



Fire PRA Maturity and Realism: A Technical Evaluation and Questions

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A historical recap...

- Three “generations” of fire PRA
 - Industry (Zion/Indian Point, Limerick, Millstone, Oconee...) + NRC (NUREG-1150, RMIEP LaSalle)
 - IPEEE
 - NFPA 805
- Used to support decision making
 - Licensing
 - Regulatory analyses
 - Vulnerability assessments and plant upgrades
 - Transition to risk-informed, performance-based fire protection
- R&D has provided results and analysis detail is increasing
- Increasing recognition of the need to treat all hazards

Is Fire PRA “a mess”?

- Voiced concerns: “Fire PRA is...”
 - “immature”
 - “untested”
 - “laced with conservatisms”
 - “not consistent with operating experience”
- Our approach
 - Structured exploration of “maturity”
 - Comparisons: operating experience, PRAs
 - *Review of technology, environment, and infrastructure
 - Observations and questions

Maturity and realism are separate concepts

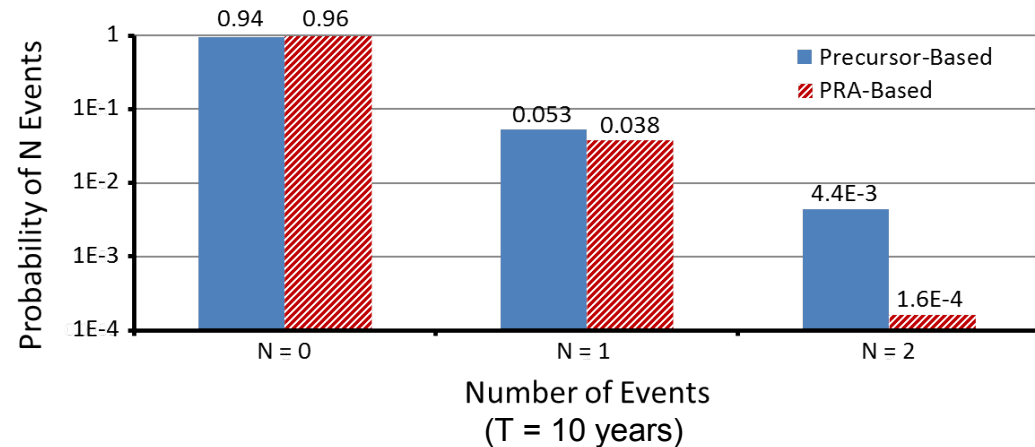
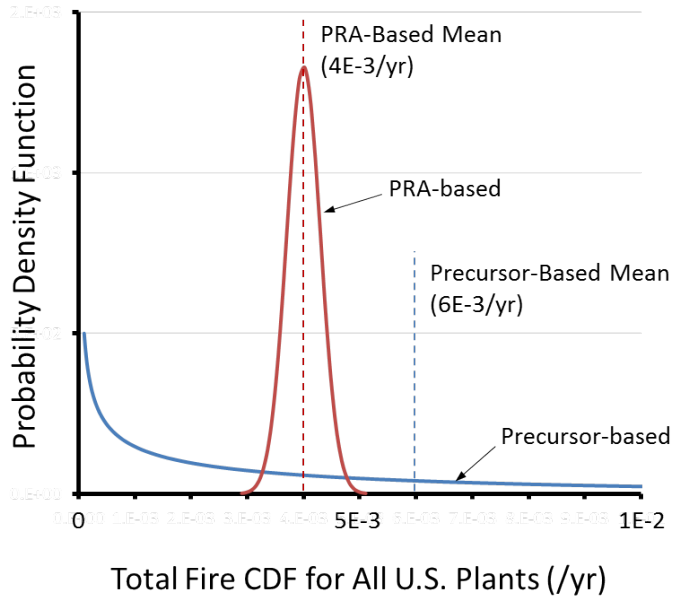
Maturity: addresses relative state of development of the technical discipline

Realism (in a PRA context): addresses degree to which an analysis represents the current state of knowledge relevant to a decision problem

Fire PRA is sufficiently mature to support major decisions

- Fire PRA has played a major role in:
 - Indian Point licensing hearings (1980s)
 - Vulnerability assessments and plant changes (IPEEEs, mid-late 1990s)
 - Transitions to risk-informed, performance-based fire protection (NFPA 805, current)
- On the other hand,
 - Fire (and other hazards) not routinely addressed in most current risk-informed applications
 - Maturity in technology ≠ maturity in application

