Changes in U.S. Nuclear Power Plant Operation & Regulation 1979-Present

Gail H. Marcus, Sc. D.
Former Deputy Director-General,
OECD Nuclear Energy Agency, Paris, France
Former Principal Deputy Director,
Office of Nuclear Energy, DOE

The Institute of Energy Economics, Japan
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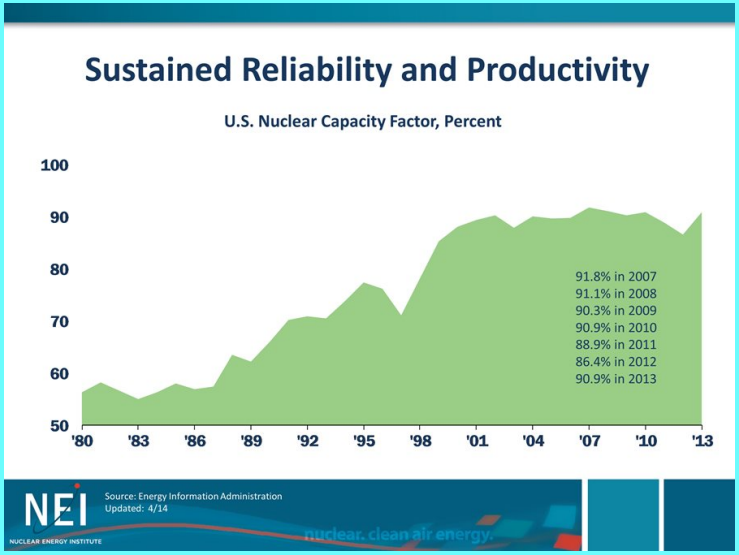
Scope of Discussion

- How U.S. restored public confidence after TMI
- How U.S. improved capacity factors

President Carter at TMI
(Source: US Government)

