THE ROLE OF NUCLEAR POWER IN THE NEW COMPETITIVE ERA

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ABSTRACT

As power generators around the world grapple with the challenges of deregulation and competition, there are those who suggest that ownership of an operating nuclear power plant may prove to be a liability. This is not the case for most plants. On the contrary, nuclear facilities that perform well will be important assets in competitive markets, whether as sources of competitively priced electricity, or as strategic factors in mergers and acquisitions. And, as the world focuses renewed attention on global climate change and the reduction of greenhouse gas emissions, nuclear power's significant environmental benefits further enhances its continued viability.

The emergence of competitive markets will create a period of tremendous opportunity and enhanced value for nuclear plants. Nuclear plants, large coal plants, and hydro are the only types that can produce power at the bus bar with production costs close to one cent per kilowatt-hour. The challenge for all nuclear plants is to reduce costs and improve performance in order to improve their net earnings stream. Prospects for dramatic reductions are very high. In recent years, average nuclear plant performance figures worldwide have improved rapidly and substantially, and average costs are dropping.

How will nuclear plants compare with alternative energy sources in an era of heightened competition? To evaluate nuclear plants in a competitive environment, this paper will look at three key areas: capital costs; operation and maintenance costs; and fuel costs, including spent fuel issues.

The paper will examine innovative strategies to deal with capital or "sunk costs" such as write-downs through securitization and regional operating companies, and will also focus on best practices in O&M and fuel where all nuclear plants have the potential to move to "best in class".

The lessons that every nuclear plant can learn from other plants can contribute significantly to the performance improvement process. What has been learned in the U.S. applies around the world. This paper will point toward specific areas in which innovative approaches to resource sharing and integration of industry capabilities have universal significance.

INTRODUCTION

In spite of the distinctive design and operating differences that permeate the global nuclear industry, economic and environmental issues have converged in the pressing debate over global growth and global climate change. Nations around the world are deliberating how to meet increasing demands for electricity in the most economical and environmentally protective way. Nuclear energy provides a ready solution to that challenge.

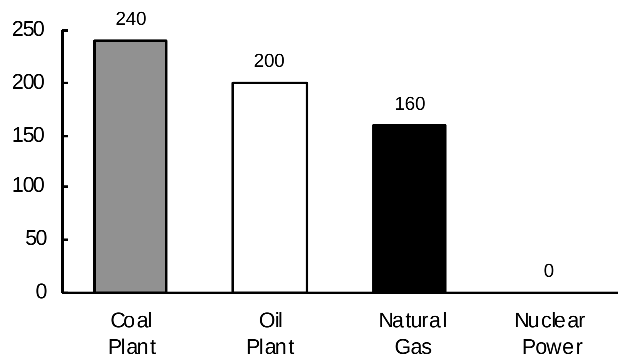
Nuclear energy's environmental benefits are significant. Only 12 countries, including the United States, reduced their carbon emissions between 1973 and 1990. In 9 out of the 12 cases, nuclear energy was a major factor in achieving these clean air benefits. In the U.S., nuclear power plants reduced carbon emissions by 147 million metric tons in 1996.

As shown in Figure 1, producing one million kilowatt hours of electricity using coal releases 240 metric tons of carbon into the Earth's atmosphere. Oil-fired plants release 200 metric tons of carbon, and natural gas fired plants release 160 metric tons. But a nuclear power plant generates the same amount of electricity entirely carbon free.

Renewable energy sources–solar, wind and geothermal–will make a contribution to clean air, but they are limited in capacity. Despite decades of research and development and private sector investment in the U.S., no renewable technology other than hydropower has gained even one percent of the electric supply market.

Although several nations have pledged to reduce greenhouse gas emissions to 1990 levels by 2000, meeting this commitment will be difficult. For the U.S. and many other countries, it will be impossible without nuclear power plants.

