Cost Benefit Analysis of Power Reliability Strategies

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[Editors note: In the last issue of The Locomotive we discussed business exposure to electric utility service outages and ways to reduce or ease the impact of those risks (“How to Protect Your Organization from Electrical Power Outages”). This article offers a model that can help you decide if the benefits to your organization are worth the cost of taking some or all of those measures to increase your power reliability.]

Any risk analysis of corporate power reliability alternatives must consider current offsite and onsite power reliability, system configuration, equipment type and age, and other factors. An initial benchmark should be established considering current and projected power availability and quality needs. The distinction between availability and quality is important.

- **Availability** takes into account the total time over a selected period that power is available to critical equipment at nominal voltage ratings.
- **Quality** involves the instantaneous voltage requirements of critical equipment.

For example, a large food refrigeration facility can often be secured without power for several days, while extremely short power outages (availability) or slight voltage variations can trip or damage sensitive controls and speed-sensitive equipment. Therefore, risk managers studying alternative power strategies must have available data and experts who understand both equipment power needs and reliability.

A Simplified Risk Model

The following simplified risk model illustrates the essential concepts. The model considers four alternatives with progressive aggregate system reliability and power quality. The base case assumes 99.9 percent reliability of power conditioning systems with postulated unavailability five times per year with mean outage times of 10 seconds.

The model assumes that the system will take 100 (mean) power outage hits per year of slightly more than one second each. This outage period was selected since it is slightly longer than the eight nanosecond power quality requirement stipulated in the Institute of Electrical and Electronics Engineers IEEE Std. 1100 for computer equipment. A system ride through factor of one second was applied to the entire unavailability per year calculated to credit the system for minimal stability to resist a coincident equipment outage and power “hit.” The successive models (2-4) represent improvements in reliability as well as increased ride through capability.
The alternatives were modeled probabilistically using commercially available software. Don’t try to analyze this type of problem with a spreadsheet, since deterministic calculations cannot accurately model the likelihood of an internal system failure coincident with a power “hit.”

Cost/Benefit Comparisons
The final step in the risk analysis entails making cost benefit comparisons of the alternatives, incorporating best estimates of loss costs from business interruption, extra expenses, etc. A complete, robust model would include the effects of financing alternatives and tax and depreciation implications.

Net present value calculations were performed for the four reliability cases discussed above:

1. Reliance on offsite power.
2. Offsite power with an onsite uninterruptible power supply (UPS) system.
3. Offsite power with an onsite UPS system and power conditioning equipment.
4. Offsite power with an onsite UPS system and power conditioning equipment supplemented with an onsite diesel generator.

Sales were assumed to be negatively affected as a linear function of power unavailability — in most cases a non-conservative assumption. Case 1 was the benchmark. The other cases compared the investment for system improvements with incremental revenue changes from the base case. As was evident from the attachment, Case 1 was not a cost effective investment while Cases 2 and 3 both demonstrated positive net present value (NPV).

Tools For Making Effective Decisions
Studies such as this example are powerful tools to assist making cost-effective decisions for power reliability and quality decisions. Risk analysis methods can provide what-if answers and help distinguish among alternatives based on specific power quality requirements.

The charts included in the appendix were extracted from the detailed financial risk analysis described above. Charts 1-4 represent the probability distributions of the annual percentage of time that acceptable power quality will not be available based on the four cases studied. Charts 5-7 represent the entire probability range of the net present value calculations for the three power quality/availability cases studied.

Using The Cost/Benefit Model
The effects of system reliability and ridethrough time length can readily be seen in the first four charts, graphically supporting the positive cost benefit of options two and three. Note: the negative exposure percentage in cases three and four do not represent actual "negative time," but the adequacy of the protection over postulated exposure hits and lengths. The actual net present value calculations and resulting mean values are provided in Appendix 2. Each case includes the capital cost of the improvement and periodic cash flow improvements based on the increased reliability. With the parameters in this example, the UPS alone is not a justifiable investment, while the final two cases are very close. It is important in an actual evaluation that the probability distributions of the cost/benefit model be studied, since the mean value may, depending on the forecast variables by a very peaked value, not be representative of the range of actual risk.
All recommendations are general guidelines and are not intended to be exhaustive or complete, nor are they designed to replace information or instructions from the manufacturer of our equipment. Contact your equipment service representative or manufacturer with questions.
Appendix 2

Richard “Gene” Feigel is vice president for Hartford Steam Boiler’s Risk Analysis Group. He consults with clients worldwide on risk-based inspection, corporate risk mitigation strategies and financial optimization of maintenance and repair decisions. Gene received a bachelor’s degree in philosophy from Purdue University and a master’s degree and Ph.D. in philosophy from Pennsylvania State University. He is a member of the Board of Governors of the American Society of Mechanical Engineers (ASME) and is lead expert for the U.S. Technical Advisory Group, ISO TC11 — Boilers and Pressure Vessels.