

Lessons Learned

Resource Allocation based on Multi-objective Decision Analysis¹

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Abstract

Beginning in the late 1990's, Northern States Power (Electric) began exploring formal tools for improving the allocation of its annual operating budget of more than \$250 million. The goal was to establish a fair, efficient, and effective process for allocating funds across territories and departmental functions. After trying several approaches, NSP created a resource allocation system based on multi-objective decision analysis and used it for three years until NSP became part of Xcel Energy in 2000. Characteristics of the system and lessons learned are presented.

The Problem and the Client Company

Northern States Power Company (now called Xcel Energy) is an electric utility serving over one million customers in Minnesota, North and South Dakota, Wisconsin and Michigan. In 1997, the electric business unit, NSP Electric, created a centralized Asset Management department with responsibility for the annual operating budget of more than \$250 million. A major challenge was establishing a fair, efficient, and effective process for allocating operating funds across territories and departmental functions. Despite previous attempts to use priority setting tools, key managers would invariably make decisions only after lengthy discussions and based largely on intuition. The process was painful; departments with the most eloquent speakers often came out ahead. As issues became more complex (invest in information technology or system hardware, for example) and as stakes continued to grow (corporate pressure to lower costs regardless of external cost drivers such as storm damage and rapid customer growth), the task became even more daunting. A better process was needed.

Methods Used and How They Were Applied

Starting in 1997, the Asset Management department undertook an effort to create a formal resource allocation system. The development effort involved decision analysis consultants (to help ensure a logical, defensible design) and stakeholders from the affected departments (to improve buy-in and to ensure that all concerns and issues would be addressed). The selected approach was based on multi-objective decision analysis.

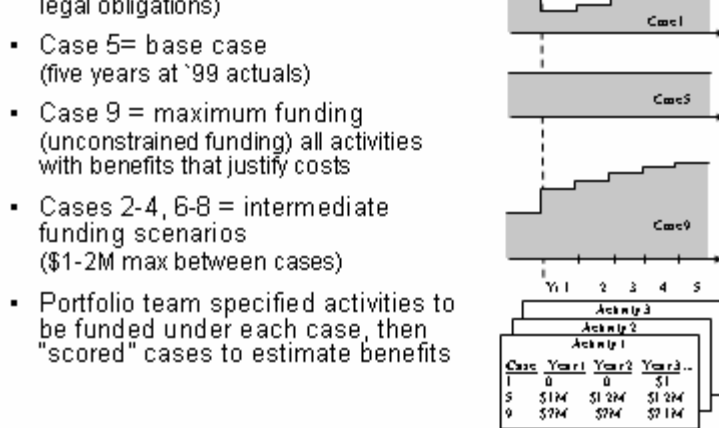
¹ This paper, and accompanying presentation, is based on material previously shared in a public forum. To provide formal peer review and create recognition for those involved, the system was entered in the Institute for Operations Research and the Management Sciences (INFORMS) 2000 competition for "Best Application of Decision Analysis". It was awarded "runner up" status and the system description was presented during judging of finalists at the November 2000 INFORMS meeting in San Antonio, TX.

Multi-objective decision analysis, also called multi-attribute utility analysis, is a formal theory for making complex decisions that impact multiple objectives. Graduate programs of many universities teach this method, and it has been reviewed and recommended by a board of the National Academy of Sciences.² Multi-objective decision analysis has been used in many high-level government and business applications.

NSP used the resulting system for 3 years to identify allocations of the operating budget that would increase reliability performance and customer service while at the same time eliminating budget gaps. Specifically, the system was used to evaluate and recommend allocations of the operating budget across 10 broadly defined delivery products (called “portfolios”).

The system operated as follows. To provide alternative allocation scenarios, each portfolio team proposed multiple five-year funding cases. Three cases were required. Case 1 assumed a “bare bones” funding level sufficient only to protect health and safety. Case 5 held funding to 1999 levels for five years. Case 9 was a “maximum” funding level encompassing every activity that could be undertaken effectively. In addition, some portfolio teams created intermediate funding cases so that increments between cases were no more than \$2 million (Figure 1).

