Lost Generation

The Risk of Regulatory Shutdown Poses Significant Asset Management Challenges for Nuclear Plants

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Executive Summary

Twenty years after Three Mile Island, twelve years since the NRC instituted the "Watch List", and at a time when the average age of the U.S. nuclear fleet is passing 19 years, regulatory-related shutdown has become the single largest contributor to unplanned loss of nuclear generation, has already impacted more than 40% of U.S. nuclear plants, has been a factor in the permanent closure of at least six nuclear units, and is currently keeping more than 10% of nuclear generation out of service. At a time when the industry is building a foundation for being competitive generators in a deregulated market, the risk that nuclear generation will be "lost", temporarily or permanently, due to regulatory issues still looms as an industry-defining challenge.

Whether these shutdowns are an appropriate and responsible exercise of regulatory oversight, or the arbitrary and out of proportion response of regulation *in extremis*, has been the subject of ongoing tension between the industry, the NRC and the political process.[1] The present condition reflects an uneasy stasis as to the expected and required safety performance of nuclear plants and the remedies that the NRC should exercise when expectations are not being met.

These expectations are particularly difficult to understand when one considers that the *safety* performance, using NRC's yardsticks, has been steadily improving.[2]

In fact it also doesn't really matter as the increasing pace of electric utility deregulation overtakes the industry, it will be applying a single yardstick of success measured in cents per kwh; no allowances for good or bad regulation. Until recently much of the costs associated with these extended shutdowns has been able to be funded through rates under electric utility regulation. Now, the costs of extended shutdowns are being shifted to shareholders and in a number of instances, plants are being permanently retired where those costs make the going forward economics unfavorable.

Pending more fundamental regulatory changes, the industry must identify early the precursors to regulatory problems and successfully intervene before more serious regulatory actions are imposed. This paper analyzes the regulatory shutdown risk and identifies the changing principles that will govern that risk in the future.

Overall Performance Trends

The overall performance trends for nuclear plants in the 90s show progressive improvement when measured by capacity factor, cost per megawatthour and by safety system performance factors. Most compelling are the gains in generating performance, while cost reductions have been more difficult to come by. On a cents/kwh basis costs have looked somewhat better, due to the lift provided by generation, but on a dollars or dollars per kw basis, costs have proved to be more resistant.

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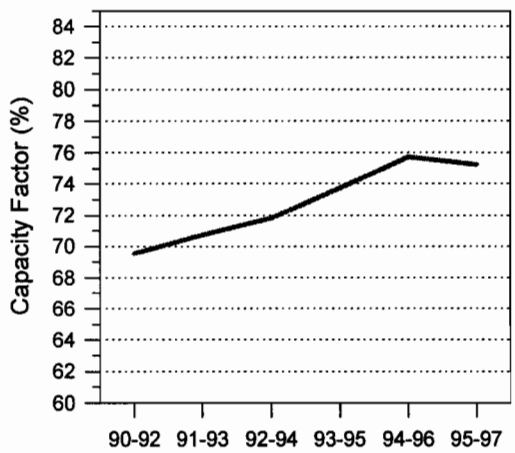
[1] In 1996 the NRC contracted with Arthur Andersen & Company to conduct an independent evaluation of the current process for placing plants on the Watch List. See Memorandum to the Commission from Hugh L. Thompson, dated January 7, 1997. More recently there was a meeting on July 17, 1998, between the NRC and a number of invited stakeholders from the industry, public and NRC staff, to discuss concerns about the NRC's regulatory program.

[2] As noted in the U.S. Senate Appropriation Committee's staff report for the 1999 NRC Budget: " In recent years, the safety performance of U.S. nuclear power plants has significantly improved. Since 1991, the number of significant events has decreased in excess of 70 percent, safety systems unavailability has decreased in excess of 60 percent, scrams while critical have decreased 50 percent, and collective radiation exposure has decreased 35 percent. Despite these improvements, in the last three years, the NRC has dramatically increased its imposition of civil fines (25 in 1995, 50 in 1996, and 71 in 1997) and level four (the least severe) violations (567 in 1995, 905 in 1996, and 1427 in 1997). The increased issuance of fines and violations is not a reflection on the safety of the nuclear industry...."