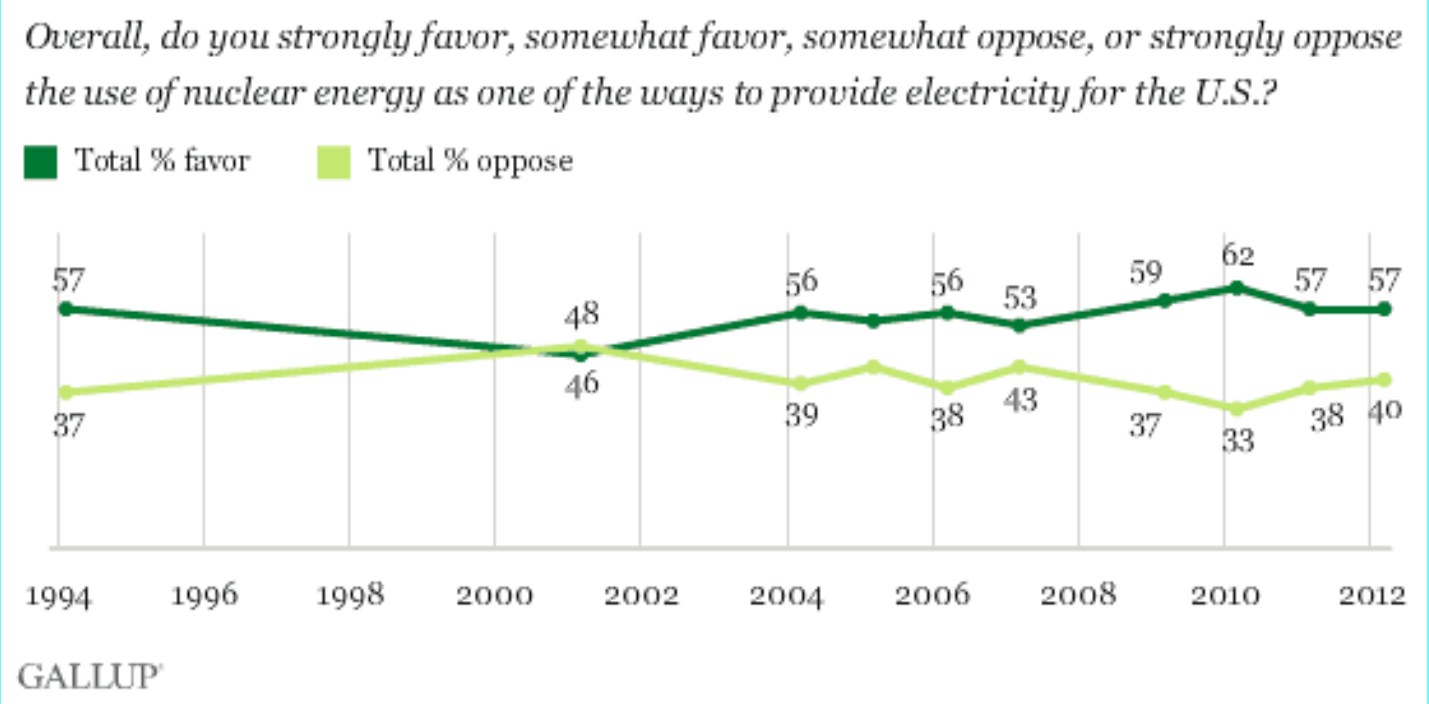


(Source: NEI)

Public Confidence in the U.S. after TMI

TMI. (Source: US Government)

Recent Public Opinion Trends in U.S.



(Source: Gallup)

Public opinion remained positive after Fukushima

Post-TMI Public Opinion in U.S.

- Public opinion has varied over time
- *Generally* positive today
  - Limited effects of TMI, especially offsite
  - Passage of time
  - Other concerns—climate change, security of supply (interest in renewables, but recognition of intermittency)
  - General trust in US regulatory system
  - Industry and regulatory responses to TMI, other events
- Anti-nuclear element remains; concerns remain

Important Contributors to Public Perception

- **Strong safety culture**
- Learning from experience
- Continuous improvement
- Strong regulator
- Industry collaboration & leadership
- Positive industry-regulator relationship
- Transparency & openness (NRC, industry)
- Use of risk-informed regulation

Strong Safety Culture

(**NOT** "See no evil, hear no evil, speak no evil")

Tōshōgū shrine, Nikkō (Source: David Monniaux)

Strong Safety Culture: What is it?

"That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."

Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident (INSAG, 1986)

Importance of Strong Safety Culture

"An accident anywhere is an accident everywhere"

- Helps lead to safe, reliable performance
- Public acceptance depends critically on public confidence that both operators and regulators are giving priority to safety (i.e., have good safety culture)
- Any impression of corruption, complacency, collusion, carelessness, lying, mismanagement, covering up (by operators or regulators), etc. erodes public confidence

Characteristics of Strong Safety Culture

- **Safety first**
- Leadership sets example
- Leadership doesn't put other priorities above safety
  - Such as saving time or money, meeting performance goals
- Leadership takes responsibility
  - Doesn't sanction "hidden procedures"
  - Doesn't try to cover up mistakes to regulator or public
- Entire staff believes they share responsibility for safety
- Staff not punished for identifying safety concerns
- Questioning attitude is cultivated
- Culture of continuous improvement
- Emphasis on following rules

Learning from Experience

TMI-2 (Source: US Government)

Pripyat (Chernobyl site) (Source: VOA, D. Markosian

Fukushima Daiichi
(Source: Wikimedia Commons/Digital Globe

Learning from Experience

- We can learn a lot from accidents
  - "When you think you've thought of everything, there will always be something you have not thought of"

    Prof. Hatamura, Chairman of Government Committee investigating Fukushima accident
- Both nuclear and non-nuclear accidents and other incidents may provide lessons
- We need to share facts and findings so that everyone learns
- Today, that means internationally as well as domestically
- No one likes to share their weaknesses, but trying to hide them is actually counterproductive

Examples of Sources of Lessons

- Major accidents (Nuclear)
  - **TMI, Chernobyl, Fukushima**
- Other accidents and incidents (Nuclear)
  - **Davis Besse, Browns Ferry**
- Non-reactor/non-nuclear accidents/ incidents
  - **Ibaraki, WIPP, cyber-security breaches**
  - Lessons are usually more generic
  - A few may be more directly applicable

Learning from Experience— Some Cautions

- It means there has already been an accident
  - It's better to anticipate if possible
- Tendency to overcompensate
  - **US:** Overregulation
  - **Japan:** Mistaking independence for isolation
- Difficulty in resuming normal activities
  - **US:** Long delays in new licenses
  - **Japan:** Long delays in restarts
- Changes may fix one problem, but create others

Continuous Improvement, (NOT "Mission Accomplished")

President Bush, San Diego, 2003 (Source: U.S. News)

Importance of Continuous Improvement

The job is never fully completed

- Changes made may not fully or appropriately address problems
- Better options become possible
- New issues arise
- Standards and expectations increase

Need to keep reviewing and evaluating performance, looking for further improvements.