Figure 1: Each portfolio team identified the activities to be conducted under several alternative five-year funding scenarios. Cases 1, 5 and 9 were required; others were optional.



A team of senior managers established 7 fundamental objectives. These objectives formed the basis to evaluate and quantify performance of every funding case. The objectives included both financial goals (e.g., cost impacts) and non-financial goals, such

² See U.S. Department of Energy, Appendix H of “A Multiattribute Utility Analysis of Sites Nominated for Characterization for the First Radioactive-Waste Repository” (DOE/RW-0074, Office of Civilian Radioactive Waste Management, Washington D.C., 1986).

as improving customer service (e.g., reliability and billing) and creating a platform for future success (e.g., enhancing corporate reputation and increasing employee effectiveness) (Figure 2). Note that safety was not explicitly represented as an objective. Safety was viewed as a constraint for decision making—regulations and NSP policy (and the definition of the minimum funding case) ensured that an adequate level of public and worker protection was provided under all funding cases.

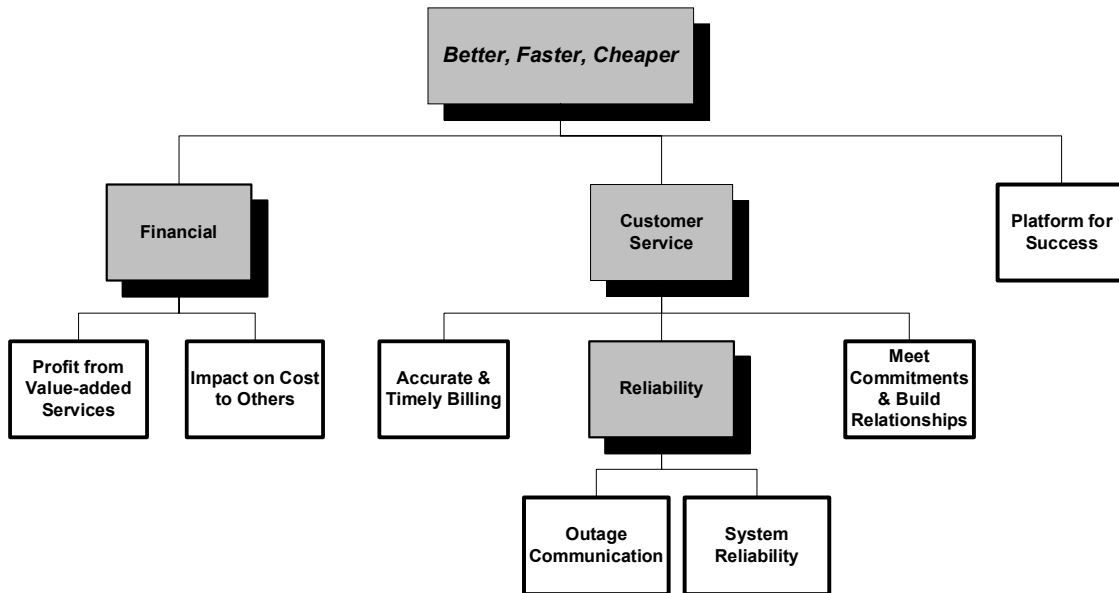


Figure 2: Objectives established for budget allocation decisions.

Management and staff developed the measures and scales that defined each objective using a formal process involving influence diagrams, a graphic device for identifying key influencing factors (Figure 3).