Figure 1 shows the trend in three year average capacity factors from 1990/92 to 1995/97. Note that these data are compiled based on total megawatt-hours of generation across all

Figure 1. Average Nuclear Industry Capacity Factor (3-Year Averages)



Note: Industry CF performance is based on total reported industry output for the period shown divided by potential output.

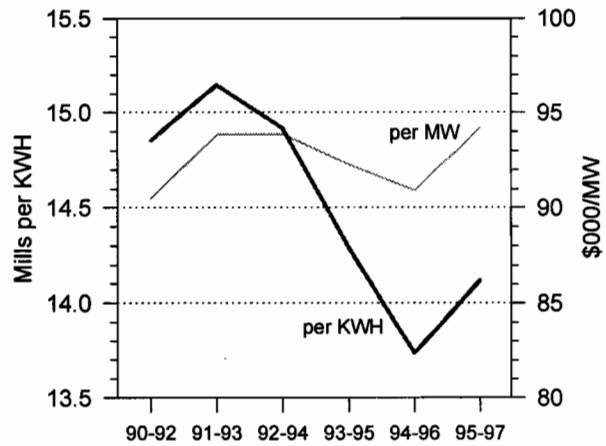
Source: Data is FERC 1 as reported in *Nucleonics Week*.

plants divided by potential generation. This provides proper weighting of the contribution of each plant based on output. Figure 2 provides two perspectives of operating costs: per megawatt-hour, as is most often reported, and per megawatt, to isolate the cost trends from generating performance.[3]

The above figures reflect that improved generation has been the key to improved overall performance. Clearly there will be continued emphasis on cost reduction measures, but given the modest progress to date and the aging of the fleet, future good performance will continue to be highly dependent on the denominator of production cost.

[3] Note that the cost values are compiled on an industry basis, such that plants with costs but no generation can be included without encountering extraneous, individual plant values. Frequently industry averages are reported based on averaging individual plant results. Plants with no generation in a particular year have to be excluded due to a zero denominator.

Figure 2. Average Nuclear Industry Non-Fuel Cost (3-Year Averages)



Note: Cost performance is based on total reported nominal (uninflated) non-fuel costs divided by total output of the plants that reported costs.

Source: Data is FERC 1 as reported in *Nucleonics Week*. Some plants are now withholding cost data. These plants are not included in the averages.

Some further perspectives on generating performance can be gained from the operating results for 1997. In this regard, Nucleonics Week stated:

> "There were few surprises in this year's reports. The best plants generally continued to be good, and the worst plants mostly stayed that way." [4]

The "two tier" nature of the industry had been reported previously in 1996[5] where certain operating organizations were identified as "advanced nuclear enterprises" or ANEs. Their plants consistently occupy the top of the performance spectrum, are continuing to improve, and are maintaining or increasing the gap relative to the rest of the industry.

"ANE", the term coined for these top performing nuclear organizations, reflected not only the top performance in capacity factor, cost and regulatory, but also sustaining that

[4] Nucleonics Week, June 18, 1998, p. 5.

[5] Capturing Stranded Value in Nuclear Plant Assets, R. Cudlin and R. Schoenberger, The Electricity Journal, June 1996, p. 59-65.

performance based on the ability to institutionalize their successful management models. Integral to those models was the ability to manage plant performance within the complex and stringent regulatory envelope specified by the NRC. This ability to manage all dimensions of performance not only results in high CF and lower costs, but avoids the potentially disastrous consequences of an extended shutdown to address regulatory issues.

As noted by Inside N.R.C.:

> "...1997 was far from the best year for U.S. utilities. ***With 10 reactors out all year*** [emphasis added], mainly for regulatory reasons, the average capacity factor slipped and total operations and maintenance (O&M) spending topped $13 billion..."[6]

Thus the effects of regulatory shutdowns are a significant drag on the industry and a key difference between upper and lower tier plants. As developed in the next section, regulatory shutdown losses have been increasing, both on an absolute basis and as a percentage of total lost generation.