Figure 1
Metric Tons of Carbon Dioxide Released to Produce One Million Kilowatt Hours of Electricity



Source: Nuclear Energy Institute, 1997

Even with the well documented environmental benefits of nuclear power, the economic impact of deregulation and competition is an area of great concern for nuclear plant operators worldwide.

Westinghouse does not believe that deregulation and competition should threaten the survival or economic value of operating nuclear power plants. In fact, given the nuclear industry's ability to innovate, utility deregulation and the resultant competition could be the start of a period of tremendous opportunity for owners and operators of nuclear plants. Obviously companies such as PECO, British Energy and Duke Energy, who have publicly expressed their interest in acquiring nuclear assets, believe in the value and the opportunity.

Nuclear power plants will be invaluable assets to their owners and countries, provided each plant gets its production costs down to the real potential that all of these plants have—somewhere near 1 cent per kilowatt-hour (U.S.) at the bus bar. A nuclear plant with production costs that allow it to offer power at that rate will be a prime competitor with coal and hydro generators, regardless of its location.

This is more than a distinct possibility. The best proof is that many nuclear power plants already perform close to that level. As Table 1 shows, 77 nuclear plants in the U.S. have operating costs below 2 cents/KWh. However, a number of capital and operating cost challenges need to be met in order to realize the full potential of nuclear power.

Table 1
Plant Operating Costs (O,M & F)
(3 Year Average: 1994, 1995, & 1996)

Plant	Cost per kwh
North Anna 1 & 2	1.16
Vogtle 1 & 2	1.22
Prairie Island 1 & 2	1.35
Byron 1 & 2	1.39
Surry 1 & 2	1.40
Limerick 1 & 2	1.44
Braidwood 1 & 2	1.45
Point Beach 1 & 2	1.46
Callaway	1.49
Wolf Creek	1.50
Watts Bar	1.51
Catawba 1 & 2	1.55
McGuire 1 & 2	1.55
Arkansas One 1 & 2	1.56
Oconee 1, 2 & 3	1.61
Farley 1 & 2	1.62
Grand Gulf	1.62
Palo Verde 1, 2 & 3	1.64
South Texas 1 & 2	1.66
Harris	1.67
Monticello	1.69
Summer	1.69
Waterford 3	1.71
Seabrook	1.72

Plant	Cost per kwh
Susquehanna 1 & 2	1.72
Comanche Peak 1 & 2	1.72
Kewaunee	1.78
Calvert Cliffs 1 & 2	1.78
Browns Ferry 1, 2 & 3	1.81
Sequoyah 1 & 2	1.82
Peach Bottom 2 & 3	1.85
Robinson 2	1.87
San Onofre 2 & 3	1.87
DC Cook 1 & 2	1.90
Brunswick 1 & 2	1.91
Diablo Canyon 1 & 2	1.91
LaSalle 1 & 2	1.91
Turkey Point 3 & 4	1.92
Nine Mile Point 2	1.94
Zion 1 & 2	1.94
Three Mile Island 1	1.95
WNP 2	1.95
Hatch 1 & 2	1.96
St. Lucie 1 & 2	1.98
Davis Besse	2.02
Indian Point 2	2.02
Beaver Valley 1 & 2	2.09
Nine Mile Point 1	2.15

Plant	Cost per kwh
Palisades	2.17
Vermont Yankee	2.18
Ginna	2.29
Duane Arnold	2.32
Crystal River 3	2.33
Clinton	2.35
Hope Creek	2.35
Maine Yankee	2.39
Fitzpatrick	2.40
Cooper	2.46
Millstone 3	2.65
River Bend	2.75
Pilgrim	2.82
Fort Calhoun	3.01
Connecticut Yankee	3.02
Oyster Creek	3.09
Quad Cities 1 & 2	3.16
Perry	3.32
Dresden 2 & 3	4.19
Fermi 2	5.02
Indian Point 3	5.39
Millstone 1	5.76
Millstone 2	5.76
Big Rock Point	5.97
Salem 1 & 2	6.62

Oct 1997

Source: 1994, 1995, & 1996 UDI Data (W)

CAPITAL COSTS

When anti-nuclear advocates speak of operating nuclear plants becoming stranded assets, they are in most cases referring to the original capital investment in building the plant, or "sunk" cost".

