

Nuclear Enterprise

Managing the Nuclear Generation Business in the 21st Century

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Executive Summary

This PowerShift LLC white paper describes changes in the nature and structure of the U.S. nuclear industry, focusing on the emergence of a new business form: the Nuclear Enterprise. We review the current challenges facing senior nuclear managers and outline a management agenda to address these challenges and create increased value at nuclear assets, especially nuclear plant portfolios.

The Nuclear Enterprise

In the turbulence surrounding the deregulation of the electric power industry, one trend has proceeded in dramatic, but less noticed fashion: the transformation of the U.S. nuclear generation industry into a *business* including the treatment of nuclear plants as fungible capital assets.¹ This transformation is driven in part by the anticipation of general deregulation of the generation industry, but has been trumped by an even larger need to affirm the economic viability of nuclear power. Such economic viability is the linchpin of continued operation of existing units under almost any economic regulatory scheme and is fundamental to the industry's future trajectory.

The strongest evidence of nuclear generation as a business is the emergence of the *nuclear enterprise* (NE) as the dominant business structure for the U.S.

¹ "Over the past year or two we have seen a quiet renaissance in the nuclear business" U.S. Nuclear Regulatory Commission Chairman Richard Meserve, National Press Club luncheon Thursday, Jan. 17, 2002 Washington, D.C.

nuclear industry in the 21st century. Already approximately two thirds of operating nuclear plants are owned or affiliated with NEs, entities focused on profitably operating a significant number of plants over the long term. The emergence of NEs creates unique management issues and opportunities, increases pressure on unconsolidated plants, and offers a path to increased value of the U.S. nuclear fleet through much higher business efficiency.

In the general sense, an "enterprise" signifies both a commercial business venture and an undertaking that brings with it boldness and passion, all characteristics of the nuclear enterprise. An NE operates a significant number of nuclear generating units, sometimes ten or more; implements a successful management system consistently across all units; and has a long-term commitment to and focus on its core business. The attribute that differentiates NEs from other operators of multiple units is the NE's focus on commercializing its nuclear operating expertise and creating measurable, ongoing business value. Such value may derive from three sources: (1) achieving incremental performance improvements at existing units, (2) acquiring additional nuclear assets via appropriate transactions and, as necessary, improving their operational characteristics to levels comparable to the original core entity and (3) applying enterprise-wide decision making to maximize the value of its total asset portfolio. The third task, where the NE seeks to create total value greater than the sum of individual asset values, represents the greatest challenge to the NE's management. Later in this paper, we define a management agenda for creating new and sustainable value from a nuclear portfolio.

Emergence of the Nuclear Enterprise

During the 1990s, two factors contributed to the evolution of the nuclear enterprise: the success of multi-site, top-performing nuclear operators and the occurrence of lengthy and costly shutdowns at certain plants to resolve NRC regulatory issues. Regulatory shutdowns emerged as the single largest contributor to lost generation in the nuclear industry in this period.² Directly or indirectly, these outages contributed to the permanent shutdown of 10% of U.S. nuclear units. It became clear to plant owners that operating a nuclear plant entailed unusual risks and required unique expertise.

The enterprise model was first noted in 1994 when we observed that certain "advanced nuclear enterprises" (ANEs) were beginning to dominate the upper end of nuclear operating performance.³ The success of these organizations laid the foundation for the commercialization of nuclear asset management and bred a cadre of highly capable managers who now provide the core management at most of today's NEs.

Our analysis of industry operating data from the 1990s highlights the performance advantage of the ANEs. **Figure 1** shows the changes in capacity factor (CF) performance by ANE and non-ANE plants for the two most recent three-year periods: 1995-1997 and 1998-2000. The figure shows two dimensions of CF performance: average and standard deviation (a measure of performance consistency). The non-ANE sector is shown with and without the inclusion of regulatory shutdowns in the two time periods (ANE plants experienced no regulatory shutdowns). In the 1998-2000 period, each sector gained similar amounts in average CF performance, *but ANEs opened a significant new performance gap by improving their reliability*. ANEs continue to be differentiated by higher, more consistent CF performance even when non-ANEs are not penalized for regulatory shutdowns.

