Investment Decision-Quality at Utilities

An Examination of Downward Trends and Upward Leverage

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EXECUTIVE SUMMARY

Allocating investment funds optimally has always been impossible, but now it's getting tougher. That sounds like something Yogi Bera would say.

Herbert Simon won the Nobel Prize in economics for uncovering the way real decisions are made in real organizations. He showed that organizations do not make optimal decisions, he showed why, and he showed what they do instead. We review these findings briefly, enough to understand how they influence current investment practices and how to use them.

As to the impossible getting tougher, the number of strategies and technologies to consider for investment is growing faster than the available funds. This is not the proverbial problem of too many opportunities and not enough funds, but rather an accelerating growth rate of opportunity against a relatively flat investment pool. We review what's behind this, and show that *things will get worse* if investment practices don't adjust.

We see that things will get worse because decisions are creeping further from optimal, in opposition to a growing stakeholder intolerance for less than optimal decisions.

Underneath it all we see the cause of increasing decision difficulty rooted in the explosion of new knowledge, creating too many choices to prudently evaluate. But we also see the knowledge explosion as a two edged sword, offering solutions to the very problems it creates.

We conclude with an example of high-leverage knowledge, and see how this can be applied to Simon's behavioral decision-making models to restore decision-making prudence.

INTRODUCTION

"Sixty-two percent of senior finance executives responding to a [*CFO Magazine*[1]] poll indicate that they are under 'great' or 'very great' pressure at work, and 68 percent say they're feeling more pressure than they did two years ago. They report working more hours — 52.9 hours a week on average, up from 49 two years ago...To most CFOs, doing the right thing for the business means leading by example. So it is not surprising that CFOs have led the cost-cutting charge of recent years by slashing their own staffs to the bone. Consequently, there is often not enough talent or experience left to get the job done right, which creates even more stress for the entire department." Keep this context in mind as we explore investment decision making in today's utility-sector environment.

This paper argues that the quality of annual-budget investment decisions is declining, but not because CFOs and their staff are under pressure or downsized. Instead, this decline is tied to the increasing complexity of investment decisions, caused by the number of choices offered by accelerating technology developments.

Pressures and tight staffing amplify the decline, of course, because attention is spread thinner and the number of alternatives to evaluate must be short-listed too quickly. These effects influence decision-making behavior at all times, whether pressure is high and slack is low, or not. How these and related influences affect decision making will be reviewed first.

DECISION MAKING BEHAVIOR

Many methods exist for making rational economic decisions. What all of these methods have in common is how to sort among alternative choices to arrive at maximum value, and the requirement that decision makers be impartial and rational during the process. There is a general assumption that information about the alternatives is sufficient for comparative purposes, and understood by those making the decision. There is also an expectation that all worthy alternatives will be considered.

Herb Simon burst that bubble with Nobel Prize winning research that observed how decision makers actually function, regardless of what *rational* method may seemingly be employed (see side bar on next page). Richard Cyert and James March, building on Simon's work, observe that an organization "... is in fact, a coalition of participants with disparate demands, changing foci of attention, and limited ability to attend to all organizational problems simultaneously." They note that these coalitions have inherent conflicts which remain unresolved, power politics and positions that often exert disproportionate influence, goals that might be ambiguously stated purposely to hide true intent, and other group-induced behavior that force departure from optimized, objective decision making.

Six concepts that largely shape decision-making behavior were identified: search, organizational slack, acceptable level rules, unresolved conflict, attention focus, and "satisficing". A brief review of each will set the stage for later discussion.

INCREASED PRESSURE ON CFOs

A late-2004 survey[1] of 227 CFOs by CFO Magazine found that average hours worked per week was 52.9, up from 49.0 two years prior. These CFO's weighed in on why:

- 52% say greater demand for support.
- 41% say new regulatory requirements.
- 41% say new business initiatives.
- 40% say staff cuts and/or hiring freezes.
- 25% say systems implementation
- Only 8% say other.

"Many CFOs believe that reduced staff and greater regulatory responsibilities are forcing staffers back into the traditional 'bean-counter' role -- the exact opposite of what they hoped to do.

PEOPLE BEHIND THE KNOWLEDGE OF DECISION MAKING BEHAVIOR

Herb Simon was awarded a Nobel prize in Economic Sciences in 1978 for his pioneering research into the decision-making process within economic organizations.