The valuation of stranded assets is determined by calculating the difference in market value of the nuclear plant asset and that of the book value.

This is not an issue to be ignored. There are many large nuclear and coal plants around the world that will never retrieve all the capital invested in them. They were built in an era of rate base economics or were caught in a drastically changing economic structure. The world has changed around them, but they are still on-line and serving a need. These plants must now be managed and evaluated for their ability to compete on the basis of their go-forward costs.

Westinghouse has done an analysis of stranded assets of all U.S. nuclear plants. Consistent with similar studies, the range is from zero to several million dollars for some plants to maximum values in excess of several billion dollars for others. The total stranded cost projection is in excess of $95B, and only six plants have forecasted investment values exceeding current book values.

The stranded asset value of any major, heavily capitalized plant in a purely competitive market is a tremendous challenge for any Chief Financial Officer.

The stranded cost issue is a balance sheet issue and should be addressed in a consistent manner. Utilities should be allowed to recover past prudent investment through securitization of the debt involved, if any, and some sort of competitive transition charge to allow a level playing field for all generators. There are solutions to the problem of sunk cost in many cases—financial innovations that are in their own way as creative as the plant's original technology. In several successful efforts seen thus far, the process has been carried out by highly skilled teams drawn together from the utility, the manufacturer, the financial world, and marketing consultants. The team examines all the plant's strengths and weaknesses: production costs; performance measures; the existing ownership structure; the power markets available to the plant; and the probable impact of effective O&M concepts, such as out-sourcing.

From all of this study comes a package proposal that addresses possible moves like refinancing, restructuring ownership, marketing part of the plant's output either to support refinancing, or as part of financing an out-sourcing arrangement. In some cases, restructuring such an asset may call for back-up power supplies that enhance the total economics of the plant.

The problem of sunk cost is being addressed aggressively in both North America and Europe. Spain has recently taken innovative steps to deal with the nearly $6B (U.S.) nuclear debt of its electrical sector. In a complex deal supported by state guarantees, long-term variable-rate securities will be auctioned off, some of it in the form of bonds and other parts as structured loans. The details are important as a model for the rest of the nuclear industry, but not as important as the fact that a highly creative financial solution has been achieved.

For plant operators and those who serve their needs, the question of sunk cost is not really relevant today. The go-forward costs of operations, maintenance, fuel, and new capital needs are the challenge that must be met.

CAPITAL ADDITIONS

Going forward production costs will still need to be competitive, regardless of the stranded asset value. As such, the ongoing requirement for capital additions must be carefully monitored. Recently, we have seen some utilities decide that the capital cost of replacing steam generators could not be justified. Others have concluded differently.

We are also entering uncharted waters with materials behavior in an irradiated environment. Evidence suggests that we will have to closely monitor reactor internals bolting materials, internal welds in BWRs and other material applications. These may result in major repairs and capital additions which will have to be closely evaluated and justified.

Thus, the issue of nuclear plant capital investment will not go away even with a satisfactory treatment of stranded assets. Requirements for major capital additions in the form of replacement steam generators, materials issues, instrumentation and control obsolescence, or other such factors will be scrutinized as never before.

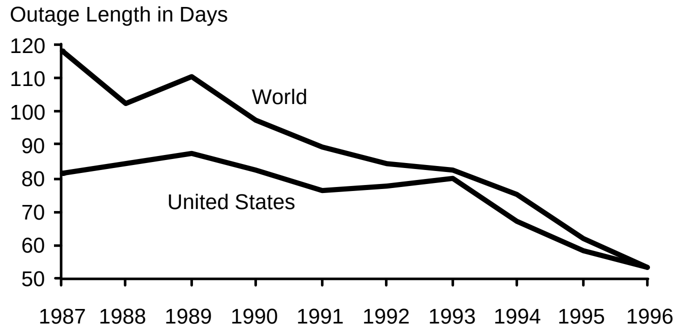
The challenge to our industry is to be way ahead of the game in planning, managing and acting to minimize the impact of such future capital requirements. We will need more creativity and innovation in our approach to maintenance.