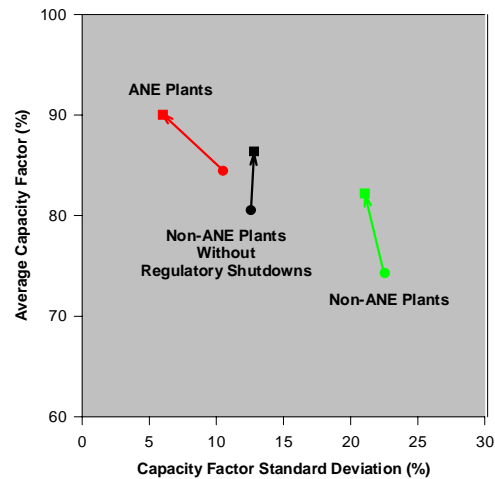
The experience of the 1990s galvanized actions across the industry. The owners of top performing nuclear plants saw opportunity in operating not just their own plants, but as the business vehicle for extending their competency to create new value in other nuclear units that could be acquired or operated under contract. On the other side, many owners of one or two plants saw the ability to exit nuclear generation by selling or contracting their plants to industry leaders who could

² R.L. Cudlin, "Lost Generation: The Risk of Regulatory Shutdown Poses Significant Asset Management Challenges for Nuclear Plants," August 1998.

³ R. L. Cudlin and R. G. Schoenberger, "Capturing Stranded Value in Nuclear Plant Assets," *The Electricity Journal* 9, no. 5 (June 1996): 59-65.

Figure 1

Capacity Factor Performance
ANE vs Non-ANE Plants
1995-97 and 1998-2000



dedicate resources, manage risk, create reliable performance and assure expertise. As nuclear asset control concentrated, the nuclear enterprise came into being as the business structure of choice for long-term, competitive nuclear generation.

Over the last few years approximately 32 units have been consolidated, leaving an industry in which two-thirds of the units are now part of NEs.⁴ The consolidators are primarily the original ANE companies looking to extend their business model to additional assets but also include new entrants such as Constellation and AmerGen. In a recent industry commentary, a utility analyst noted this approach being taken by Entergy Corporation, an original ANE:

Entergy is "one of a handful of companies that is able to acquire nuclear plants for attractive values and increase productivity to create great returns with limited commodity risk..."⁵

⁴ The consolidation has occurred via utility mergers and acquisitions, the sale or auction of individual plants, and the formation of nuclear generating and management companies.

⁵ Paul Patterson, ABN Amro analyst, reported by Reuters Jan. 8, 2002.

Nuclear Asset Management

We have observed that the most important driver of nuclear asset value is the quality and capabilities of the management team. Historically, much of management's value was in its ability to operate safely and maintain the confidence of safety regulators because of the potential for significant regulatory actions, including extended plant shutdowns. Today, the regulatory environment reflects an evolution to a less intrusive mode and, at the same time, there has been a transition to a more competitive environment for nuclear plants. Management is still the key determinant of value but the required skill set and agenda have shifted. The new management agenda must originate from within the NE based on a clear vision of a future business model. This business model will include a performance-based approach to managing and a new asset management mission.

Deregulation mandates that generation businesses shed the legacy of cost-based philosophies and adopt a strongly performance driven business model. A performance-based approach emphasizes total value being created across all assets which derives from plant performance and reliability, the ability to replicate that performance across a growing portfolio of generation assets, and the ability to manage the commodities at either end of the business value chain: fuel and power.

As performance-based entities the best NEs will see their mission as being *premier nuclear asset managers*, i.e. operating nuclear plants to generate electricity safely, reliably and efficiently, maximizing the current and future value of the assets to their owners and other stakeholders. What is the essential ingredient of an asset management mission? In a broad business context, the answer has been summarized as follows:

"A business can assess its intrinsic ability as an asset manager by evaluating how well it makes decisions about its asset base and how effectively it is organized to implement them. Good decision makers have a detailed knowledge of the way different kinds of maintenance or upgrade work affect their assets' performance, what this work will cost, and what a failure of the assets will mean for the company. *They translate this knowledge*

*into strategies that indicate what work should be done, under what circumstances, on each asset."*⁶ (emphasis added)

For nuclear assets we would add the ability to integrate safety into the engineering and commercial dimensions of decisions regarding what work to do on what assets.

The Nuclear Enterprise Agenda

To successfully achieve the nuclear asset management mission in a competitive electric market, NEs should implement an agenda that focuses on top-level enterprise value as the overarching financial objective of the NE. This agenda recognizes the central role of *culture* in achieving high performance and reliability. It demonstrates that the *resource allocation process* and *scalable value* are key to maximizing value across the nuclear portfolio. Finally, it incorporates *performance consistency* and *risk management* to address the fact that nuclear plant performance is most accurately understood in probabilistic terms.

1. ***The NE organization must sustain a high performance culture where safety and environmental excellence, business performance, and personal values are in balance.***

The recognition of the asset management mission can be a transforming event for the NE, crystallizing the organizational performance and cultural requirements needed for success. Culture defines the values and behaviors necessary to achieve the management agenda and provides a meaningful enterprise-level driver for lower tier policies and decision-making.