Simon is credited with founding the field of behavioral economics with his concepts of "bounded rationality", which broke from the classical notion that business decisions are made under optimal conditions and strive for optimal results.

These concepts are described in his book *Administrative Behavior*[2], which the Nobel committee called epoch-making, and form the basis for the "important work", according to Simon, of Richard Cyert and James March, published as *A Behavioral Theory of the Firm*[3].

Satisficing is Simon's word. It is an important concept to understand, and encompasses much of the other five. According to economic theory (predecessor to behavioral theory) decision makers are supposed to find and evaluate all possible choices, and then maximize value by selecting the best among them. In reality, where time and attention are scarce resources, and complexity reigns, the decision maker, according to Simon, "...looks for a course of action that is satisfactory, or 'good enough'....Because they treat the world as rather empty and ignore the interrelatedness of all things (so stupefying to thought and action), they can make their decisions with relatively simple rules of thumb that do not make impossible demands upon their capacity for thought. Simplification may lead to error, but there is no realistic alternative in the face of the limits on human knowledge and reasoning."[2]

Attention focus is limited for decision makers. Generally all have other ongoing duties with daily deadlines and surprises which compete for attention. On top of this is the shear complexity and impossibility of trying to anticipate all of the unintended consequences that will ensue from any decision. When limited available attention is directed at the decision making process, it is focused where personal urgency is felt. This gives priority to a manageable subset of issues. Only so many things qualify for urgency at any one time, for any one person.

Unresolved conflict is a natural artifact of modern organizations. The separation of responsibilities and objectives in a hierarchical structure pits different sub-groups in competition for resources and strategic focus.

Acceptable level rules circumvent conflicts that would otherwise deadlock a coalition or disenfranchise some participants. Basically they "...require that local decisions satisfying local demands made by a series of independent decision centers result in a joint solution that satisfies all demands."[3] One noted impact of this rule is the lowest common denominator effect.

Organizational slack refers to the operating efficiency, or leanness, of an organization at a specific point in time. When times are bad and downsizing has run its course, for instance, slack is at a minimum or non-existent. Under these conditions decision mistakes that waste time or squander resources can be very costly, perhaps unrecoverable. In such times decision makers are very wary and highly risk averse, and more inclined to search harder for good choices. In good times organizational slack increases. Under these conditions risks with interesting reward potential are viewed more favorably, and *satisficing* is quicker to settle for acceptable choices.

Search is the activity that identifies and selects candidate choices for consideration. Satisficing behavior tends to limit search activity initially to a small number of candidates, and generally will not begin again unless the initial pool of candidates do not meet objectives. Search is influenced by three factors: the current amount of organizational slack, who is in charge of the search, and, importantly, a tendency to look for candidates that are similar in nature to what has been chosen in the past. There is an inclination to stay inside the box unless adequate choices cannot be found. In any event, the person or sub-group in charge of the search has a dominant influence on which candidates will be considered. The final influence is organizational slack. When high, there are excess resources available to spend more time looking for more candidates. Satisficing will often counter this effect. Since high slack reduces the pressure to find an optimal fit, search may end when the first candidate is found that appears to meet all of the objectives.

For a deeper appreciation of both group and individual decision-making behaviors the reader is referred to *Perception and Misperception in Decision Making*[4].

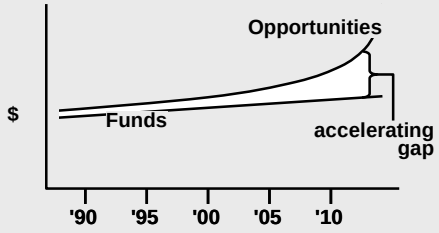
INVESTMENT OPPORTUNITIES

Just looking at the T&D side, most of the investment candidates below are recent additions to the utility vocabulary, and the rest are new versions of older concepts:

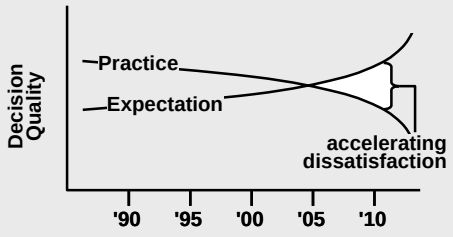
- AMR, IVR, Wireless
- Real Time Pricing, Demand Response
- BPL, Smart Appliances
- Outsourcing
- IT Integration, SOA, EII, EAI
- Business Process Management
- SCADA TCP/IP
- Cyber security
- SOX Controls
- Environmental Compliance
- Business Intelligence, Dashboards
- CIS, OMS, GIS
- CRM, ERM, EAM
- Plant Asset Upgrade and Replacement
- ...and many more

KNOWLEDGE-DRIVEN GAPS

Without countermeasures, dissatisfaction will increase at an accelerating rate ("S" curves will inflect again and approach limits). Put the dates where you like, the shape of the curves won't change.



Interesting investment opportunities are proliferating faster than investment funds.



Optimal investment becomes harder as opportunities proliferate, while increasingly-knowledgeable stakeholders expect more.

THE GAP GROWS BETWEEN OPPORTUNITY AND FUNDS

Investment opportunities are growing exponentially while investment funds are growing linearly. Before looking at the implications of this widening gap, it is important to understand the nature of this truth.

Investment funds, in the long run, are tied to operating profits, which in turn are tied to sales. According to the Energy Information Administration[5], retail sales growth of electricity in the United States was flat for the last 50 years, at slightly over 1% per year.

Investment opportunities, in the long run, are tied to technology. Technology is the total body of knowledge available for use, and ranges from business practices, such as outsourcing and demand-response pricing, to products, such as wind generators and enterprise software. Knowledge grows exponentially[6], because knowledge feeds on knowledge, and the eventual effect is explosive. We're in a world of cell phones, iPods, www, and genetic engineering that was unthinkable a few years ago - just to scratch the surface.

Take a look at the Investment Opportunity side bar, an incomplete list at best. How many of those were in the utility vocabulary ten years ago? We don't control the pace of new knowledge, and we just happen to live in the period of its quickening. Though his future views are controversial, Ray Kurzweil's Law of Accelerating Returns[7]substantiates the exponential track of knowledge through historical data.

Recalling an earlier point...economic theory tells us that decision makers are supposed to find and evaluate all possible choices, and then maximize value by selecting the best among them. The side-bar opportunity list is incomplete, yet it is doubtful that any utility does an annual comparative evaluation of all the categories on the list, not to mention all the candidates within each category.

Satisficing is rampant. It is a practical strategy in the face of complexity, provided, of course, that the objectives being satisficed are sufficient.

THE GAP GROWS BETWEEN PRACTICE AND EXPECTATION

The opportunity-funding gap causes a decrease in the optimality of investment decisions. A growing number of opportunities are simply not considered, let alone evaluated. It is unlikely that the unconsidered opportunities are all of lesser quality.

Knowledge also drives stakeholder expectations. Customers, regulators, directors, and share-holders have awesome access to information. Search engines level the knowledge field, email reaches anyone, and blogs create community leverage. If they don't like the news they now have the power to make some of their own.

A small but constant difference in decision quality between any two utilities can become a big and glaring difference in just a few years. Big because of the exponential effects. Glaring because of the visibility that best-in-class obtains among stakeholders hungry for better, however they may define that individually.

"Now wait a minute," you say. "We've always had more things to spend money on than can be accommodated. This is just more of the same." That thought misses the crucial point. We are living in the time, right now, when the growth of knowledge is outrunning our traditional methods for dealing with it. It is the quickening exponential effect near the knee of the curve.

"Not to worry," say the people who watch these things, the growth of knowledge creates new solutions as well as new problems. We just need to make new problem-solution connections and adjust the way we make decisions accordingly. A process looked at next.

UTILITY MANAGEMENT SAYS DECISIONS NEED BETTER DATA

LONDON, Jul 13, 2005 -- 40% of UK utilities participated in research[8] commissioned by LogicaCMG and conducted by Coleman Parkes:

- 70 per cent said that increasing industry regulation and socio-economic demands have increased the amount of data needed to make investment decisions, and 67% feel these factors have increased the amount needed for operational decisions.
- 67% admit that the quality of their maintenance and repair data needs improvement.
- 64% say that that the quality of data used to identify trends and problems... needs enhancement.
- Most feel the data used to support capital investment decisions was OK - with water companies more optimistic than electricity and gas.