Plant-level statistics do not support claims of conservatism

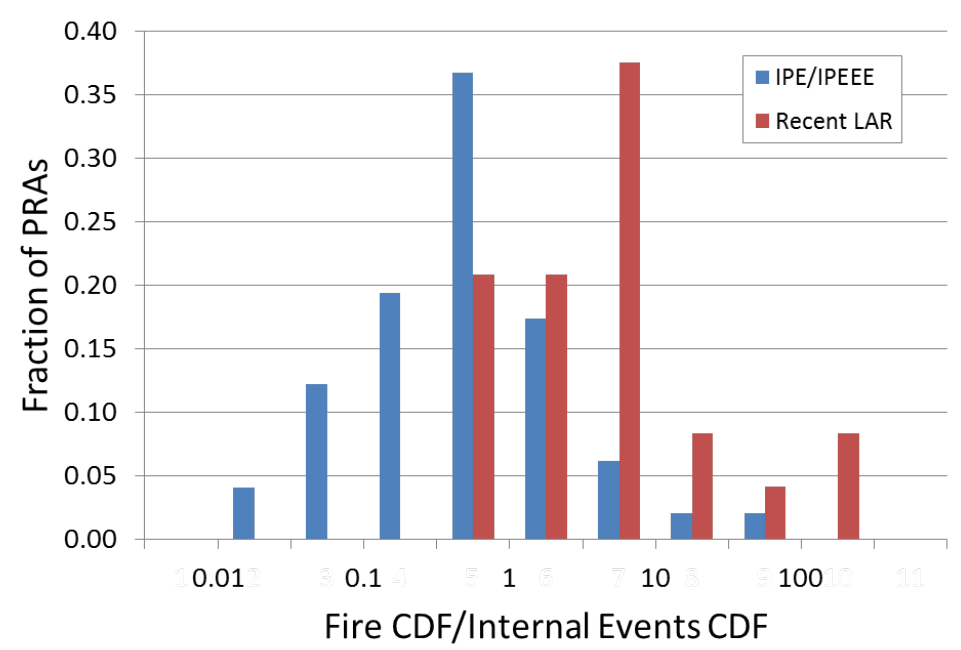
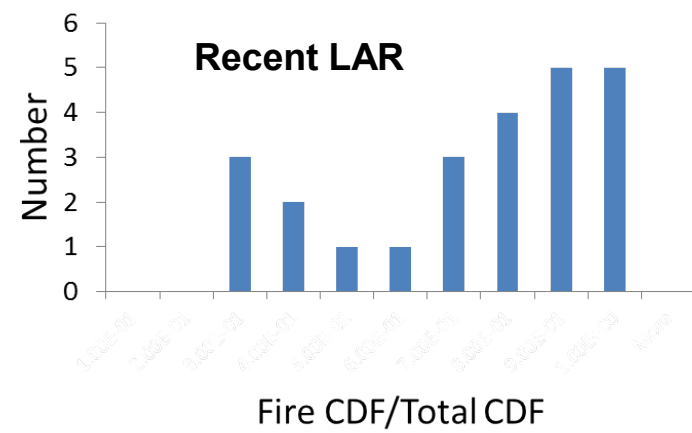
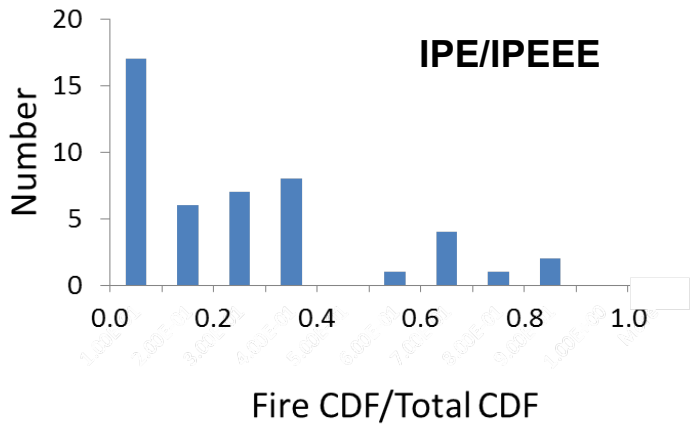


- Following and extending Gallucci (2006)
- Evidence = CCDPs from events involving fire (USNRC Accident Sequence Precursor – ASP – Program)
- Bayesian updating of constrained non-informative prior distribution
- Address US total (rather than “average plant”)

Be careful with statistical analysis

- ***Assumption of exchangeability***
- Only addresses precursors involving an initiating event (i.e., no precursors involving degraded conditions)
- Includes precursors where fire was involved but not a major factor in the actual event
- Conditional core damage probabilities (CCDPs) address a limited set of “what-ifs”
- Methods and models for assessing CCDPs have changed over time
- Results are sensitive to CCDP assigned to Browns Ferry, and very sensitive to the inclusion of Browns Ferry

Relative CDF – an indicator of conservatism?



