



Analytical and Regulatory Issues Surrounding U.S. Nuclear Performance Standards (NPS)

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George Fitzpatrick's Relevant Experience

- US Nuclear Performance Standard analytical and expert witness experience:
 - Palo Verde 1,2,3 (Texas, New Mexico, California and Arizona)
 - Comanche Peak 1 and 2 (Texas)
 - Indian Point 2&3 (New York)
 - Wolf Creek (Kansas and Missouri)
 - Plant Vogtle (Georgia)
 - Plant Hatch (Georgia)
 - Shoreham (New York)
 - San Onofre 2&3 (California)



Historical U.S. State Regulatory Focus On Nuclear Generation

- Safety
- Security
- Capacity Factors
- Forced Outages
- Refueling Outage Cost and Durations
- Operation & Maintenance Costs
- Capital Additions Costs

These inquiries were usually initiated by a particular event or specific cost reviews as part of a rate case. They were not part of an automated regulation process.



An Overriding US NRC Concern- Effects of Performance Standards on Safety

- On July 24, 1991, the U.S. Nuclear Regulatory Commission (NRC) expressed its safety-related concerns if state commissions imposed Nuclear Performance Standards (NPS) on its Licensees. The following points were stressed:
 - Certain forms of economic performance incentives may adversely affect the operation of nuclear plants and public health and safety;
 - Certain methods of measuring nuclear performance are of particular concern (e.g., use of sharp thresholds, short time interval measurements, lack of “null zones”, and reliance on SALP (Systematic Assessment of Licensee Performance) scores);
 - NRC will continue to monitor state commission activity in this area
 - NRC urges that licensees and regulatory commissions inform the NRC of NPS programs that are being considered for application to NRC licensees



Nuclear Performance Observations

- US nuclear units that I have statistically modeled go through a non-linear maturing process. As units progress toward the end of their lifecycle, Capacity Factor is likely to decline and Operation & Maintenance Costs may increase (significant management effort/ initiatives would be required to reverse this trend)
- Using industry averages to set targets for performance for individual nuclear units is a statistically inferior approach. Informed averages, or model-based “most likely performance” estimators are better statistical measurement methods
- In the case of U.S. Pressurized Water Reactors, for example, there are 11 statistically significant variables that have either a positive or negative effect on Capacity Factor. These factors would likely affect CANDU unit performance as well.
- “Extraordinary Events” should also be identified and agreed to in advance of an NPS and then be excluded from any model-based performance calculation. Based on my experience, this process involves lengthy discussion over many months.

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Examples of Statistically Significant Factors Affecting U.S. PWR Nuclear Unit Performance

- Maturing operating age (non-linear variable structures track plateauing then declining capacity factor)
- Immature operating age (e.g., less than 6 years from Commercial Operation Date)
- Cooling Water type
- Cooling Tower type
- Containment type
- Reactor system type

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Examples of Statistically Significant Factors Affecting U.S. PWR Nuclear Unit Performance

- Steam Generator type
- Steam Generator Replacement completed
- Reactor Vessel Head Replacement completed
- Commercial Operating Date (the older the vintage, the lower the performance)
- Fleet vs. Non Fleet units



Conclusions Based Upon My U.S. Nuclear Performance Modeling and Regulatory Experience

- Nuclear unit performance follows an “S” shaped trajectory that shows Capacity Factor increasing to its mid-life and then plateauing and declining as it reaches the end of its lifecycle
- The earlier the design and Commercial Operating Date, the lower the expected lifecycle capacity factor, all else equal
- The challenge for nuclear plant management: get the best performance from aging nuclear assets while maintaining the highest level of safety



Conclusions Based Upon My U.S. Nuclear Performance Modeling and Regulatory Experience

- Key question for regulators: Will the imposition of an NPS cause plant management to operate any differently? My interactions with a representative sample of U.S. nuclear plant management indicates they will always strive for excellence in both safety and performance. Based on my U.S. experience, incentives (penalties) tied to performance standards would not change nuclear performance
- The vast majority of US state commissions that I have worked with have reached that same conclusion



Conclusions Based Upon My U.S. Nuclear Performance Modeling and Regulatory Experience

- Many U.S. commissions opt for frequent communications on costs and performance between commission staff and nuclear personnel
- According to the NRC, Nuclear Performance Standards can have unintended consequences that could affect decision making and safety
- According to the nuclear plant senior management personnel with whom I have worked, Nuclear Performance Standards can have unintended consequences that could affect employee morale and ultimately the retention of qualified experts and proven senior management