Utilities are collecting what they have to, but not what they need to make intelligent, pro-active decisions, says LogicaCMG.

HERB SIMON ON INFORMATION

(From *Administrative Behavior*[2], pg 78)

In the contemporary world all of us are surrounded by, even drowned in, a sea of information, only an infinitesimal part of which can be attended to.

Given the general scarcity of attention, people and organizations can enhance the quality of their decision-making by searching systematically, but selectively, among potential information sources to find those that deserve the most careful attention, and that might provide items for the agenda.

A common responsibility of planning units...is early recognition of problems. One mechanism for problem recognition is to build computational models of the system of interest and use them to make predictions.

BALANCING THE KNOWLEDGE EQUATION

The general need to manage this knowledge explosion has not escaped attention. Early response exists with names like business transparency for internal visibility; and business intelligence (BI), business activity monitoring (BAM), and business dashboards as IT application initiatives at the enterprise level. Depending on the vendor, BI has external as well as internal information sources, and performance management as well as information access components. In the end, however, information is translated into knowledge when it is related to cause and effect, and drives decisions for meaningful action.

More specifically to our focus, Herb Simon suggests that: "The function of knowledge in the decision-making process is to determine which consequences follow upon which of the alternative strategies." See the side bar for more of Simon's thoughts on the role of knowledge. Note his suggestion that careful selection of information sources is paramount. Also note his suggestion for a computational model of the system of interest, one that can help recognize opportunities and predict the outcome of decisions. Later we will see an example of such a model.

The opportunities for investment will continue to increase as new and better knowledge drives innovation. If the evaluation and comparison of opportunities were done by an impartial industry group, amortizing the time and expense across all utilities could balance the equation. But no two utilities have the same profile of strategy, customers, infrastructure, plant assets, and other dimensions that impact the fit and appropriateness of an investment opportunity – not to mention the detail involved in plant asset decisions. You can't get away from doing your own evaluation and comparison of alternatives.

Corporate objectives fall into a variety of categories, like cost reduction, revenue growth, reliability, customer satisfaction, compliance, governance, and risk reduction. Some have quantitative financial consequences while others are more subjective and qualitative. Regardless, investment strategy is tied to these objectives.

Simon tells us it is necessary and unavoidable to satisfice – to focus limited attention on a short-list of opportunities that contain satisfactory objective-meeting alternatives. Fair enough. But this doesn't mean that better alternatives which exceed the performance goals of the objectives can be ignored. The trick is finding these better alternatives, if they exist, without spending more time at it.

For instance, an objective to reduce operating cost by 2% a year for the next 4 years could satisfice by searching only so far each year for another 2% reduction opportunity within the investment allowance. On the other hand, comprehensive deep knowledge about plant cost-causes could rank order reduction opportunities and accomplish a four year goal in two or less, with full return for half the investment.

As to gaining comprehensive deep knowledge, Simon suggested a computational model of the systems of interest. For the transmission and distribution (T&D) business segment, a comprehensive model of the plant asset network right down to the customer's meter would encompass most of the investment interest. This is where the operating costs and losses occur, where maintenance and upgrade costs occur, where outages are caused and fixed, where reliability is determined, where a good bit of customer satisfaction is determined, where performance metrics are determined (SAIDI, SAIFI, CAIDI, etc), where new revenue sources are enabled, and where operating margin is created.

A computational model that encompassed all of this could be probed for numerical answers to investment options, and could identify causes of costs and enablers of performance improvement that warrant investment consideration. This would balance the knowledge equation.

UTILITY CONSULTANTS SAY DECISIONS NEED BETTER DATA

(Excerpts from a Jan 2005 trade article[9] by LogicaCMG's Chuck Drinnan)

Managers who have recognized the importance of asset management are exploring ways to measure return on asset investment, extend the useful life of their assets. and better utilize their existing assets. Utility managers, motivated to manage their assets better, ask questions like:

- What is the full life cycle history of an asset?
- What impact does the asset have on delivery of energy and revenue production?
- What expenditures has the utility made on the asset?
- What is the return on asset investment?
- How can the maintenance and inspection budget be allocated to increase asset life while maintaining reliability standards?

To answer these questions, asset managers need data that is captured and organized differently. For each asset, they need to know each life cycle event, its associated costs, and its effect on the asset's reliability and expected life time.

