12 beds – 36 total valves</td>
</tr>
<tr>
<td>Alternative 4</td>
<td>Maintain status quo – replace/repair as needed</td>
</tr>
</tbody>
</table>
## Initiative 3

### Focusing on Alternative 3,
Alternative 3 Capital Expenditure Risk Variables

#### Alternative 3 – Proactively Refurbish Polisher Boundary Valves, 1, 2 & 4 for All 12 beds – 36 Total Valves

<table>
<thead>
<tr>
<th>Type of Cash Flow</th>
<th>Description</th>
<th>Minimum</th>
<th>Most Likely</th>
<th>Maximum</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>Hours for replacement per 10” valve</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>Capital</td>
<td>Number of workers for 10” valve</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>Capital</td>
<td>Labor cost $/hr per worker</td>
<td>50</td>
<td>75</td>
<td>80</td>
<td>Standard</td>
</tr>
<tr>
<td>Capital</td>
<td>10 inch 316 stainless steel valve kit ($)</td>
<td>1,000</td>
<td>5,000</td>
<td>7,500</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>Capital</td>
<td>10 inch carbon steel valve kit ($)</td>
<td>500</td>
<td>2,500</td>
<td>5,000</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>Capital</td>
<td>3 inch carbon valve kit ($)</td>
<td>400</td>
<td>800</td>
<td>1,100</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>Capital</td>
<td>Hours for replacement per 3” valve</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>Capital</td>
<td>Number of workers for 4” valve</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Engineering judgment</td>
</tr>
</tbody>
</table>
### Initiative 3

#### Focusing on Alternative 3, Alternative 3 O&M Risk Variables

**Alternative 3 – Proactively Refurbish Polisher Boundary Valves, 1, 2 & 4 for All 12 beds – 36 Total Valves**

<table>
<thead>
<tr>
<th>Type of Cash Flow</th>
<th>Description</th>
<th>Minimum</th>
<th>Most Likely</th>
<th>Maximum</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>O&amp;M</td>
<td>Percentage WO reduction 10”</td>
<td>30</td>
<td>45</td>
<td>50</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Number of workers per day - 10”</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Duration of work (days) – 10”</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>Based on Plant-specific historical data</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Component Cost ($) – 10”</td>
<td>5,000</td>
<td>8,700</td>
<td>17,400</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Average # of WOs per year – 10”</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>Based on Plant-specific historical data</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Percentage WO reduction - 3”</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Number of workers per day - 3”</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Duration of work (days) – 3”</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>Based on Plant-specific historical data</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Component Cost ($) – 3”</td>
<td>500</td>
<td>850</td>
<td>1,700</td>
<td>Engineering judgment</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Labor rate $/hr</td>
<td>50</td>
<td>75</td>
<td>85</td>
<td>Standard</td>
</tr>
</tbody>
</table>

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## Present Value Cost Analysis of all Alternatives

<table>
<thead>
<tr>
<th>Alt</th>
<th>Description</th>
<th>I(0) / Unit 10” Valve, Material, Labor &amp; Engin $K</th>
<th>I(0) / Unit 3” Valve, Material, Labor &amp; Engin $K</th>
<th>PV Costs (Both units) $K</th>
<th>PV WO Savings (Both units) $K</th>
<th>Net PV Costs Total (Both units) $K</th>
<th>WO Freq / yr</th>
<th>WO duration days / yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Proactively replace Polisher Boundary Valves, 1, 2 &amp; 4 with a new design for all 12 beds</td>
<td>(589)</td>
<td>(38)</td>
<td>(922)</td>
<td>812</td>
<td>(110)</td>
<td>5.0</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>Proactively replace Polisher Boundary Valves, 1, 2 &amp; 4 with like-for-like for all 12 beds</td>
<td>(520)</td>
<td>(35)</td>
<td>(815)</td>
<td>463</td>
<td>(351)</td>
<td>5.0</td>
<td>3.2</td>
</tr>
<tr>
<td>3</td>
<td>Proactively refurbish Polisher Boundary Valves, 1, 2 &amp; 4 for all 12 beds</td>
<td>(144)</td>
<td>(24)</td>
<td>(247)</td>
<td>463</td>
<td>216</td>
<td>5.0</td>
<td>3.2</td>
</tr>
<tr>
<td>4</td>
<td>Maintain status quo – replace/repair as needed</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>(1,160)</td>
<td>5.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Focusing on Alternative 3, Alternative 3 has 90% probability of costing less than $96,000