Initially, performance culture and values will flow from organizational acceptance of the NE mission. Increasingly though, NE management will need to find ways to track the organization's "pulse" reliably and in close to real time. This will provide a critical feedback loop to initiate compensatory measures *before* the organization loses its performance "edge" and results are compromised. This is an area with significant opportunity for innovation and could easily become a key source of differentiation between NEs and across the industry.

Nuclear Enterprise Mission

A premier asset manager, operating nuclear plants to generate electricity safely, reliably and efficiently, maximizing the value of the assets to their owners and other stakeholders.

⁶ David J. Birch and Eileen Burnett-Kant, "Unbundling the Unbundled," The McKinsey Quarterly 2001, no. 4: 109.

The foremost cultural priority is to maintain and promote safety and environmental excellence. Performance in these areas is essential to *protecting and preserving* asset value, i.e., avoiding plant events and actions by regulatory agencies that could impact operating performance or costs. But safety performance is just one consideration; NEs must sustain safety and safety culture at the same time as the organization is stressed to achieve complex business objectives balanced with employees' personal needs and values.⁷ It is also unlikely that an organization will suffer degradation in only a single dimension; the characteristics of a high performance organization typically transcend any specific subset of values or behaviors.

The need for multi-dimensional performance, led by the safety component, became apparent during the 1990s. The first lesson offered by ANEs was their commitment to safety performance as an intrinsic dimension of overall excellence - one that complemented strong operating performance. Even in the cost dimension there was a pragmatic view that any additional cost associated with achieving safety excellence was less than the cost risk associated with potential regulatory actions - a view that was validated time and again in the 1990s.

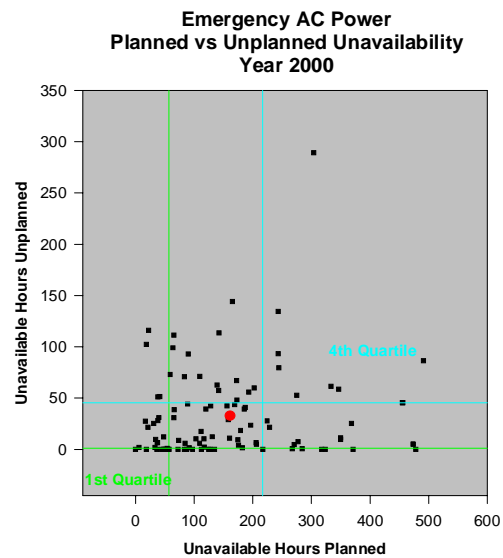
Although safety performance was paramount, the industry (and NRC for that matter) lacked tools or other means to monitor changes in safety culture up to the point of a significant deterioration in actual performance. It is still the case that commonly tracked performance indicators, employee concerns programs and occasional organizational "point" surveys will not yield timely and accurate signals to the NE management team regarding the nuances of a high performance culture.

The NRC performance monitoring system initiated in 1999 is not intended to close this gap but offers potential opportunities for improved insight. NRC performance indicators (PIs) measure performance in 18 areas against specified action thresholds for increased NRC engagement. The NRC publishes the PI values for each plant and, where applicable, the underlying data from which the PIs are developed. With the total population of indicators

across all plants greater than 1800, currently less than 1% are non-green. In the most important sense this is good - it reflects the very good safety performance being achieved across the industry. But this system does not provide insight into the subtleties associated with the overall performance culture. In the long run, a set of green PIs may be sufficient to preserve asset value, i.e., avoid regulatory action, but not be sufficient to ensure a plant's competitive position in the marketplace.

One way NEs may be able to obtain additional insight and forward perspective is by greater forensic analysis of their own indicator data and that of other nuclear plants. **Figure 2** illustrates this for one NRC indicator - one that measures the unavailability of the emergency AC power safety system. This NRC indicator is based on total unavailable hours, which may be comprised of hours that were either planned, unplanned or associated with fault exposure. Figure 2 highlights two of the contributors to total unavailability - the individual black points are the actual planned and unplanned unavailable hours for all U.S. nuclear plants for the year 2000. The large red circle is the industry average. All of the plants in the figure are rated as "green" for regulatory purposes based on total unavailable hours. Yet it is clear there is a

Figure 2



significant variation of actual performance across the industry, including the relative amounts of planned versus unplanned hours. The best operators have always measured themselves relative to their peers and doing so may still be of considerable value as an indicator of cultural health. In addition, we suggest that the data be examined for strategy insights. The variation of

⁷ As noted in a study of the organizational transformation at the Millstone nuclear plant, the culture needs to be "...healthy enough to find a consistent balance between the company's need for performance and the needs of individuals" John Carroll and Sachi Hatakenaka, MIT Sloan Management Review 42, no. 3 (Spring 2001): 77.

the data, particularly the relative amounts of planned and unplanned hours, indicates there are many different strategies for achieving the required level of system unavailability. How each of these strategies "fits" with the other demands on the organization could be an important input to achieving overall balance in the organization's performance. In addition, trending these data over time may indicate which strategies align with optimal performance in other dimensions, e.g., capacity factor and high reliability, such that performance becomes self-reinforcing.