With this history, managers perform an asset oriented analysis to drive asset based decisions. Asset life cycle history should include:

- Implementation including cost of equipment and installation prorated to the individual asset
- Design parameters – the distinguishing features of the asset and the engineering parameters required for detailed analysis
- Compliance, inspection, and maintenance events including the evaluated status and associated costs
- Asset utilization parameters and events – faults, loads, power factors, etc.
- Maintenance procedures performed on the asset and associated costs – refurbishments, treatments, reconfiguration, etc.
- Special environmental conditions
- Decommissioning events and associated costs

CONSENSUS ON PLANT ASSET KNOWLEDGE

The recent quantity and diversity of trade articles devoted to asset management indicates a growing focus by management consultants on this subject, generally an indicator of industry demand. No wonder, according to LogicaCMG's Chuck Drinnan: "In a utility that has generation, transmission, distribution, and retail segments the transmission and distribution segments will spend most of their revenues on the extension and maintenance of the utility network – that is, the utility's assets. These regulated business segments (Wires and Pipes) acquire and maintain assets rather than generate or sell [merchant] energy."[9]

In a 106 page report on asset management Bruce Humphrey, a Xenergy practice leader at the time, leads off with an excellent intent statement: "The core of asset management is to have the data, analysis, and corporate culture to make decisions across every class of assets subject to a single set of stakeholder-driven criteria."[10]

LogicaCMG's Chuck Drinnan (see side bar) promotes the advantages of doing ROAI analysis (Return On Asset Investment) to determine optimal allocation of finite funds among assets. Principally this method makes use of deep operational information to determine which assets will return the most value for investments in maintenance, upgrade, and replacement.

Not a surprise: improving reliability of upstream assets affects a larger revenue base than assets closer to fewer customers, and takes priority in a limited budget, all else being equal. All else isn't equal, however, so revenue-base numbers have to be factored by expected reliability and outage effects. These expectations should come from the life histories of specific individual assets as well as asset-family life history. Life history analysis cannot be done effectively if the data isn't comprehensive, accurate, and readily accessible. We'll look at a benchmark for these attributes later.

According to Drinnan, ROAI is similar to EPRI's Reliability Centered Maintenance (RCM) proposal, but "instead of using reliability as a measure of the value of a maintenance strategy, the ROAI investment uses evaluated cost avoidance." Though some will take issue with this difference, both methods are only as good as the data that drives them.

Kema's view: "Simply put, asset management is the art of balancing performance, cost, and risk...It also requires that the corporate culture, business processes, and information systems be capable of making rigorous and consistent spending decisions based on asset-level data...Capital planning when viewed in isolation is not compatible with asset management. When planning a system, capital projects must be weighed against operational projects and maintenance projects. To be aligned with asset management, planning must integrate all spending that impacts performance and risk. If performance is only related to voltage regulation and equipment loading, capital planning can arguably be decoupled. As soon as performance includes reliability or other measures, traditional planning criteria, processes, and information systems become inadequate."[11]

Kema goes on to address the intimate role played by information systems within T&D, especially when it comes to "the ability to make data-driven decisions about asset spending." And they recognize the value of comprehensive asset history data: "Fundamental to asset management is an asset registry. Is there a repository of all T&D asset that tracks information related to economic and technical performance? Can a geographic information system or a maintenance management system serve this purpose? Is asset-level information used for all decision making processes including forecasting, planning, engineering, operations, and maintenance?

UTILIPOINT INTERNATIONAL STATES THE CASE

(Ethan Cohen, in May, 2005 *IssueAlert*[14])

Historically, utility decisions on where to spend capital and/or maintenance cash have been driven by system needs viewed through an engineering perspective. Load growth and system performance have therefore been the primary drivers of most investment decisions. Planning activities have been centered on maintaining adequate voltage, power factor, and system flexibility for outage restoration. Utility rates have been governed by return on investment and adequate funding was generally available. Regulators utilized the less stringent standard of “used and useful” rather than optimal value or necessity to determine whether capital was invested appropriately.