Example: System Reliability objective

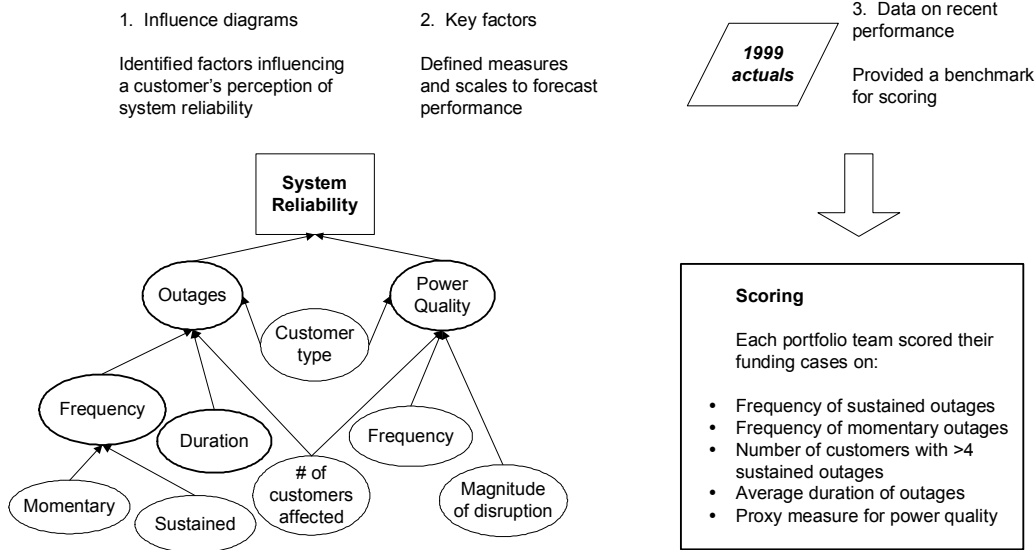


Figure 3: Process used to develop scoring scales and metrics.

The senior management team then assigned relative priority, or weight, to the objectives using a “poker chip” exercise based on methods recommended in multi-objective decision analysis literature.³ This exercise helped establish a consensus priority and a range of weightings for sensitivity analysis. Technical experts “scored” the alternative funding cases using the measures and scales. Using a mathematical algorithm, system software in a spreadsheet translated “scores” assigned by technical experts and “weights” established by senior executives into estimates of “utility”. Utility is a composite measure of benefit indicating both the degree to which a funding case improves objectives as well as the importance of the improvement.

System Outputs

System outputs included a benefit vs. cost curve for each portfolio (Figure 4). The graph illustrates how benefit improves as funding for this portfolio increases. The vertical axis shows utility (degree to which the funding case achieves objectives), and the horizontal axis shows cost (in this case, five-year cost). Each point on the graph represents a funding case.

³ See, for example, W. Edwards and J.R. Newman, “Multiattribute Evaluation,” in H.R. Arkes and K.R. Hammond (eds.), Judgment and Decision Making, Cambridge University Press, Cambridge, England, 1986, 13-37 and C. Kirkwood, Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets, Duxbury Press, 1997, 53-61.