2. *Maximizing total value, as measured by the net present value of future cash flows, is the primary business goal of the NE.*

Historically, most nuclear plants have used indicators of relative industry performance as their primary goals. Top quartile, or even top decile performance for capacity factor, cost and safety are common targets. For the NE such rankings may still be of interest but not as primary business goals. Relative rankings may provide useful insight as to what levels of performance are achievable or as precursors of cultural issues (as discussed above). Most importantly, NEs might even find that single-minded pursuit of rankings may be *contra* to their larger business purpose and objectives.

An NE's primary business goal should be maximizing total value of its asset portfolio. Maximizing value should have a direct bearing on all actions, investments and policies followed by the NE in the conduct of its business. Intrinsicly it also provides the strongest possible reinforcement of safety.

What does maximizing value mean? First, value itself may be expressed in a variety of ways, e.g., measured on an accounting basis using a parameter such as EBIT⁸, or measured on a cash basis using cash flows. We have a preference for cash flow based value since it involves fewer accounting variations and provides a going forward (i.e., no sunk costs) perspective that is appropriate for existing plants.

Second, value should be summed over time and the traditional method for this is present value using an appropriate discount factor. This provides inherent balance between current, short and longer term performance, with future performance appropriately discounted. Present value also

maintains a sense of urgency to achieve performance improvement. Often investment in an asset to maintain or increase performance will occur in the present time period while benefits will accrue in later periods. Present value appropriately incorporates these time-based effects and supports determination of the return on asset (ROA), i.e., how much incremental return can be realized for a certain investment, such as an equipment upgrade.

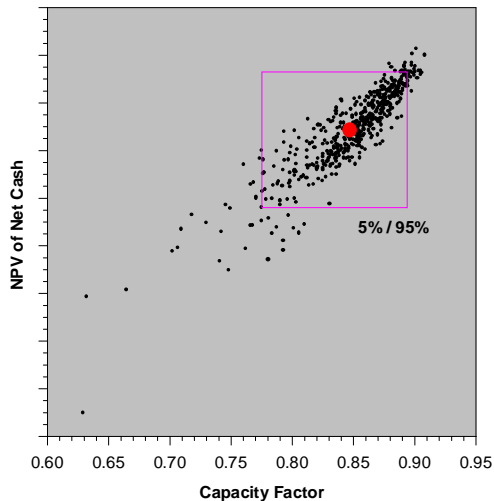
Value-based goals also shift attention from the traditional focus on plant operating cost performance. Value integrates and balances the various performance contributors such as capacity factor, operating costs, and electricity price. It also brings to bear other asset characteristics, such as plant capacity or PPA prices, which will vary across plants and directly impact potential value achievable by a plant. Thus each performance contributor must be managed in relation to its impact on value, and on other contributors, including impacts that extend beyond the plant boundary to include other plants in the portfolio or the overall nuclear enterprise.

Finally, value, as with most performance parameters, should be understood as a statistical distribution of possible outcomes reflecting the uncertainty and variability of performance in operating, cost and revenue dimensions. **Figure 3** illustrates these effects with a scatter plot of 10-year net present values (NPVs) for a 1000 MW nuclear unit.⁹ Each small black data point is the outcome for a single simulated 10-year operating period, with the distribution of black data points representing the variability of performance for this plant. The large red circle is the average NPV and CF for all runs and the purple box encompasses all outcomes within the 5% and 95% confidence limits (90% of the population of all outcomes).

⁸ Earnings before interest and taxes.

⁹ The analysis was performed using our POWERGEN nuclear business simulation model. This model incorporates the significant operating and financial parameters for a nuclear plant, dynamically linked to capture key performance characteristics and interrelationships. This particular analysis used 500 simulation runs for a 10-year period. NPV was calculated for each 10-year run and plotted against the average CF for that period.

Figure 3
1000 MW Nuclear Plant
10-year Average CF vs NPV of Net Cash



For the NE, perceiving and being able to quantify value as a distribution of possible outcomes positions the organization for achieving its specific goals. It supports complex decision making (such as resource allocation and risk management discussed below) over a diverse set of assets and circumstances against a common and rational framework. Further, by aligning employee incentives with value goals, all NE stakeholders will hold common interests in the performance of the asset portfolio.