Strong, Competent Regulator

NRC Headquarters (Source: NRC)

Strong, Competent Regulator

Improves public confidence
Gives industry credibility

- Characteristics
  - Puts safety first
  - Sets high standards
  - Consistent in review and enforcement
  - Seeks, considers, and addresses **ALL** viewpoints
- Subscribes to high standards itself
  - At NRC, embodied in Principles of Good Regulation

NRC Principles of Good Regulation

- Independence
- Openness
- Efficiency
- Clarity
- Reliability

Independence

Nothing but the highest possible standards of ethical performance and professionalism should influence regulation. However, **independence does not imply isolation**. All available facts and opinions must be sought openly from licensees and other interested members of the public. The many and possibly conflicting public interests involved must be considered. Final decisions must be based on **objective, unbiased assessments** of all information, and must be **documented with reasons explicitly stated**.

Openness

Nuclear regulation is the public's business, and it must be transacted publicly and candidly. The public must be informed about and have the opportunity to participate in the regulatory processes as required by law. Open channels of communication must be maintained with Congress, other government agencies, licensees, and the public, as well as with the international nuclear community.

Efficiency

The American taxpayer, the rate-paying consumer, and licensees are all entitled to the best possible management and administration of regulatory activities. The **highest technical and managerial competence** is required, and must be a constant agency goal. NRC must establish means to evaluate and continually upgrade its regulatory capabilities. **Regulatory activities should be consistent with the degree of risk reduction they achieve**. Where several effective alternatives are available, the **option which minimizes the use of resources should be adopted**. Regulatory decisions should be made **without undue delay**.

Clarity

Regulations should be coherent, logical, and practical. There should be a **clear nexus between regulations and agency goals and objectives** whether explicitly or implicitly stated. Agency positions should be readily understood and easily applied.

Reliability

Regulations should be based on the best available knowledge from research and operational experience. Systems interactions, technological uncertainties, and the diversity of licensees and regulatory activities must all be taken into account so that risks are maintained at an acceptably low level. Once established, **regulation should be perceived to be reliable and not unjustifiably in a state of transition**. Regulatory actions should always be fully consistent with written regulations and should be **promptly, fairly, and decisively administered** so as to lend stability to the nuclear operational and planning processes.

Observations about Independence

"Independence does not equal isolation"

- Independence is knowing all facts and viewpoints and reaching one's own conclusions
- Independence means not being unduly influenced by anyone else—industry, political pressure, or public opinion
- Openness and transparency help demonstrate that actions are based on independent judgments

Personnel Practices Contributing to a Strong Regulator

- Regulatory issues are highly technical and need deep technical expertise
  - **NRC has one of the most highly trained and educated staffs in the US Government**
- Technical expertise at NRC comes from both internal (staff) and independent external sources
  - Research organizations (such as universities) perform experiments and run simulations
  - Advisory committees with independent members review research, debate findings, and make recommendations
  - However, regulatory staff can independently assess the research results and recommendations, and make final decisions based on their own understanding

Industry Collaboration and Leadership

INPO Headquarters (Source: INPO)

Industry Collaboration and Leadership

- **Operators are responsible for safety**
- Industry should be proactive
- Industry should cooperate to share lessons learned and improve performance of all
  - INPO
  - Owner's groups
  - EPRI
- Industry should appreciate role of regulator, and engage in constructive dialogue with regulator

INPO: Mission and Areas of Effort

- "Our mission at the Institute of Nuclear Power Operations (INPO) **is to promote the highest levels of safety and reliability** – to promote excellence – in the operation of commercial nuclear power plants.
- We work to achieve our mission by:
  - Establishing performance objectives, criteria and guidelines for the nuclear power industry
  - Conducting regular detailed evaluations of nuclear power plants
  - Providing assistance to help nuclear power plants continually improve their performance"

Note: Areas of effort include plant evaluations, training and accreditation, events analysis and information exchange, and assistance

INPO: Values

"Our values at INPO are the foundation of all that we do professionally and personally.