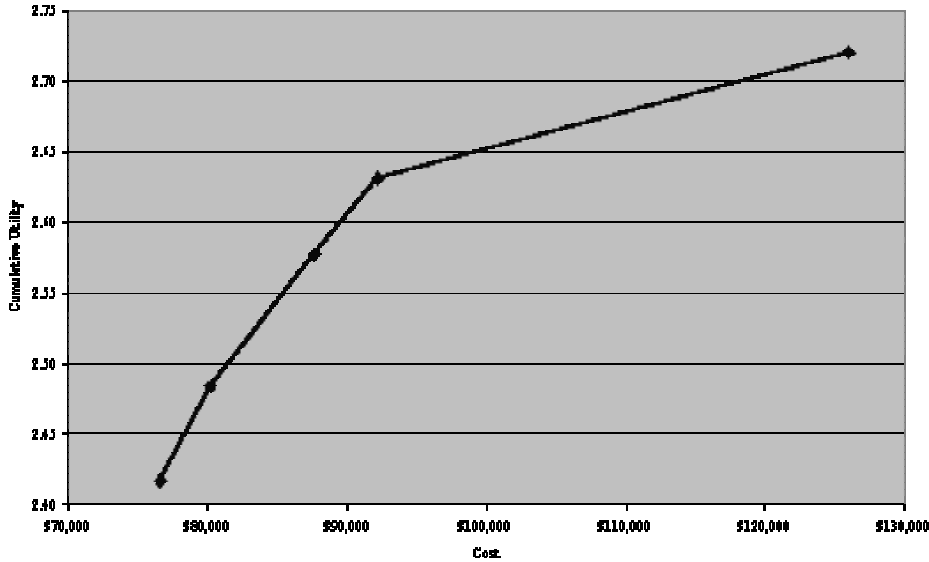


Figure 4: Sample Portfolio benefit-vs-cost curve

System outputs also included a Total benefit vs. cost curve, a representation of the optimal allocation of funds (Figure 5). To obtain this curve, system software ranked funding cases from all portfolios by declining overall benefit-cost. A table, read from top to bottom, shows optimal allocations across portfolios for any total budget level (Figure 6). Each row corresponds to one point on the curve. Funding levels 21 through 31 are shaded to illustrate funding requirements above the budget guideline. The arrow on the curve in Figure 5 points to the allocation producing the largest total benefit at the budget-year guideline (funding level 20 in the table). For comparison, the triangle shows “benefit” of keeping all portfolios at 1999 funding levels. Since the budget curve is well above the triangle, the system was able to identify funding allocations that produce much more benefit than the “status quo”.