<table>
<thead>
<tr>
<th>Issues</th>
<th>Problem Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Valves no longer supported by vendor (Jamesbury)</td>
<td>Excessive leakage past valve seats increases plant burden, i.e., mntc, operations, engineering, chemistry</td>
</tr>
<tr>
<td>- Leak-by prevents establishment of boundaries for mntc work</td>
<td></td>
</tr>
<tr>
<td>- Leak-by results in excessive water usage and high chloride levels</td>
<td></td>
</tr>
<tr>
<td>- Valve leak-by continues despite replacement or refurbishment</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing probability and frequency distribution for costs of Alternative 3.](image)
### Issues
- Valves no longer supported by vendor (Jamesbury)
- Leak-by prevents establishment of boundaries for mntc work
- Leak-by results in excessive water usage and high chloride levels
- Valve leak-by continues despite replacement or refurbishment

### Problem Statement
Excessive leakage past valve seats increases plant burden, i.e., mntc, operations, engineering, chemistry

---

#### Overlay of 4 Polisher Vessel Valve Alternatives

<table>
<thead>
<tr>
<th>Probability</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 0.04</td>
<td>0</td>
</tr>
<tr>
<td>0.04 - 0.08</td>
<td>0</td>
</tr>
<tr>
<td>0.08 - 0.12</td>
<td>10</td>
</tr>
<tr>
<td>0.12 - 0.16</td>
<td>20</td>
</tr>
<tr>
<td>0.16 - 0.20</td>
<td>30</td>
</tr>
</tbody>
</table>

**Overlay of 4 Polisher Vessel Valve Alternatives**

- Polisher Vessel Valves - Alt 2
- Polisher Vessel Valves - Alt 1
- Polisher Vessel Valves - Alt 4 - Status Quo
- Polisher Vessel Valves Alt 3
## Strategic Fit and Risk Discussion of all Alternatives

- Prior analysis focused on financial returns
- Additional, non-financial benefits from the Alternatives include:

<table>
<thead>
<tr>
<th>Initiative 3</th>
<th>Alt 1 New Design</th>
<th>Alt 2 Like-for-Like</th>
<th>Alt 3 Refurbish</th>
<th>Alt 4 Status Quo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving personnel safety</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Increasing effectiveness and efficiency of training</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Improving human performance due to Human Machine Interface commonalities</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Potential for economies of scale on spare parts</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Cross-system equipment testing</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Reducing operator distractions, work-arounds, plant burden</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Improving equipment maintainability</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Increasing operational flexibility</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Improving system image</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Increasing pride of ownership</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>
Recommendations

- Preferred Alternative
  - Alternative 3, Proactively refurbish Polisher valves 1, 2 & 4

- Basis
  - Alternative 3, Refurbishment, should provide a return on the investment
  - Seat leakage is an operator burden
  - Status quo is economically the least favorable
## Cost Comparison of Composite Solution – Initial vs. Recommended

Business Cases Analysis informs the LCMP

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Alternatives</th>
<th>Initial I(0)</th>
<th>Recommended I(0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiative 1</td>
<td>Alt 1: Upgrade Modicon with Ovation Module with new field instrumentation</td>
<td>$2,260,000</td>
<td>$2,260,000</td>
</tr>
<tr>
<td>Initiative 2</td>
<td>Alt 4: Maintain status quo with respect to Polisher linings</td>
<td>$1,500,000</td>
<td>-</td>
</tr>
<tr>
<td>Initiative 3</td>
<td>Alt 3: Proactively refurbish Polisher Valves 1, 2 &amp; 4</td>
<td>$1,254,000</td>
<td>$336,000</td>
</tr>
<tr>
<td>Initiative 4</td>
<td>Alt 2: Proactively refurbish all Regeneration vessel vales and actuators</td>
<td>$768,000</td>
<td>$303,00</td>
</tr>
<tr>
<td></td>
<td><strong>Totals:</strong></td>
<td><strong>$5,782,000</strong></td>
<td><strong>$2,899,000</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Δ(-$2,883,000)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Contact Information

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