- **Excellence** – make it better
- **Perseverance** - there is no finish line
- **Leadership** – make things happen
- **Relationships** – knock down walls and build bridges
- **Integrity** – we are what we say and do"

Positive Industry-Regulator Relationship

NRC Chairman Marfarlane, INPO CEO Conference 2013
(Source: NRC)

Positive Industry-Regulator Relationship

- **NRC and industry** have largely shed the “us versus them” attitude
- **NRC** realizes it needs the input from the “boots on the ground” of the operators
- **Industry** realizes that a strong regulator gives the public confidence in them
- Of course, there are times the industry still charges the NRC with over-regulating, and anti-nukes still charge that NRC does whatever industry wants
- But both parties recognize critical role of other and are committed at the highest levels to open dialogue

Industry View on NRC Role

"We need to maintain a strong, credible regulator"

Marvin S. Fertel, President and CEO, Nuclear Energy Institute, in Citizens for Nuclear Energy Technology Awareness Edward Teller Lecture, October 21, 2013

Transparency and Openness

RIC Conference Announcement, 2015 (Source: NRC)

Transparency and Openness: Government-wide U.S. Laws

- The U.S. has legal, Government-wide requirements for public access to government activities and decisions
  - **Freedom of Information Act (FOIA)**
    - Requires agencies to provide most material requested by members of the public
  - **Government in the Sunshine Act**
    - Requires most meetings by agency bodies (like Commissions) to be announced in advance and open to the public
  - Exceptions for national security, personnel-related, other
- The U.S. has legal, Government-wide requirements to solicit public input on Government decisions, like rules
  - Proposed rules must be published in advance
  - Public must have time to comment
  - **Agency must publish responses** to issues raised in comments (addressing what it did to address the comment, or why the issue doesn't need to be addressed)

Transparency and Openness: U.S. NRC

- NRC openness has evolved over time
- NRC used to be insular, and especially cautious about dealing with industry
- NRC now tries to engage with **ALL** "stakeholders" (interested parties)
- Interaction is not one-way; NRC really listens and reacts
- Some still say NRC's interactions aren't balanced
  - **BUT** criticism comes from both ends of spectrum!
    - Anti-nukes claim NRC is industry's "lapdog"
    - Ardent pro-nukes claim that NRC impedes industry

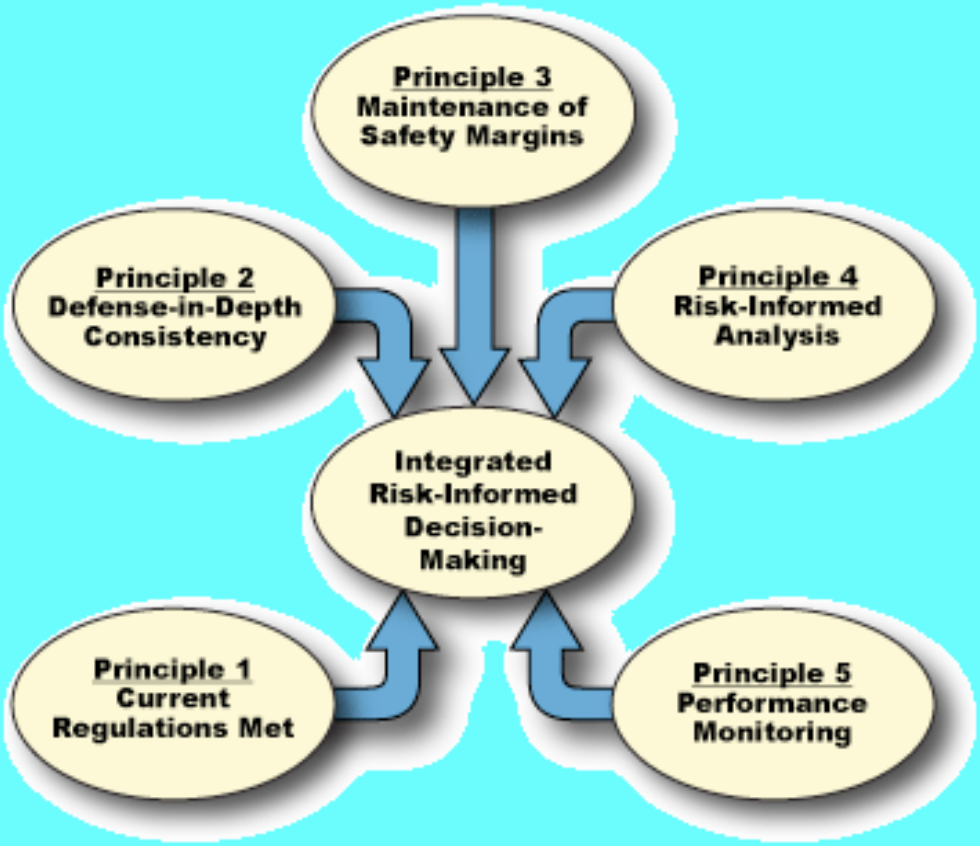
Transparency and Openness: Industry

- U.S. industry has discovered that transparency and openness are important for them as well
  - Developing and maintaining dialogue with local community
  - Being available and being accurate in discussing incidents
- Openness and transparency do add to the level of effort for all parties (industry and regulator)
  - Must schedule and hold meetings
  - Regulatory staff may need to travel to meet with public
  - Must prepare documentation and responses
- Openness doesn't eliminate all criticism, but does improve credibility