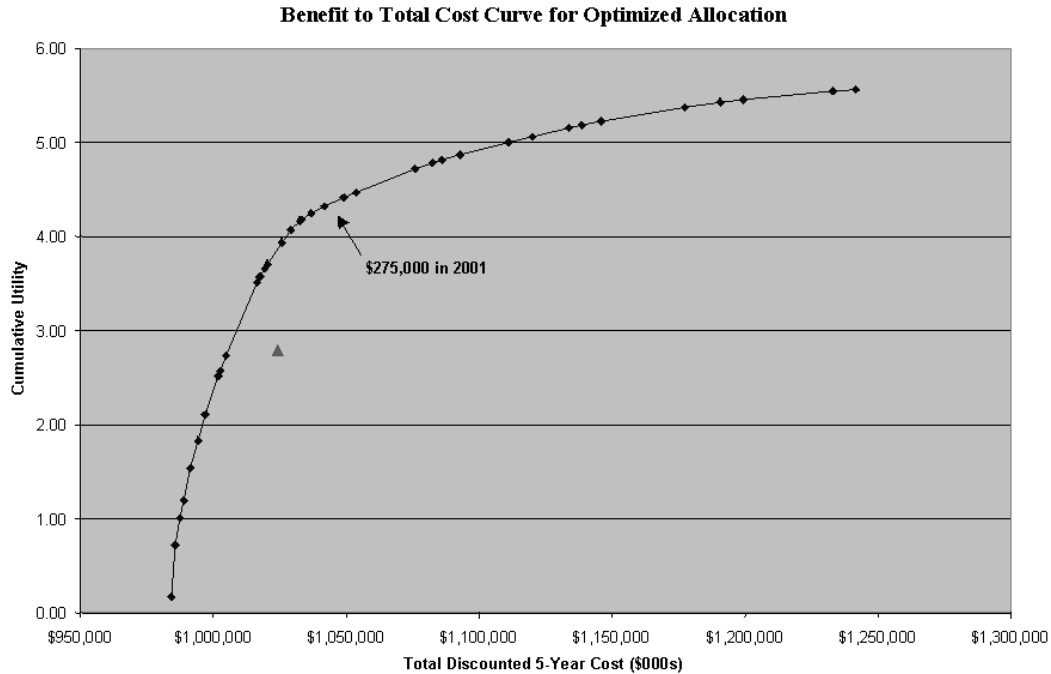


Figure 5: Total benefit-vs-cost curve

| Funding level | Portfolio Abbreviation | Cases | Incr. Utility | Incr. 2001 Costs (\$000s) | Cumulative Costs for 2001 (\$000s) |
|---------------|------------------------|---|---------------|---------------------------|------------------------------------|
| 1 | SOS | Case 5 ('99 Actuals) | 0.17 | \$ 462 | \$ 218,502 |
| 2 | C&I | Case 2, Case 3 | 0.55 | \$ 3,422 | \$ 221,924 |
| 3 | B&P | Case 3 | 0.29 | \$ 3,046 | \$ 224,970 |
| 4 | C&I | Case 5 ('99 Actuals) | 0.19 | \$ 1,505 | \$ 226,475 |
| 5 | SOS | Case 6 | 0.35 | \$ 688 | \$ 227,163 |
| 6 | SOS | Case 7 | 0.29 | \$ 750 | \$ 227,913 |
| 7 | Dist Sust | Case 3, Case 3.5 | 0.28 | \$ 3,463 | \$ 231,366 |
| 8 | EP&S | Case 2 - Protect, Case 4-Begin Growth, Case 5 ('99 Actuals) | 0.41 | \$ 7,234 | \$ 238,600 |
| 9 | R&O | Case 5 ('99 Actuals) | 0.05 | \$ 622 | \$ 239,222 |
| 10 | B&P | Case 5 ('99 Actuals) | 0.16 | \$ 2,556 | \$ 241,778 |
| 11 | R&O | Case 5.1 RTS+X1, Case 5.2 RTS+GIS1+X1, Case 6 GIS2+RTS+X2 | 0.78 | \$ 2,695 | \$ 244,473 |
| 12 | Met Read | Case 3 - Limited AES rollout | 0.06 | \$ 2,430 | \$ 246,903 |
| 13 | Met Serv | Case 2 | 0.09 | \$ 2,248 | \$ 249,151 |
| 14 | Met Read | Case 5 - Scheduled AES rollout | 0.05 | \$ 2,400 | \$ 251,551 |
| 15 | Trans | Case 5 ('99 Actuals) | 0.23 | \$ 5,398 | \$ 256,949 |
| 16 | Trans | Case 6 | 0.14 | \$ 1,254 | \$ 258,203 |
| 17 | Dist Sust | Case 5 | 0.10 | \$ 3,394 | \$ 261,597 |
| 18 | Met Serv | Case 4 | 0.01 | \$ 642 | \$ 262,239 |
| 19 | LC | Case 4 | 0.07 | \$ 10,600 | \$ 272,839 |
| 20 | Met Read | Case 7 | 0.07 | \$ 1,305 | \$ 274,144 |
| 21 | LC | Case 5 ('99 Actuals) | 0.09 | \$ 8,003 | \$ 282,147 |
| 22 | LC | Case 6 | 0.05 | \$ 1,700 | \$ 283,847 |
| 23 | EP&S | Case 6-Prepare Compete, Case 9-Full strategy | 0.25 | \$ 5,794 | \$ 289,641 |
| 24 | R&O | Case 7 GIS3+TRBL1 | 0.06 | \$ 1,718 | \$ 291,359 |
| 25 | Met Serv | Case 5 ('99 Actuals), Case 9 | 0.03 | \$ 2,192 | \$ 293,551 |
| 26 | Met Read | Case 9 - Growth(Data Dream) | 0.05 | \$ 1,873 | \$ 295,424 |
| 27 | SOS | Case 9 | 0.13 | \$ 4,900 | \$ 300,324 |
| 28 | B&P | Case 7 | 0.06 | \$ 2,384 | \$ 302,708 |
| 29 | R&O | Case 9 TRBL2 | 0.09 | \$ 4,262 | \$ 306,970 |
| 30 | B&P | Case 9 | 0.03 | \$ 1,265 | \$ 308,235 |
| 31 | Dist Sust | Case 6.9 | 0.04 | \$ 1,900 | \$ 310,135 |

Figure 6: Sample table output showing priority order for incrementing portfolio funding

Similar outputs were generated using different weights and other assumptions for sensitivity analyses. Because the system was tied to a database of activities by portfolio,

it also indicated the specific work items to eliminate and resulting benefits lost under any budget-cutting scenario.