Regulatory Shutdowns

What is a regulatory shutdown? Rarely are plant outages explicitly characterized as due to regulatory constraints or issues.[7] Often a plant shutdown for other purposes, such as refueling or component repairs, can get extended to address regulatory concerns or issues. Or, where there is a mounting level of issues with regulatory implications, licensees may choose to shutdown a plant rather than risk an overt action by the NRC. Thus regulatory shutdowns are de facto for most plants, and become commingled with a variety of other issues and conditions affecting operations.

For purposes of this discussion, regulatory shutdowns will be based on the following definition:

Regulatory shutdowns are those unplanned or extended outages, closely associated with some explicit[8] or implicit regulatory action, and where resolution of certain NRC issues or NRC approval is required prior to restart of the plant.

Figure 3 presents a compilation of regulatory shutdowns since approximately 1985. The chart identifies the periods when plants have been shutdown as well as the duration of a plant's residence on the NRC's Watch List. Because of the lack of clear accounting for shutdown outages, and the mixed purpose nature of at least part of these outage periods, the amount of outage period that is purely a regulatory shutdown is not certain and perhaps overstated by this accounting. However it is clear that a large fraction of the shutdown time is directly associated with regulatory issues and would not otherwise have been incurred absent such issues. The overall trends associated with regulatory shutdowns are also clear.

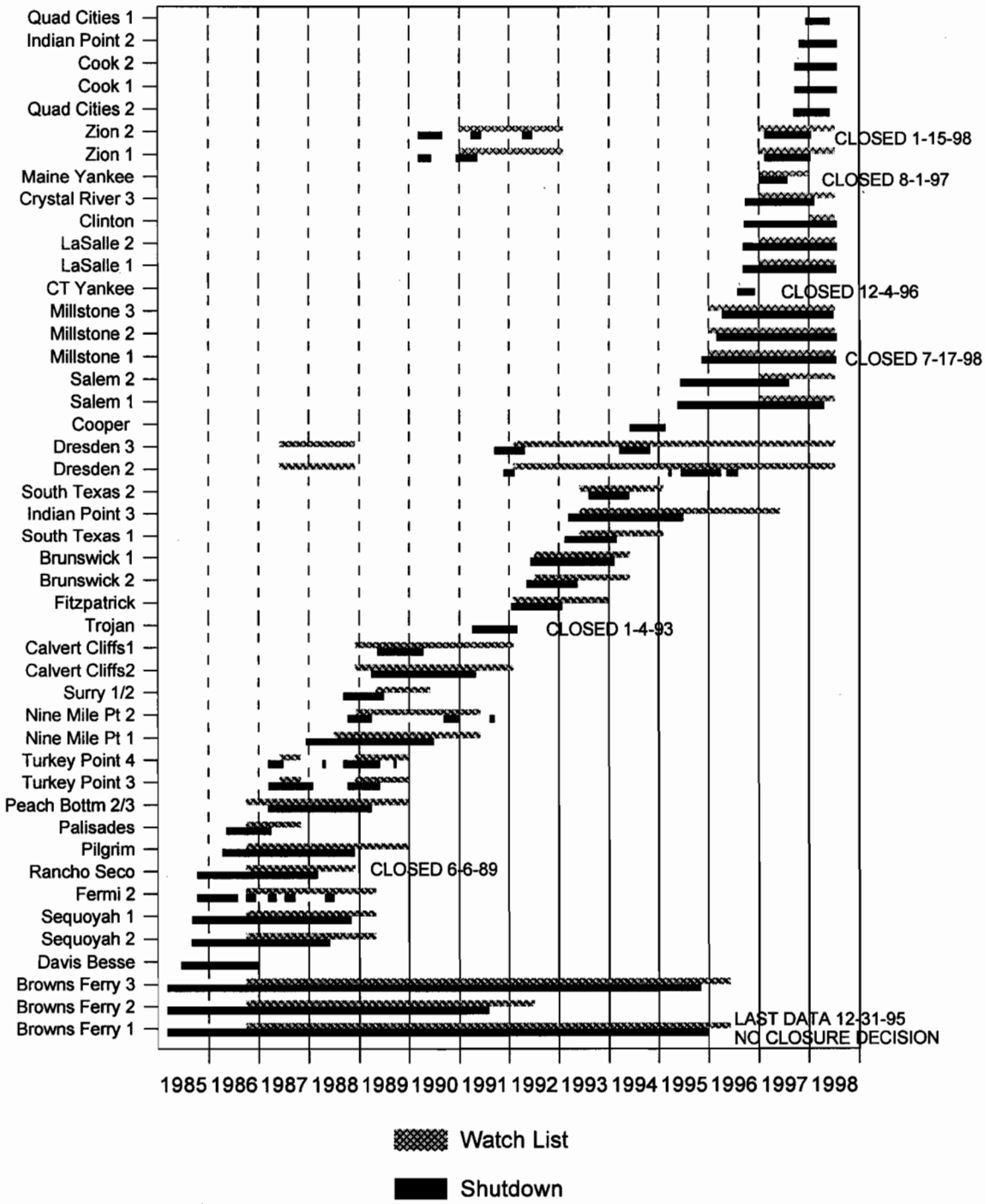
Figure 3 shows that there have been several "cycles" of regulatory shutdowns. In the mid-1980s, the NRC introduced the Watch List and regulatory shutdowns emerged as an enforcement option. During this period there were up to eight units down simultaneously, with shutdowns that extended over multiple years. The early to mid-1990s had fewer regulatory shutdowns of relatively shorter duration. The current cycle is evidencing a dramatically higher level of shutdowns, including several high visibility cases and the