Demands for more rigorous financial integrity, the impact of the collapse of the merchant market on investor confidence, and competing demands for scarce financial resources are driving a new focus on efficiency and spending optimization. In addition, regulatory agendas are shifting to include greater focus on customer and financial issues. Customer demands for lower rates mean that utilities have less to spend, but there is also growing pressure for improved reliability. At the same time, shareholders are looking for more stability and higher rates of return. As a result, most utilities are no longer driven by engineering views, but by the need to optimize asset performance and financial returns.

Thus, enterprise asset management is emerging as a critical capability for utilities and energy related companies of all sizes. With the capital intensive nature of the energy delivery infrastructure, the ability to extend the useful life of transmission and distribution assets through improved asset tracking, replacement planning and more effective preventive maintenance can deliver robust return on investment.

Enterprise Asset Management (EAM), as some are calling this practice, often gets started without the data that makes it effective. "Even though many utilities use well established life-cycle based asset management techniques, particularly for the management of physical assets, UtiliPoint research shows that...some utilities have made the sometimes costly mistake of thinking that they can put into effect asset management without understanding the current 'condition' of their enterprise. Effective asset management begins with an understanding of what the current condition of an asset is, and evolves into a process wherein management and construction options can be scenario tested – to the end of making the best decision possible with all the relevant facts at hand." See the side bar for more.

UtiliPoint goes on to argue that asset knowledge must be combined with awareness and appreciation of risks before "...the enterprise can make decisions about asset management strategies and asset management solutions. Putting the cart before the horse by trying to identify solutions without completely understanding problems will be the root cause of utility asset management mistakes."

A SIMPLE BUT REAL EXAMPLE OF NEED

The NESC (National Electric Safety Code) task force is considering an issue that appears ROI-based, yet is unsupported with any data. "Distribution poles shorter than 60 feet may have to be strengthened if a proposed change to the National Electric Safety Code is approved. Such poles have been exempt from design requirements that they withstand extreme winds...The [NESC] administers a review of the Safety Code every five years...Don Heald, ... head of the NESC task force considering the 60-foot exemption, describes the evidence on both sides of the issue as 'anecdotal.' But, he says, 'It's hard to justify saying that high winds do not blow below 60 feet.'...Asked if this increased cost would be justified by a comparable increase in safety or reduced outages, Heald said, 'I don't know if we can put a number on it.'[12]

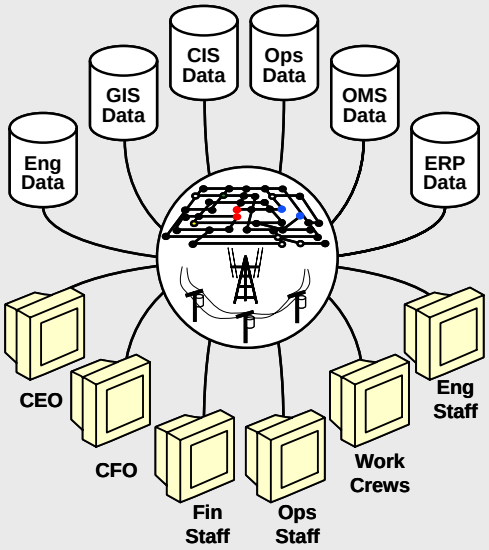
Why not? Data needed:

- Total number of unstrengthened short poles
- Total number of all other poles
- Number of wind damage incidents in each pole category
- Outage incidents and costs associate with short-pole wind incidents
- Safety incidents and costs associated with short-pole wind incidents.

For a statistically reasonable period of time, tally the wind-damage events to poles greater than 60 feet and to unstrengthened poles under 60 feet. Convert that to a percentage of the population in each category. The comparison would indicate if something might be gained or not. If so, the next question focuses on cost vs gain. Identify and tally the safety and outage incidents associated with the unstrengthened short-pole population during that same period. Calculate the investment needed to strengthen all short poles. Assume after investment that short-pole wind problems will be reduced to the same population percentage as other poles, and consequently the safety and outage incidences will be reduced by the same percentage. Is this cost reduction larger or smaller than the investment? Perhaps safety and outage incidents cannot be simply translated into dollar values as there are other values as well – like customer satisfaction scores and human life – introducing subjective quantities to the evaluation.

This short-pole wind-strength issue is reviewed anew every five years. Whether it passes this time or not, a selected group of utilities could accept the responsibility to collect the data for the next five-year review. Regardless of what the data shows, these utilities will gain by proving that the investment will return value or that the cost cannot be justified. And this data collection need not cost anybody anything, if it is collected by utilities with the benchmark system discussed next.