Observations on Independence and Openness

- It may seem counterintuitive for regulator to meet with industry while trying to overcome image of “nuclear village”
- However, regulator can only have complete understanding by looking at issues from all perspectives
- It is important that:
  - Meetings with industry are open and documented
  - Similar meetings are held with other interested parties
  - Decisions of regulators are objective and are explained in documents available to the public

Use of Risk-Informed Regulation



(Source: NRC)

Use of Risk-Informed Regulation

"An airplane that is 100% safe would have so much equipment on it that it would be too heavy to fly"

- Careful consideration of risk provides guidance for both operators and regulators
- Risk evaluations help identify vulnerabilities and set priorities
- Risk-informed regulation
  - Assures adequate safety is met
  - Balances costs and benefits beyond adequate safety
  - Provides rationale for determining how what safety measures are enough, and what are too much

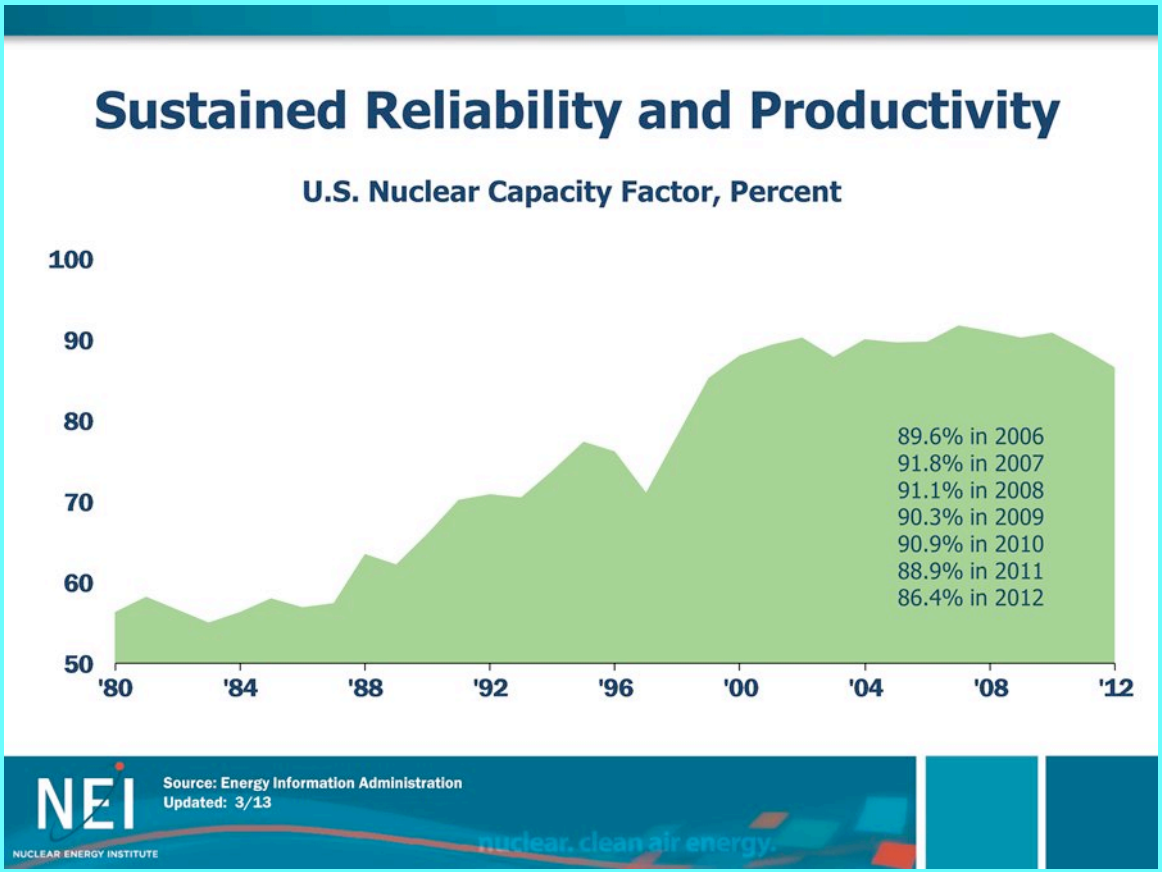
Quantity versus Quality

- Traditional safety approach is “defense in depth”—several “layers” of safety in case one doesn’t work
- This is still an appropriate approach
- **HOWEVER**, defense in depth also needs diversity
  - Operator can’t rely completely on more and more engineered systems
  - More equipment does not replace the need for other measures (ex., training, maintenance, operating procedures, emergency procedures)
  - Added measures can sometimes introduce other risks
  - Wrong added measures can distract attention and resources from more safety-significant measures and actions
  - Overemphasis in one area can shortchange other areas

NRC's Backfit Rule

- NRC is charged by law with responsibility to assure adequate protection of the public health and safety
- Beyond adequate protection, costs must be justifiable in terms of safety benefit
- This is codified in NRC's "Backfit Rule" for new requirements to existing facilities
  - Adequate protection is always required
  - Beyond adequate protection, there must be a substantial increase in public health and safety justifying the direct and indirect costs of the measure

Capacity Factor Improvements



(Source: NEI)

Contributing Elements to U.S. Capacity Factor Improvements

- Improvements were based on experience
- Continuing changes were made over time as more experience was gained
- Post-TMI actions by NRC and industry contributed
- Improved NRC-licensee relationship probably contributed

Some of these contributions may be difficult to demonstrate or quantify

Many Interrelated Contributors to Improved Capacity Factors

Extended refueling outage intervals
Reduced refueling/maintenance outage durations
Reduced unplanned automatic scrams

- Improved maintenance
- More on-line maintenance
  - May reduce both outage frequency and duration