[6] Inside N.R.C., June 22, 1998, p. 6. This was an increase of $500 million from 1996.

[7] For example, the NRC's Daily Report does not identify any of the currently shut down plants as due to regulatory concerns; rather outages are labeled as maintenance, refueling, etc.

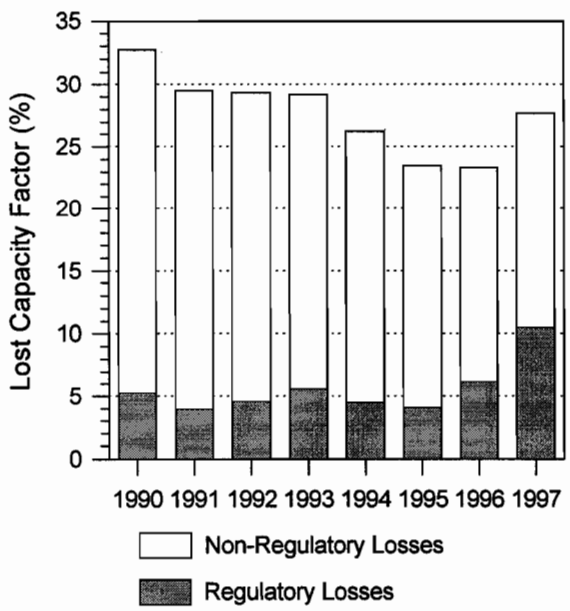
[8] Explicit regulatory actions include Watch List designation, trending letters, confirmatory action letters (CALs) or orders.

Figure 3. U.S. Nuclear Plant Regulatory Shutdowns



closure of three plants that were in the early phases of regulatory related shutdowns. Figure 4 provides additional perspective on the relative significance of regulatory shutdowns to the overall generating performance of nuclear plants. As indicated in Figure 1 above, nuclear generating performance has shown steady progress in the 1990s until last year. Thus there has been a shrinkage in generating losses each year as shown on Figure 4. Total losses include refueling outages, forced outages and maintenance outages, other losses due to operating and environmental limits, as well as the effects of regulatory shutdowns. The shaded area within each bar identifies the contribution of regulatory shutdowns to total losses for the year.

Figure 4. Nuclear Generation Losses as a Percent of Capacity Factor



Overall generating losses have been reduced due to improved planning and performance of refueling outages and to reduced forced outages, particularly those associated with unplanned reactor scrams. On the other hand, regulatory related losses are relatively constant from 1990 to 1996 at around 5% of total capacity factor. On a relative basis, the impact of regulatory related losses has grown from less than 20% of total losses to 27% in 1996 and 38% in 1997. Regulatory losses are also the primary culprit for the reversal in 1997 of the industry's performance improvement trend – non-regulatory generating losses were approximately 17% for 1997, essentially the same as 1996, but high regulatory losses caused total losses to increase. It would appear that the industry, without regulatory losses, is reaching an asymptote in generation that would yield an average capacity factor in the low to mid-eighties. *Regulatory shutdowns now pose the greatest unplanned loss of generating capacity for the nuclear industry, and the only one where there has been no improvement over an entire decade.*

One of the contributing factors to the lack of progress for regulatory losses may be in the serial nature of regulatory shutdowns. Other losses tend to be recurring for each plant and receive continuing attention to improve results. However, regulatory shutdowns have been for the most part, one-time events. They have spread across the industry such that as of now, 40% of U.S. nuclear plants have been affected.