Qualitative comparisons of actual and fire PRA scenarios look generally reasonable

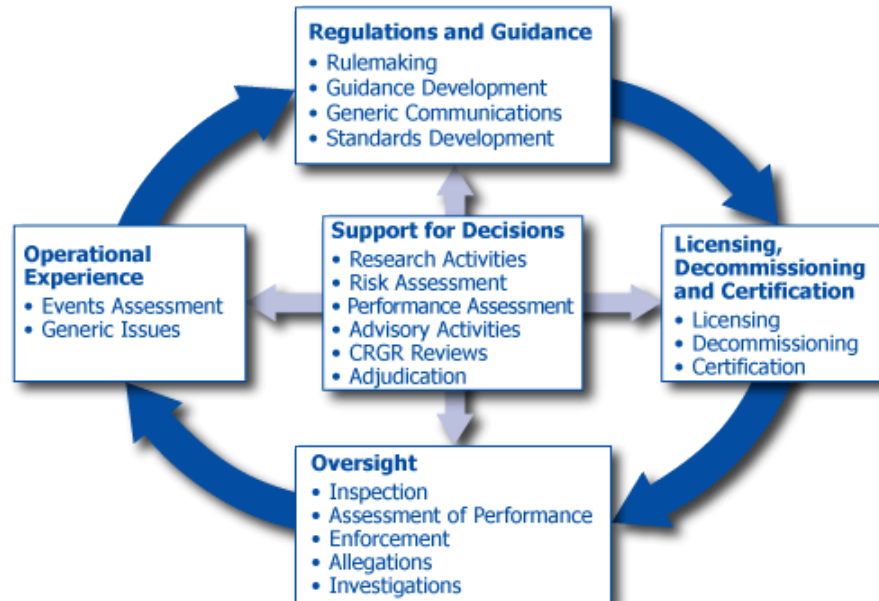
- Sample = important events
 - Accident precursors (ASP program SECY papers)
 - International events w/severe challenges to core cooling (NUREG/CR-6738)
- Important events include important fire PRA scenarios (electrical fires in key plant areas, large turbine building fires)
- Differences:
 - PRA-estimated importance of yard fires
 - Unanalyzed features of important fires: multiple fires, multiple hazards, non-proceduralized actions
- A similar analysis of events (~1700) in the EPRI Fire Events Database would be useful

Technology improvements are underway

- Technology = methods, models, tools, data
- Industry areas of concern (late 2013)
 - probability of fire-induced short circuits (“hot shorts”);
 - duration of fire-induced hot shorts in direct current (DC) circuits;
 - effectiveness of incipient detection systems
 - frequency-magnitude relationship for the heat release rates associated with actual plant fires

The application makes a difference

- 10 CFR 50.48(c) (“NFPA 805”): transition to a risk-informed, performance-based fire protection program
- Other applications



Multiple viewpoints influence the development and use of fire PRA

- Different technical disciplines with different problems and problem-solving approaches
 - PRA (initial developers)
 - Fire protection engineering (later involvement)
- Different roles
 - Licensee/applicant vs. regulator
 - Analyst vs. decision maker
- National Research Council (1994, 1996):
“...the first and probably most important step in effective risk assessment and risk management is to establish public participation that involves all the stakeholders.”

Summary Observations

- Maturity and realism are separate concepts
- Fire PRA is sufficiently mature to support major decisions
- Plant-level statistics do not support claims of conservatism (but be careful)
- Changes in relative CDF estimates indicate recent fire PRA results could be conservative
- Qualitative comparisons of actual and fire PRA scenarios look generally reasonable
- Fire PRA technology improvements are underway
- The needs of a risk-informed application can affect analysis realism
- Multiple viewpoints influence the development and use of fire PRA

What do you think?

- Does the issue of fire PRA maturity warrant additional activity beyond what's being done to improve realism?
- Have there been any recent international important, fire-related precursor events? Do these show the same characteristics as exhibited by U.S. events?
- How do the quantitative and qualitative results of international fire PRAs compare with U.S. results?
- Over the years, have there been any major changes in international perceptions regarding the key contributors to fire risk?
- Does the international PRA community have concerns regarding the realism of fire PRA? If so, do these concerns affect the use of fire PRA results in practical applications?
- What are the key outstanding technical issues in international fire PRAs? Do these need to be resolved to alter the use of fire PRA results?