ACCESSIBLE, COMPREHENSIVE DECISION-SUPPORT KNOWLEDGE



4DataLink's active intelligent model:

- Mirrors real-time condition of entire T&D asset network.
- Records life history of each asset.
- Recalls past asset and asset-family data for any time or period.
- Simulates what-if futures.
- Resolves conflicting data for accuracy.

Key Concepts:

- Model includes asset-objects, each linked to (virtually any) source databases that contain asset-related information.
- Asset-objects mirror real-world operating status and network connectivity from transmission through distribution to customer metering.
- Asset-objects are richly characterized with complete life history such as physical location, name-plate data, original cost, age, condition, maintenance records, load, outages, and more.
- Model accommodates work-reality by accepting asynchronous updates coming from independent sources.
- Model fidelity actively reflects changes in the actual system in near-real-time.
- Model history is actively recorded in real time as asset status-changes occur.
- Model integrity is actively monitored and maintained for accurate, current truth.

A BENCHMARK FOR DECISION-SUPPORT KNOWLEDGE

Survey data from utility management agrees with the views of leading utility consultants: more accurate and more comprehensive operational information is needed to support investment decisions. Look around any utility and you'll find plenty of operational information exists, but it's not easily accessible, current, accurate, comprehensive, or even in agreement. Utilities tend to have a large number of stand-alone functionally specific data-bases and IT applications. For instance: a poll of CIOs at a recent round table[13] asked how many other systems the Customer Information System interfaced with – the answers ranged from a low of 25 to a high of over 100.

The approaches called for by LogicaCMG and Kema offer clear advantages to what is generally found at utilities now. Simon's suggestion goes a step further, calling for a computational model that can help with discovery, numerical support, and prediction. Such a model can transform information into decision-ready knowledge, without tying up scarce staff time to identify opportunities and track down the supporting numbers.

Precedence can be found in the system offered by 4Datalink. This company's approach to utility modeling is unique, and stems from its genesis in South America where deregulation created new reporting and record keeping needs. Until just recently they were focused on South American markets, where they dominate, so they are relatively unknown in the US (at this writing).

4DataLink's model is synchronized with the live real-time condition of the plant. The model is composed of asset-objects (as well as other objects), each independently tracking the condition of their live asset counterpart in the plant, like a substation, transmission line, or 50MVA transformer in an electric utility. Changes to an asset's condition are time stamped and recorded when they occur. For instance, if a work crew replaces a damaged transformer with a new one from inventory the model captures these facts for both transformers when the work crew updates the maintenance record. Notably, the model accommodates work-reality by accepting asynchronous updates; permitting a work crew, for instance, to enter a transformer installation before the inventory manager gets around to entering its withdrawal. Integrity monitoring ensures that reconciliation occurs in reasonable time.

The unique distinction is that this is not simply a passive warehouse or data base of recorded items for later review, but rather an *active intelligent* model of the plant operating condition through time. *Active*, in that it is updating itself in synchrony with its real-world counterpart, and verifies among redundant data bases that its representation and recorded history of asset status is consistent. *Intelligent*, in that the model knows what values of asset condition are reasonable, knows where an asset sits in the network and what it affects downstream, can display accurate images of the past from memory, and can project physical effects of changes into the future.

This active intelligent model displays operational status, history, and reports in views customized for specific users. An electric utility engineer, for instance, may want to see the electrical circuit schematic for a specified substation, while a repair crew sees a map showing the physical location of all lines and equipment in that substation, and a customer service rep sees a street map and location of the customers served by that substation. All views are generated on the fly from asset-object data.

In finance, all customers affected by a prolonged outage might be displayed as an expected-revenue-loss overlay on a service-area aerial view, or all distribution assets with a troublesome service record might be tabulated and sorted by downstream meter revenue. Just as easily, a geographical map display could show the locations of specified assets or all members of an asset family (such as 50MVA transformers made by a certain supplier), and then color code the displayed assets by additional

criteria, such as age, downstream customer revenue, or amount of unscheduled outage time in the last 36 months.

The result is a current, accurate, comprehensive body of knowledge that can be probed and queried for past, present, and future conditions of interest. 4DataLink's plant model is unlike anything else on the market, principally because it was originally developed to satisfy requirements born of South American deregulation.