3. Management understands and applies a hierarchy of the different mechanisms for creating new value.

With the objective to maximize value across all assets, how does the enterprise create ongoing, increasing business value? We begin by noting that value can be created via many mechanisms, and that these mechanisms do not all contribute the same type or quantity of value. To illustrate this concept, we use the *scalable value proposition* (see figure on following page) for nuclear asset management.

The curve on the chart represents the exponentially increasing value multiplier correlated to an asset hierarchy. The value multiplier escalates with the increasing leverage associated with cost savings, increased revenues and growth of the enterprise's profits. How value is measured follows a consistent progression as shown in the right hand column. By applying a common hierarchy for

assets and value creation mechanisms, we can show how these mechanisms link progressively to enterprise level value creation.

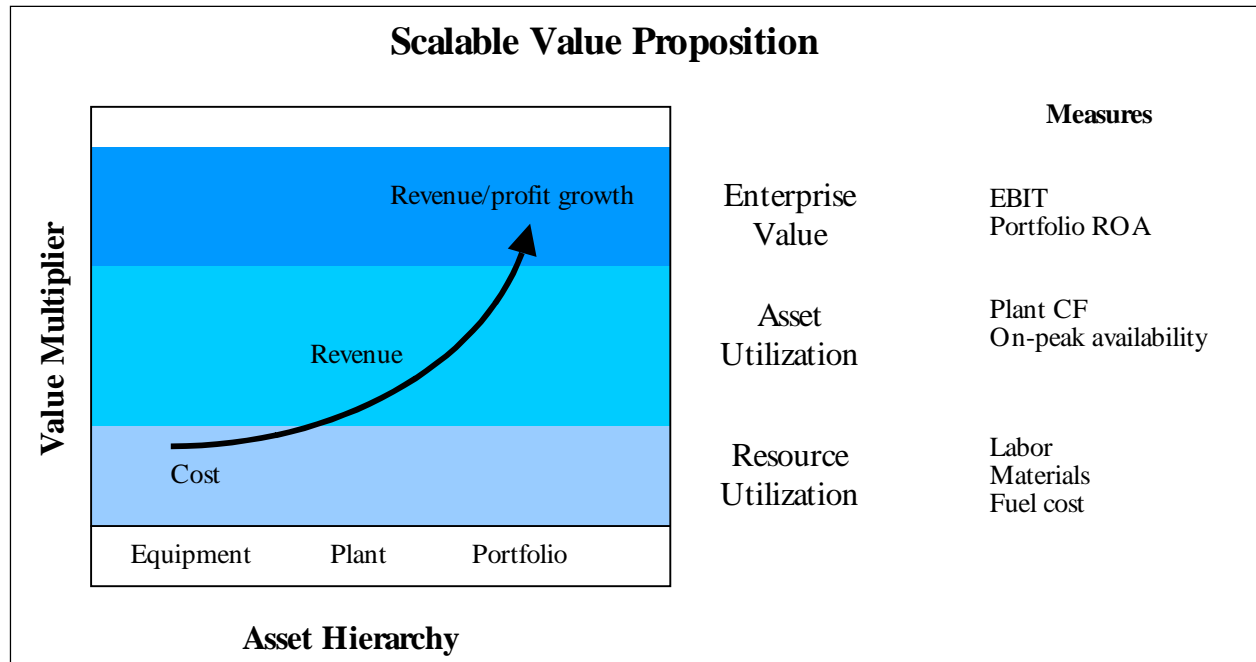
It is clear from the scalable value proposition that business functions impacting the middle and top levels will have significantly greater leverage on enterprise value than those at the bottom level. This is not to say that potential benefits at the bottom level should be ignored, rather that asset management should consider the entire value hierarchy. It is the responsibility of NE management to map their portfolio value improvement opportunities against the value hierarchy and prioritize accordingly.

Traditionally, nuclear organizations have focused on the bottom, or resource utilization level - essentially those value contributors that are cost-based.¹⁰ While these may be most visible and measurable, they offer the smallest value opportunities and, if they receive too much attention, can be counterproductive to the real goal: increasing the value of the generating asset portfolio.¹¹ Value can be created at this level using value-creating mechanisms such as tightly coupled business processes, particularly involving work and supply chain, and equipment life cycle management.

At the asset (plant) level, asset utilization is a function of both performance level (capacity factor) and reliability (consistency). Key value-creating mechanisms at this level include planning, risk management, reliability centered and predictive maintenance, and continuous improvement and organizational learning programs. These are supported by visibility of how each plant asset contributes to portfolio level objectives.