Thus, reduction of regulatory losses requires two ingredients: avoidance by plants that have not yet been impacted, and no or very low recurrence at plants with a prior history. The first ingredient is not being met. This may be due to several reasons. First, the incidence of regulatory shutdowns may be a strong function of the prevailing posture of NRC management and could reflect a progressive "sweep" of the industry to bring plants up to a common, current standard of regulatory performance. Second, there is clear evidence from the specifics of individual plant shutdowns, that many of the contributing issues and causes are highly similar across the plants. Thus for other plants to continue to be impacted may imply a lack of reliable leading indicators and, consequently, a management posture that is too reactive to stay in front of emerging problems.

Further examination of Figure 3 indicates that one possible indicator of impending regulatory problems, assignment of a plant to the NRC's

Watch List, is not a leading indicator. In all but a few instances, plants have been shutdown prior to being placed on the Watch List. And plants are generally maintained on the Watch List for a period following restart to establish a track record of improved performance in an operations mode. In practice, the Watch List has served to confirm the situation at a plant (and regulatory actions such as shutdown) more than as a barometer of future regulatory actions. In addition, since the Watch List process occurs only two times per year, it could provide only a blunt edged instrument at best.[9]

A final observation about Figure 4 relates to what the figure does not show. A total of seven nuclear units have permanently closed during the course of a regulatory shutdown. These are indicated on Figure 3. The total generating capacity associated with these seven units is 6151 MW. If these plants had returned to service they would now account for approximately 6% of total nuclear capacity. Thus the industry is 6% smaller in addition to the generating losses of those plants currently shut down. While it is likely that other factors contributed to the overall decision to close these reactors, the decisions being made in such proximity to major regulatory actions suggests a more than a casual linkage.

Lessons To Be Learned

The impact on nuclear generation due to regulatory shutdowns would be sufficient to prompt action under any circumstances. But the changing context arising from the deregulation of the electric utility industry creates an even more compelling need to ensure that the economics and business risks associated with nuclear plants are acceptable. Plants will need to be competitive on a going forward cost basis, including the costs associated with any regulatory actions and the reduced generation over which to spread those costs in the event of a regulatory shutdown. The most recent permanent closures of five nuclear units does not bode well for plants confronting extended outages – and where the light at the end of the tunnel is a competitive market.

The following "prescriptions" suggest lessons that should be learned as a result of what has occurred to date and what can be allowed in the future.

- *Nuclear plant owners must avoid the circumstances that can lead to a regulatory shutdown. It should be assumed that any regulatory shutdown could lead to permanent plant closure.*

The data in Figures 3 and 4 present a nominal industry view. The reality is that specific plant situations can dramatically alter the risk of regulatory shutdown. Clearly there are a subset of plants that have made top regulatory performance an absolute condition of their operations[10], have not suffered a shutdown and probably have virtual immunity from one. At the other end of the spectrum are those plants who are "at risk" because they share some of the issues that have been associated with regulatory shutdowns at other plants and are not aggressively identifying the issues and taking appropriate actions. For these plants,

[9] The Arthur Andersen study of the NRC's Senior Management Meeting process, which decides on regulatory actions including assignment to the Watch List, concluded that there was a "...focus on analyzing the operational causes of particular events rather than attempting to predict performance...". See "Recommendations to Improve the Senior Management Meeting Process", Arthur Andersen & Company, December 30, 1996.