Table 2
U.S. Electricity Production Costs

	Coal	Nuclear	Gas	Oil
1981	3.52	2.11	5.91	9.62
1982	3.59	2.36	6.44	9.01
1983	3.51	2.54	6.55	8.38
1984	3.38	2.81	6.50	8.49
1985	3.27	2.74	6.18	7.86
1986	3.09	2.92	4.48	4.88
1987	2.85	3.01	4.02	5.15
1988	2.65	2.93	3.97	4.22
1989	2.51	2.86	3.85	4.43
1990	2.42	2.63	3.73	4.90
1991	2.34	2.48	3.43	4.06
1992	2.21	2.42	3.43	3.93
1993	2.14	2.33	3.69	3.70
1994	2.03	2.12	3.07	3.39
1995	1.94	1.98	2.76	3.88
1996	1.83	1.91	3.38	4.14

Source: 1997 Nuclear Energy Institute

Figure 2
1987-1996: Average Refueling Outage Duration U.S. and Worldwide



Source: McGraw -Hill, World Nuclear Performance, 2/97

O&M COSTS

The key cost-cutting target is the refueling outage—the extended maintenance activity that is scheduled to coincide with each shutdown for refueling.

Figure 2 confirms the trend of recent years of the average refueling outage duration dropping in both the U.S. and worldwide. The worldwide average has now matched the U.S. average.

Refueling outages have really been a success story in the U.S. as seen in Table 3. Just three years ago, the average outage duration was 75 to 80 days. That average today is about 50 days, and it keeps getting shorter. In 1997, TVA and Houston Lighting and Power had recorded outages of 19 and 17 days respectively.

Outage optimization efforts are producing impressive results. As outage lengths are reduced, the focus should include the design of optimal outages which facilitate required maintenance.

Maintenance optimization is an increasingly key element, including an aggressive, but safety based, on-line maintenance program. Many utilities are doing it and doing it safely. For example, one U.S. utility established system outage windows on a 13-week rolling schedule. This permits work to be accomplished safely and efficiently with the unit on line. They use probabilistic risk assessment to help plan the windows and activities. They also take advantage of scheduled load drops and the end of cycle coastdown period to do work they would not conduct at full power. In general, on-line maintenance can minimize the complexity of an outage…and the surprises.

Table 3
1996 Top Eleven Refueling Outage Duration U.S.

Plant	Utility	Vendor	Duration
Peach Bottom 2	PECO	GE	21
South Texas 1	HL&P	Westinghouse	22
Limerick 1	PECO	GE	25
Point Beach 1	WEPCo	Westinghouse	25
Robinson	CP&L	Westinghouse	27
North Anna 1	Virginia Power	Westinghouse	29
Callaway	Union Electric	Westinghouse	30
Browns Ferry 2	TVA	GE	31
Arnold	IES	GE	33
Brunswick 1	CP&L	GE	33
Surry 2	Virginia Power	Westinghouse	33

Source: McGraw-Hill, World Nuclear Performance, 2/97

Table 4
1996 Fuel Costs – U.S. PWRs

Fuel Vendor	# of Stations	¢/KWhr Median
Westinghouse	25	0.49
ABB-CE	6	0.52
Siemens	6	0.52
FCF	8	0.54

Source: FERC Form 1 and EIA Form 412

These same plants are also making inroads in the cost of day-to-day activities. In 1996, costs at U.S. nuclear power plants dropped by 7 percent—the most impressive decline in the industry's history. Combined operations and maintenance (O&M) and fuel costs for domestic plants decreased from an average or $121 million in U.S. dollars per plant to $112 million. The top performing plants had total costs below $100 million in U.S. dollars a year. For 1000 MWe plants, this translates to 1 cent/kWhr.