¹⁰ "The supply chain management value proposition seems to be mired in trimming costs and reducing assets" Nicholas Seiersen, "10 Trends in Supply Chain Management," Supply Chain and Logistics Journal 2, no. 3 (November 1999), www.infochain.org/quarterly/Nov99/Seiersen.html.

¹¹ In our work on generating asset business performance, we have demonstrated that cost is primarily a *dependent* variable, driven by the performance of plant level assets. While certain investments such as information systems may be viewed as having direct cost benefits, the better perspective is to focus on their impact on asset performance - which can provide much higher ROA and, in turn, is the link to enterprise level value.



At the portfolio level, value creation mechanisms include financial arrangements (e.g., customer contracts), portfolio effects on risks, resource allocation and achieving economies of scale. Scale is a strategic advantage in a global business involving procurement, production and sale of commodities, e.g., nuclear fuel and power. Scale can provide benefits in obtaining lower prices on the procurement of nuclear fuel and other resources and can aid in realizing higher prices for power through leverage in the marketplace.

4. Resource allocation at all asset levels is the key to maximizing total enterprise value.

As discussed in agenda item 2, the primary goal of NE management is maximizing enterprise value. Enterprise value is built at multiple levels, per the scalable value proposition; covers multiple plant assets; and should add a premium over the sum of values achievable at each individual plant. *Obtaining the enterprise premium is intrinsic to the NE business model and the asset management mission.* The premium can be derived in many ways such as economies of scale, portfolio-based risk management; and sharing resources, practices and technology across the enterprise. But the most significant premium opportunity lies in an NE's ability to intelligently

allocate financial and human resources across its assets. The NE's resource allocation strategy must apply to all assets in the asset hierarchy, including both "hard" (i.e., physical assets such as plants, plant systems and equipment) and "soft" (e.g., warranties, service contracts and operating license extensions) assets. In the NE, resource allocation cannot be *ad hoc* and cannot be at the sole discretion of individual asset managers.

The key to resource allocation is knowledgeable application of return on asset (ROA) analyses to determine the relative impacts on net present value (NPV) of resource allocation decisions. Under traditional rate base regulation it could be argued that every dollar of allowed investment was worth the same, i.e., the utility earned the allowed rate of return on the investment whether it was a power plant or a desk. For the NE, investments of resources can have widely variable impacts on the ability of the enterprise to generate revenue and earnings over time, and ROA will vary considerably. Thus, enterprise value will be a function of how efficiently, in terms of ROA, resources are allocated among all the possible investments that may be made in the NE's assets.

Nuclear plants are not all created equal ... and the resource allocation strategy must recognize and exploit the differences.

Does maximizing enterprise value imply that maximizing the value of each plant asset is not necessarily the objective? It does. This may be the most striking change from both cost based regulation and traditional nuclear plant

management but is the essential differentiator of NE success. Because an NE will include nuclear plants with a variety of attributes (capacity, efficiency, cost structure, PPA parameters, age, taxes, etc.) it is all but certain that each asset will have a different ability to generate value for the NE. It is also clear that each plant will have a variety of opportunities for improving its performance and value. The consequence is that the NE must determine how best to optimize its overall value based on the relative value-contributing capability of each plant in its portfolio and for equipment and other assets within each plant.¹²

The following example illustrates an enterprise approach to resource allocation. Under a new market-based scheme a fleet of three power plants will operate subject to PPAs that pay specified prices and incorporate incentives and penalties for plant availability based on targets set out in the PPAs. ROA analysis addressed the potential value associated with the avoidance of these penalties through a system upgrade to increase plant performance reliability. The required investment was approximately equal for each plant.

First the CF performance of each plant was analyzed using its current operating data and the risk of incurring PPA penalties was calculated (without the proposed upgrades). The proposed upgrades would reduce the likelihood of the longest forced outages at the plants. Revised forced outage probabilities were developed, assuming the upgrades were implemented, and used in analyzing the "adjusted" performance of each plant. Adjusted CF probability distributions provided the basis to quantify the reduced

likelihood of incurring penalties at each plant.

Without the investment the total risk exposure was approximately \$1.2 million for the three plants.¹³ **Table 1** shows risk adjusted benefits for each plant in the fleet with the proposed upgrades. The total risk reduction (right column) is approximately \$880K due to improved capacity factor distributions for each plant. However, Plant B benefits are significantly more than the other plants - notwithstanding the much higher penalty rate (\$ per %) for Plant A. Thus to maximize the total value of the fleet, investment should be directed preferentially to Plant B where the benefit is the highest. Of course whether any investment is justified is a function of the ROA for each plant, taking into account the cost of the improvement initiative, timing, and competing opportunities for those investment dollars.