Scoring Process

A notable characteristic of NSP's system was the detail and rigor of the scoring process. For example, there were five different measures for estimating impacts of funding on reliability. Data on previous year performance was provided to improve forecasts and reduce gaming. Scorers were trained and supplied with a detailed manual of scoring instructions. A team was available to answer questions and provide assistance. Scores were formally audited in group reviews and quality assurance sessions.

A Continuous Process of Learning and Improvement

Over the 3 years that the system was in use, it was refined and expanded with each application as employees became more comfortable with the methodology and saw ways to improve it. For example, the application for the 2001 budget added a multi-year perspective to track 5-year funding needs and to account for the longer-term impacts of some funding decisions.

What Was Learned and How the Organization Used the Results

In addition to improving funding decisions, the system generated other more subtle but important improvements to the planning and budgeting process:

- It improved mutual understanding by efficiently communicating needs and the resources required to address those needs.
- It promoted accountability and responsibility by forcing managers to go on record regarding what they expected to accomplish with their resources.
- It clarified objectives and values. When defining funding alternatives, managers frequently redefined and shifted dollars among activities to get the highest possible performance. And, it pointed out where operational measures needed improvement.
- It helped change company culture regarding customer commitments. The relatively high weights on objectives related to customer service and the need to forecast performance created an increased awareness of the importance of interactions with customers.

Most importantly, the system provided a framework for evaluating funding requests that was fair, consistent, and promoted a complete and thorough consideration of relevant issues.

Identified Areas for Improvement

Using this system caused participants to identify changes needed to improve the resource allocation process. In interviews after the 2000 application, NSP managers and experts saw key deficiencies:

- Lack of Data. The transmission area lacked measures to adequately represent reliability drivers for bulk transmission. Very little analysis tied maintenance

practices to equipment failure. No analyses were available for confirmed scoring judgments of prior years.

- Lack of Incentives to Prevent Gaming. Some funding cases were too large and generic, allowing the distribution maintenance areas to group activities rather than consider their benefits individually. Tension continued between “engineering” areas and “marketing” areas.
- Budgeting Disconnects. Frustrations with the budgeting processes for capital and operating as well as the lack of direct tie between departmental budgets and portfolios continued to be an issue.

These issues were to be addressed in the 2001 application and tested in a pilot project to allocate resources for tree trimming across Xcel Energy’s 12 state service territory. This pilot, however, was not approved and the system was canceled.

Lessons Learned Three Years Later

Although this system provided many benefits to NSP Electric, incoming Xcel Energy senior management wanted their own management system. Focused on merger activities, they lacked understanding and ownership of the multi-objective decision analysis methodology. They wanted a system that relied primarily on analysis of historical data and statistical risk and less on the professional judgment of those closest to the problem.

In order for this or any portfolio optimization tool to be successful, senior management must understand and sponsor it. In addition, department managers – those responsible for day-to-day spending decisions – must support the process and be willing to give up some autonomy for the good of the whole, trusting that the method is fair. No tool solves all organizational issues and inefficiencies. Being clear about scope – what’s in and what’s out – as well as having firm sponsorship is important to success.

When applied properly, Operations Research and Management Science tools, such as multi-objective decision analysis, are mathematically sound and provide accurate recommendations. They can combine “hard” data – data obtained directly from customers, through benchmarking surveys or from operating statistics – with “soft” data – judgments and critical insights that are only available from field and other knowledgeable personnel. These tools define methods that counter and minimize biases associated with subjective judgments. The structure helps participants be disciplined and rigorous, giving format and direction to a complicated process. Computer software provides a convenient means for collecting data, documenting assumptions, performing calculations, conducting sensitivity analysis and reporting results.

In summary, key benefits of the selected approach included:

- It forced senior management to articulate clearly what is important and why.
- It captured all benefits from proposed work, not just financial benefits.
- It provided a defensible process for determining the dollar value of project benefits.
- It captured technical judgments of frontline supervisors regarding needs and the effectiveness of proposed projects.

By doing these things, it helped participants spend more time evaluating alternatives and less time arguing that their funding should not be decreased.

Although not a tool for all problems, multi-objective decision analysis is an excellent tool for improving resource allocation and optimizing a portfolio.