FUEL COSTS

In order to achieve competitive operating costs at or near 1 cent/kWhr, fuel cycle costs need to be near the lowest levels that are being realized today. This a challenging goal, but it is possible. As shown in Table 4, we are proud of the fact that in 1996, Westinghouse-fueled PWRs in the United States are achieving median fuel cycle costs, substantially lower (5 to 10%) than those fueled by other suppliers.

Uranium and enrichment costs dominate total fuel cycle costs. Utilities need to be vigilant in achieving the lowest cost sources for these commodities. Also, relatively small changes in uranium and enrichment costs can have a big impact on overall cost. With regard to fabrication, utilities need to work effectively with their fuel vendors to achieve cost-effective and highly reliable designs which maximize the utilization of their enriched uranium.

Technology improvements are another significant contribution to lower fuel costs. Advanced fuel product features such as ZIRLO™ cladding and advanced high burnup fuel rods contained in Westinghouse PERFORMANCE+ fuel help achieve excellent performance in enriched uranium utilization. Westinghouse fuel-related engineering services like Dynamic Rod Worth Measurement techniques and the BEACON core monitoring system help utilities achieve more efficient outages and faster startups.

But, being at the leading edge of performance has challenged fuel use to a degree that none of us could have foreseen ten or twenty years ago. Critical issues like Zircaloy-4 fuel rod cladding corrosion, ZrB_2 IFBA rod internal pressure, axial offset anomaly, and incomplete control rod insertion provide clear indications of the complex challenges fuel designers now face.

Dealing with these issues is why our top priority is a specific focus on fuel engineering excellence. We have formed full-time dedicated teams led by our most capable engineering managers. We chartered the teams to resolve these issues by mid-1998. We continue to enhance our engineering tools with investments in analytical resources and test facilities. And we are implementing a new product and process development approach that will help make sure our priorities for change are in step with those of our customers.

Another significant contributor to fuel costs in the U.S. hinges on the resolution of spent fuel disposal issues. The current charges in the U.S. for ultimate disposal of spent fuel (1 mil/kWhr) are typically greater than the amount paid for fuel fabrication.

U.S. utilities are running out of space in their spent fuel pools. Even with high density re-racking, many utilities are forced to use dry spent fuel storage to preserve their full core discharge capability. And at nuclear plants that are closing, the spent fuel must be removed prior to or during decommissioning. This creates an additional need for dry storage at on-site installations. In November 1997, Maine Yankee Atomic Power Co. announced that the decommissioning of the Maine Yankee nuclear plant will cost $139 million more than previously estimated, mostly due to the expense of managing spent fuel for 15 years longer than initially expected.

Nuclear waste legislation was introduced in the U.S. Senate and House of Representatives because the U.S. Department of Energy acknowledged that it had no plans that would enable it to meet the obligation of accepting used fuel from nuclear power plants by January 31, 1998. In April 1997, the Senate approved a nuclear waste bill and the House of Representatives passed their version of the legislation in November. Differences between the two bills will be resolved in a conference committee early next year, followed by a vote in both Houses of Congress.

The legislation will mandate the development of an interim storage facility for used nuclear fuel. The facility, to be located at the Nevada Test Site would open in 2002.

FUTURE ADVANCES IN PERFORMANCE AND COST IMPROVEMENT

Much of the success to date in performance and cost improvement has been the result of the nuclear industry just doing its job. These improvements came at a time that was more critical than initially understood. As the word "competition" entered the vocabulary of each utility, the pressure to improve performance and reduce costs has intensified. Today there is an increased openness from utilities and the desire by vendors to look for innovative ways of working together to improve plant performance and reduce costs.