5. Consistency of performance is critical to achieving higher levels of mean performance and for maximizing the value of nuclear power generation.

The competitive advantage of nuclear generation compared to other sources of generation hinges on performance reliability and consistency, and the NE is the favored structure to deliver this value proposition. As shown in Figure 1, nuclear industry performance consistency has been improving.¹⁴ Consistency creates new value two ways: by delivering a given level of performance at a higher confidence level and by supporting optimal capital investment strategies. It has been noted that "volatility leads to lower capital investment because you can't plan."¹⁵ The implication of this statement is that investment is

Table 1

	Target	Penalty (\$/1% Avail)	Probability < Target	Average Avail Below Target	Penalty Risk	Delta Benefit
Plant A	90.03%	\$6.8 M	2.6%	89.6%	\$71 K	\$68K
Plant B	83.5%	\$1.4 M	6.2%	80.5%	\$260 K	\$800K
Plant C	86.0%	\$200 K	6.5%	84.0%	\$26K	\$12K

¹² This is analogous to the approach used in PRA analyses applied to plant safety performance and RCM for allocation of maintenance resources to systems and equipment. Both use the concept of "importance" (importance to accomplishing a safety function or limiting challenges to safety systems) to prioritize among the many complex systems and components in a nuclear plant.

¹³ The expected value of the yearly penalties across all plants.

¹⁴ The highly consistent performance of ANEs is probably a prerequisite to the very high average CF levels delivered by those organizations.

¹⁵ Adam Sieminski, oil strategist at Deutsche Banc Alex. Brown, "Lower Oil Prices May Not be Worth the Volatility," Wall Street Journal, Nov. 19, 2001.

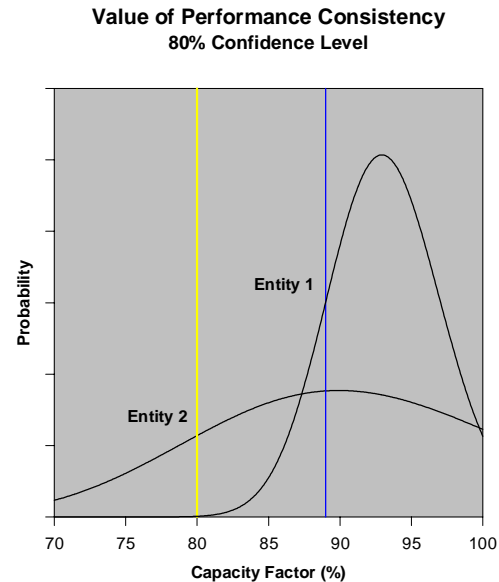
biased toward shorter term, lower risk projects versus longer term, more uncertain projects even though the longer term projects may hold out significantly more potential in terms of asset performance and value.

For a nuclear plant, operating performance volatility erodes the value of the asset by creating uncertainty. As with our discussion of total portfolio value, operating performance should be viewed as a statistical distribution of possible outcomes. This may be represented by a probability distribution plot of CFs for the plant. The standard deviation (SD) of the probability distribution is a measure of how widely dispersed the values are and indicates the "risk" of the distribution. The quantitative effects of variability can be determined by use of confidence levels. A confidence level expresses the probability that plant CF will equal or exceed a certain level. For example, the 80%¹⁶ confidence level for a certain plant might be 85% CF. This means that there is an 80% chance that annual CF will equal or exceed 85%. The effects of variable performance are highlighted at higher confidence levels or when different plants are compared.

An example of the effect of consistent performance can be taken from the 1998-2000 capacity factors of plants owned and operated by two different entities. **Figure 4** presents the CF distributions for two nuclear operating entities for this period. Each distribution is a probability curve fitted to each entity's plant data. Both entities had essentially the same mean CF for the period (Entity 1's mean was 93% and Entity 2 was 92%). However the SD for Entity 1 was about 3.9% whereas for Entity 2 it was about 11.5%. Thus the two sets of plants had comparable mean performance, but Entity 2 had much more variable performance as measured by its higher SD. To quantify the effect of this, we evaluated each distribution to determine the value of CF corresponding to an 80% confidence level. For Entity 2 there is an 80% confidence that CF will be 80% or higher (left vertical yellow line on Figure 4). For Entity 1 there is an 80% confidence that CF will be 89% or higher (right vertical blue line on Figure 4). Thus Entity 1 would be expected to produce and could commit to sell an amount of generation almost 10% greater than Entity 2 (assuming comparable plant capacities), at a similar risk level, due to Entity 1's ability to operate more consistently. Thus NEs will need to recognize and realize the value associated with

performance consistency as a specific dimension of their business strategy.

