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

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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

*Ongoing work

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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

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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

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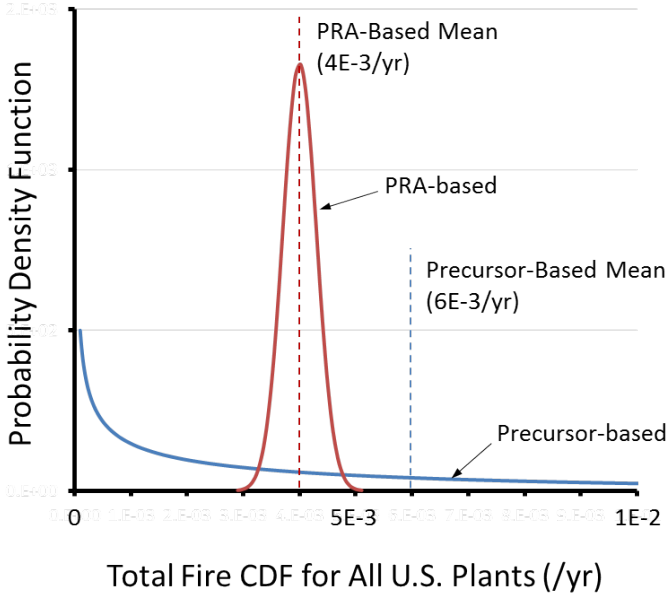
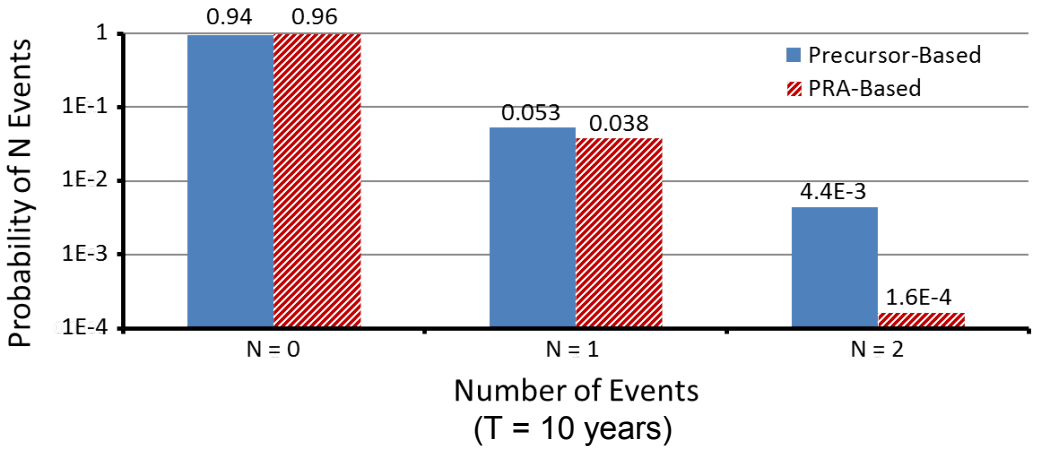
Plant-level statistics do not support claims of conservatism





- 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”)

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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

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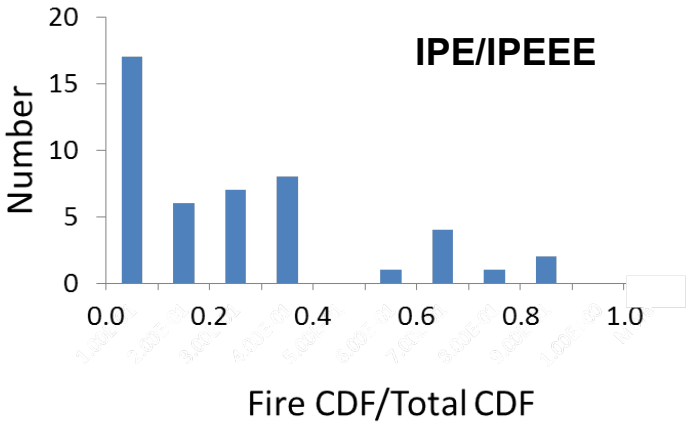
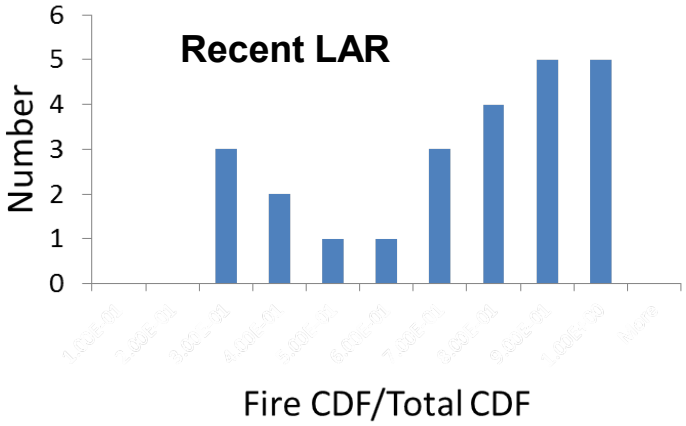
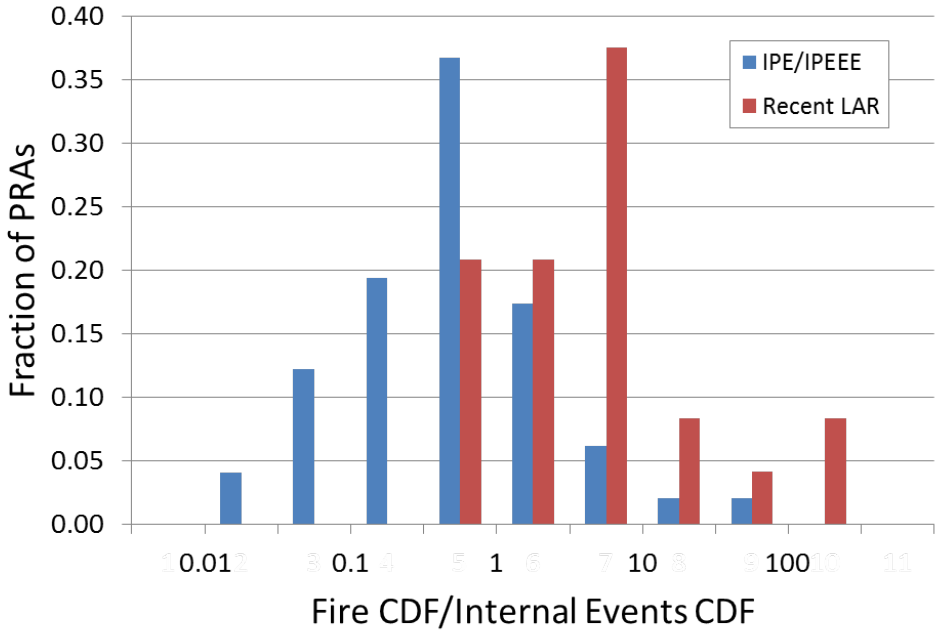
Relative CDF – an indicator of conservatism?







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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

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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

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The application makes a difference

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

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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."

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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

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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?