Much of the progress to date has been driven by capacity factor improvements primarily from shorter outages. While there is still room for some capacity factor improvements, traditional utility/vendor relationships will not provide much more opportunity for cost reduction. In order to keep capacity factors going up and costs going down, we need to explore fundamental changes in the way we do business.

Organizations are now realizing the need to focus on their core competencies. If resource availability and management attention permit, investment in other competencies may be justified. If not, alternative sources of supply should be pursued. In the future, this should take the form of out-sourcing, teaming, or merger partners.

One of the most compelling industry trends we're seeing is the closer integration of the industry's many capabilities. There is a new emphasis on sharing resources all across the industry. This integration of capabilities holds promise as the next major advance in performance improvement and cost control.

PERFORMANCE-BASED CONTRACTS

For Westinghouse and two of our utility customers, this integration of capabilities has taken the form of performance-based contracts with balanced risk and reward terms. At Wolf Creek Nuclear Operating Company's Wolf Creek plant, and TUElectric's Comanche Peak plant, we have entered into long-term agreements covering engineering and outage services. Our agreement at Comanche Peak also includes steam generator and reactor coolant pump reliability programs.

Both of these agreements feature contractual aligned goals that are tied to the customer's success criteria…such as safety, cost and production. These contracts promote a better understanding of both parties' management and operational approaches and better utilization of both companies' inherent core competencies. And, they create added incentive to find innovative ways to achieve the customer's success criteria.

WESTINGHOUSE INTEGRATED LOGISTICS COMPANY

Another innovative partnering concept that we have been pursuing with a number of customers is called WILCO…Westinghouse Integrated Logistics Company. WILCO is a new business concept designed to help nuclear plants reduce total supply management costs by 10 to 25 percent by taking systematic advantage of multi-plant economies of scale.

WILCO would offer multi-utility, full-scope materials management with costs distributed across all participants. The key to WILCO's ability to deliver supply chain services at the lowest cost is the use of a centralized operations facility. By providing these functions for multiple plants from one central location, duplication of manpower, facilities and equipment at individual sites can be eliminated, resulting in immediate savings for all participants. Centralized purchasing for multiple plants will provide additional leverage to negotiate lower prices for materials.

Although the WILCO approach may be considered a dramatic departure from traditional nuclear supply management approaches, it represents a model that has been successfully demonstrated in other deregulated industries. We believe that WILCO offers a supply management alternative worthy of consideration.

PLANT ENGINEERING NETWORK

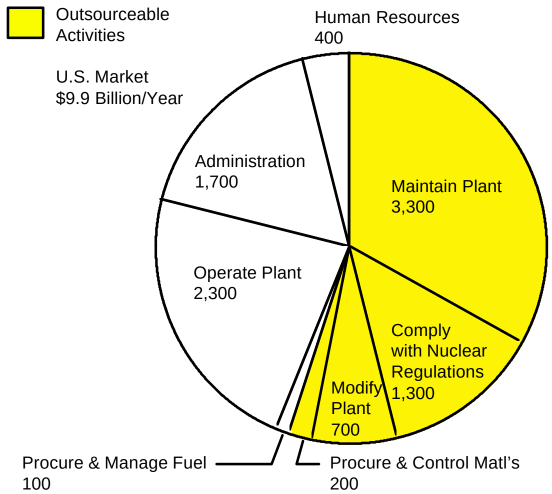
There is indeed a growing emphasis on resource sharing industry-wide. Individuals—expert at some aspect of plant operations—have been temporarily assigned from one utility to another. Westinghouse has borrowed utility people, and we have assigned ours to operating plants for months at a time. No plant, anywhere in the world, can afford to carry full-time costs for part-time work. As Figure 3 shows, of the total $9.9 billion spent by U.S. utilities on O&M, over $5.5 billion are in areas utilities consider out-sourceable.