Figure 4



6. Risk management in both business and safety contexts is necessary to realize full value of a nuclear portfolio.

The operating and safety risks associated with nuclear generation have long dominated the debate about its competitiveness and the prudence of a significant U.S. national commitment to new nuclear plants. Without minimizing the need for continued vigilance, the industry's continually improving safety record and lack of significant operational events over many years seem to indicate that safety is a manageable risk. NEs will further reinforce this trend through the concentration of top management resources and

"Superior knowledge of business risks and the ability to manage those risks = competitive advantage."

Wall Street Journal, May 10, 2001

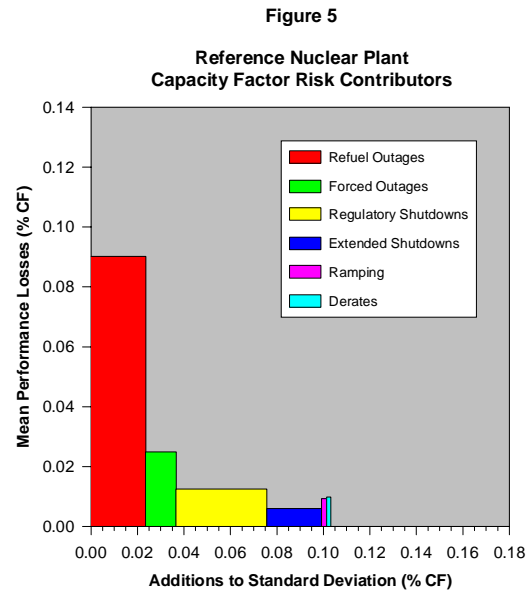
expertise, their understanding of safe operations practices and a significant commitment to maintain a strong safety culture. Within the NE business model the potential for regulatory intervention provides an additional, very large incentive to aggressively manage safety risk.

¹⁶ 80% is a frequently used confidence used in business planning and financial projections.

In a nuclear *business* context, risk management is a less well established practice though there is ample experience to draw from utility experience in managing commodity risks. Futures and hedging contracts are commonly used to manage volatility in commodities, including the procurement of fuel. In addition, many of the NE plants will have PPAs governing the sale of much of their output, which will mitigate market risks. *NEs will need to break new ground in managing performance risk across their plant assets.* Initially the NE has some advantage in that portfolio effects associated with their ownership of multiple nuclear units provide intrinsic risk management benefits.¹⁷ The NE will need to direct attention at ways to further reduce other challenges to consistent operation, including increased assurance of plant availability during peak periods for electricity prices.¹⁸ Improvements will need to be accomplished with due regard to the resource allocation issues previously raised, including consideration of risk transference to third parties. Operating cost-based risk is the most likely to be transferred through outsourcing certain work at fixed prices, purchase of equipment warranties, insurance and other means. Operating availability-based risk will draw on many of the same concepts applicable to achieving consistent performance.

Figure 5 illustrates how certain operating risks may be understood and quantified on a relative basis. The chart shows the various contributors to lost capacity factor such as refuel outages, forced outages, ramping losses, etc. for a hypothetical 1000 MW plant. The height of each bar represents the average reduction in CF for each source. The width of each bar represents the variation of a particular source; a wide bar indicates that the reduction in CF from that source could be much larger or smaller than the average amount indicated by the bar height. The blue bar (fourth from left) is for extended equipment shutdowns. It indicates that on average this source contributes a very small amount to reduced average CF, but the width of the bar indicates it is the source of significant variability. Figure 5 demonstrates one way that various risk contributors can be ranked

and quantified (similar charts can be done for cost risks as well) providing the basis for NEs to apply such practices across their portfolio.



Conclusion

Nuclear Enterprises will lead fundamental change for the better in the nuclear industry. They will bring a far more efficient business structure for the ownership and management of nuclear plants and reduce nuclear generation risk through highly competent management, performance consistency and pooling of assets. What remains to be seen is whether NEs will be able to deliver the top increment of value, *enterprise value*, that can be realized by leveraging resources and decision-making across their portfolios.

¹⁷ In its debt rating for Exelon Generation Company LLC, Fitch observed "The significant nuclear exposure is mitigated by the diversity of the portfolio, with 19 units at 11 nuclear stations" Fitch Inc. press release, May 8, 2001.

¹⁸ Refuel outages have been one area where increased focus on risk has paid benefits. "A primary component of the planning effort and philosophy became identifying and addressing risk" Brian L. Renwick, "Nuclear Station Performance Fuels Industry Renaissance," Power Magazine, July-August 2001.