- Reduced scrams may reduce need for maintenance
- Improved training
  - May reduce scrams, improve outage performance
- Specific measures that allowed longer times between maintenance shutdowns, such as
  - Chemistry changes to increase component life
  - Improved motor-operated valves

Possible Post-TMI Contributors

- Establishment of INPO
  - Disseminates information on operational best practices, shares lessons learned
  - Exert peer pressure on poor performers
- Improved training (and other industry initiatives at least partly motivated by TMI)
- Perhaps on-site resident inspectors, more risk-informed approaches, and other NRC regulatory initiatives
  - Ex., Reactor Oversight Process
- Improvements in design of plants built after TMI

Possible Contributions of NRC-Industry Relationship

- During period that capacity factors improved, NRC and industry relationship also improved
- May have facilitated initiatives that improved performance
- Example: Industry-developed guidance documents
  - Documents are developed by industry groups as proposals
  - Industry provides rationale
  - NRC reviews carefully before endorsing (or not)
  - Openness and transparency assure that decisions are made appropriately
    - Exchanges between NRC and industry are made public
    - The NRC review process Is clear, thorough and objective

Roles and Responsibilities in Improving Capacity Factors

- Industry had significant role in improving capacity factors in U.S.
  - Pressure to improve capacity factors is more financial than safety
- Many improvements resulted from collaborative efforts
  - EPRI, Owner's Groups, INPO
- NRC role has been primarily to assure that its regulations permit operational improvements if safety is not affected
  - Review regulations in response to industry proposals
  - Modify regulations as long as safety is maintained
- Move to risk-informed regulation may have been a factor
  - Ex., maintenance rule required licensees to take a risk-oriented approach to maintenance
  - This helped reduce unplanned automatic scrams

Refueling—Different Considerations in U.S. and Japan

- U.S. nuclear plants typically have longer intervals between refueling than do Japanese plants, and shorter outages
- This contributes to a higher capacity factor
- Government requirements may constrain the refueling schedules in Japan
- The U.S. does not have similar requirements
- In the U.S. refueling intervals were increased by industry initiatives as experience was gained
- Some NRC rules (such as rules for permissible burnup) may also be contributing factors

Final Thoughts—on Post TMI & Capacity Factor Discussion

- It's difficult to regain trust once it's been lost
- It takes time and consistently improved performance
- Strict adherence to the highest levels of behavior and performance is necessary
- Both the licensee and the regulator must have a strong safety culture

Contact : report@tky.ieej.or.jp