The logic of out-sourcing makes it a valuable part of the entire nuclear industry's future. It is a powerful cost-cutting technique. Engineering for major work to be performed in definable time periods can and should be supplied from separate sources, as needed. This arrangement creates a wider but still effective form of benchmarking, as a pool of working engineers carry their own lessons learned from one plant to another.

With this in mind, Westinghouse and Pacific Gas & Electric working together on the Plant Engineering Network (PEN) concept, through which resources among Westinghouse and plant utilities are shared. PEN maximizes utilization rates through resource sharing, and eliminates redundant functions among utilities and Westinghouse. PEN is a "just-in-time" organization, but through the support of the computer network and access to expanded technical expertise and information, it can handle any "just-in-case" event.

PEN can help reduce costs by working toward common goals and through more efficient utilization of resources. PEN provides the infrastructure that will enable nuclear utilities to work together to exploit economies of scale whenever possible, and ultimately reduce the total amount of engineering performed.

Figure 3
U.S. Outsourcing Market Size ($ Million)



Source: Westinghouse Outsourcing Study

Table 5
Outsourcing Opportunities Identified by Utility Executives

Outsourceable	**Maintain Internal**
• Select Engineering – Modifications – Design – License and analysis maintenance • Fuel Management • Select Maintenance – NSSS components – Common components (e.g. valves, I&C) – Preventative maintenance programs • Materials Management – appears to be no current industry solution • Select Training – non site-specific, corrective actions • Configuration and Records Management	• Systems Engineering • NRC License Compliance • Quality Assurance • Daily Maintenance • On-Board Operations & Support Functions • Local & State Regulation Compliance

Source: Interviews with U.S. Utility Executives

JOINT PLANT SERVICES INITIATIVE

Another trend that we are seeing is a growing emphasis on long-range planning. The cost of last-minute heroics has become so high that planning has become the most important procedure of all. Long-range plans that seek to levelize costs result in better budgeting and financial predictability. Long-term relationships make possible the planning that reduces, or even eliminates costly surprises. A simple extension of this same logic points toward long-term, continuous integration of service capabilities with operations.

Over the past year, we have conducted dozens of interviews with utility executives on out-sourcing and future partnering concepts. Based on the plant function out-sourcing opportunities that they identified (Table 5), we are in discussions with several utilities on a joint initiative to provide comprehensive operating plant services. The approach would be similar to existing performance-based contracting with the potential for innovative ownership concepts. This type of joint initiative would capitalize on best practices and economies of scale not achievable through individual efforts. There is also the potential to take a successful demonstration of this concept to a broader market.

CONCLUSION

With a consistent approach to the issue of stranded assets allowing generators to recover past prudent investment, nuclear power plants will be invaluable assets to their owners and countries, provided each plant gets its production costs down to the real potential that all of these plants have—somewhere near 1 cent/Kwhr (U.S.) at the bus bar.

Significant progress has been made in reducing production costs primarily through capacity factor improvements driven by shorter refueling outages. Additional outage and maintenance optimization programs can yield additional cost reduction benefits.

Uranium and enrichment costs dominate total fuel cycle costs. Utilities need to be vigilant

in achieving the lowest cost for these commodities and work closely with fuel vendors to achieve cost-effective and highly reliable designs. In the U.S., the spent fuel disposal issue represents a major impediment to improved fuel costs. However, the recent passage of spent fuel legislation by both the U.S.

Senate and House of Representatives provides some optimism that an interim storage facility will be in place by 2002.

In order to keep capacity factors going up and costs going down, we need to explore fundamental changes in the way we do business. One of the most compelling industry trends we're seeing is the closer integration of the industry's many capabilities. This integration holds promise as the next major advance in performance improvement and cost control.

Continued success in the new competitive era will require new approaches to organizational design and operations—approaches such as performance based contracts, "just in time" engineering networks, integrated materials management and joint service initiatives. Cooperative efforts to share the best practices, best people, and best equipment are important at any time, and vital in the new competitive era.