In one South American country, for instance, deregulation requires that electric utilities report detailed asset valuation and tracking information twice yearly. The company's client there operates multiple electric utilities in that country. After 4DataLink's system went live, the marked difference in consistency of reported asset information prompted the Regulatory Authority to inquire. They developed sufficient respect and understanding for the mechanisms that ensure accuracy and completeness that now they ask, on occasion, to have some "what if" scenarios of potential regulation changes tested. Names have been obscured in this disclosure purposely, but verification can be obtained from 4DataLink directly.

KNOWLEDGE LEVERAGE

Knowledge or not, Simon's decision-behavior insights still reign. But their ill effects are countered when comprehensive, accurate, and relevant knowledge is readily accessible. To quickly summarize how knowledge mitigates bad behavioral effects:

- ***Satisficing*** is the natural means for reducing decision complexity to a manageable set of considerations. This is both necessary and inescapable, and even pares the quality and breadth of knowledge prepared by staff as decision support. A good plant model arms staff with deep knowledge and numerical evidence with relative ease, negating the tendency to satisfice too soon.
- ***Attention focus*** is limited and directed where personal urgency is felt. Only so many things qualify for urgency at any one time, for any one decision maker. A good plant model provides the data for staff to make sound, clear, understandable investment priority arguments that command attention.
- ***Unresolved conflict*** in a corporate decision-making group comes from the competition among them for scarce resources. Departmental objectives dominate for the individuals. Accurate knowledge with numerical proof won't change this competition, but it will help gain agreement when corporate objectives would clearly be sacrificed to departmental objectives.
- ***Acceptable level rules*** facilitate mutual agreement among the decision making group by allocating some of the investment funds into the interests of each. A good plant model can provide irrefutable numerical support ranked for best return to counter some of this effect.
- ***Organizational slack*** impacting investment decision quality is specifically the slack among the staff involved in the investment decision preparation and homework. In low-slack lean staffing times (is it really ever otherwise?) short cuts are the order of the day. An active intelligent plant model is a productivity amplifier, providing numerical data and promising candidates in short order.
- ***Search*** finds alternatives that will be evaluated as investment candidates. It is driven generally by a set of strategic objectives and known problems that need attended to. Satisficing tends to stop the search activity as soon as acceptable candidates are found. An active intelligent plant model, asked a few simple questions, can alter or verify the assumptions about objectives and problems with real numbers, and quantify new problem areas that can be compared with those already on the short list – a reality check that focuses search activity where it will return the most.

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CONCLUSION

It is impossible to prudently consider and evaluate the increasing number of investment opportunities. Decision quality declines as a result, at the same time that better informed stakeholders are expecting more.

Sarbanes-Oxley has recently focused attention on the quality of governance. One effect is that boards, commissions, shareholders and customers want visible evidence that management is competent. Depending on their individual and personal interests, they look for indicators such as lower rates, better service, more environmental responsibility, new desirable services, and best practices as defined by what other utilities are doing. All of these are dependent on investment priorities and accomplishments.

The natural forces that impede optimal investment decision making have always been here, but their effects are gaining strength in these quickening times of tech-knowledge development, and are destined to get worse if business as usual prevails. The antidote is to counter quickening knowledge development with better quality and easily accessible decision-support knowledge.

In Herb Simons words: "Given the general scarcity of attention, people and organizations can enhance the quality of their decision-making by searching systematically, but selectively, among potential information sources to find those that deserve the most careful attention, and that might provide items for the agenda...A common responsibility of planning units...is early recognition of problems. One mechanism for problem recognition is to build computational models of the system of interest and use them to make predictions."

His words illuminate the path to higher decision quality. 4DataLink provides a benchmark and proof-of-concept that shows how this path might be followed.

Typically the CFO and finance staff have little access to the operational reality of the T&D plant, yet this is where most of the investment money is directed, and where meaningful return is determined. Justifying an investment in a comprehensive knowledge resource for decision support sounds like one of those intangible arguments that gets postponed perennially.

As model-based plant-network systems gain appreciation, however, the tangible benefits for operations and other departments will provide acquisition justification, and finance will enjoy the benefit of comprehensive accessible knowledge as a byproduct.

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