[10] For example, Diablo Canyon made this an explicit goal of their operations, in part reflecting the terms of their settlement agreement with the California PUC which provided for recovery of costs through a price per kwh generated. Loss of generation was simply too expensive as it will be for all plants under competition. Speaking at the California Energy Commission in 1988, Pacific Gas & Electric's CEO stated: "The agreement reinforces PG&E's firm commitment to running Diablo Canyon safely. Safety has always been our first priority and the settlement is consistent with that commitment. It creates the strongest possible economic incentive for PG&E to operate the plant at the highest possible levels of safety, efficiency, and effectiveness: if we don't, the plant won't run, and we won't get paid"

there is a much higher likelihood of a regulatory response than indicated by industry averages.

Because of the very high impact of a regulatory shutdown, and because most if not all nuclear plants will be economic only at relatively high performance factors, it should be anticipated that the occurrence of a regulatory shutdown will not be able to be rationalized by the plant owners on an economic basis. Thus, as has been the case recently, plants will simply be closed and decommissioned.

> ***"...the business is changing and we need to change the way we regulate it and still maintain public health and safety...."***
>
> ***Joe Colvin, NEI President and CEO***
> ***NRC Stakeholder Meeting***
> ***July 17, 1998***

The needed result is for all plants to achieve "virtual immunity" from regulatory shutdown, and to accomplish that within current or even lower levels of spending.

- *Nuclear operating organizations must take a proactive approach to issues that could affect the regulatory assessment of their performance; methods need to be devised to identify and prevent adverse trends from escalating to the threshold for regulatory action and, if possible, to insure that the consequences of any shutdown does not contribute to an economic termination of the plant.*

Experience across many plants where regulatory shutdowns have occurred indicate a high degree of common organizational performance issues across plants – further suggesting that appropriate initiatives could be effective in providing notice of impending problems and addressing negative trends. It is also clear that if organizations do not take actions prior to active NRC involvement, there is a high likelihood that control of the situation will be lost, leading to extreme remedies such as shutdown.

The essential elements of organizational performance include (1) a well-defined and understood hierarchy of performance measures and expectations; (2) consistent and effective management processes such as accountability and prioritization; (3) use of best work processes, particularly in key areas such as work management, corrective actions and engineering management; and (4) enterprise-wide management tools including data bases and information systems. The organizational environment, including safety culture, must also be appropriate to the complexity and high reliability requirements of nuclear generation.

Recognizing these essential elements is the starting point for monitoring organizational performance and triggering intervention where required to maintain or improve results, and avoid regulatory shutdowns. The "pulse" of the organization may provide an important and advance indicator of overall performance health by synthesizing, on an ongoing basis, the many contributors and factors that ultimately manifest in specific operating results. In addition, the risk of regulatory shutdown may need to be treated similarly to other risks to generation – through specific risk management programs and even insurance. Such programmatic measures have been effective in providing the focus required to minimize occurrence and consequences of risks such as natural hazards, fire, major equipment damage and industrial safety.

- *The result? Ultimately an end to regulatory shutdowns. Either through the ability of the industry and the NRC to avoid this extreme solution or closure of plants that don't and can't afford the consequences. Certainly the industry and the NRC both should be able to find ways to succeed at the former rather than accept the latter.*

To a large degree the imposition of significant operating penalties has been self-reinforcing – plants that have been targeted by the NRC for intense scrutiny have responded (with only a few exceptions) with comprehensive programs and changes that have resulted in significantly

improved regulatory performance. Thus the NRC may feel justified, and even more likely, to continue using such remedies. However the effectiveness of this "tool" is really dependent on the ability of nuclear organizations to afford the consequences of an extended shutdown. Results are achieved but at a very high price. If nuclear plant owners can no longer afford this price under deregulation, the "tool" may become too drastic to be used except under the most intractable circumstances.

Of course it is very hard to predict how the NRC will, or should, react to the growing impact of its policies or to the new paradigms of a competitive industry. A shift in the regulatory cycle could occur – either due to industry advocacy efforts and/or a reluctance by the NRC to be cast as the death knell of nuclear plants. But it is hard to imagine the circumstances under which it would be prudent to anticipate that changed NRC policies *alone* should be relied on as the answer. On the other hand, a shift will occur if each nuclear plant takes steps to immunize itself from conditions leading to a significant regulatory action and limits the consequences of any such regulatory actions that do occur.