Using Fire Event Experience Beyond Fire Ignition Frequencies

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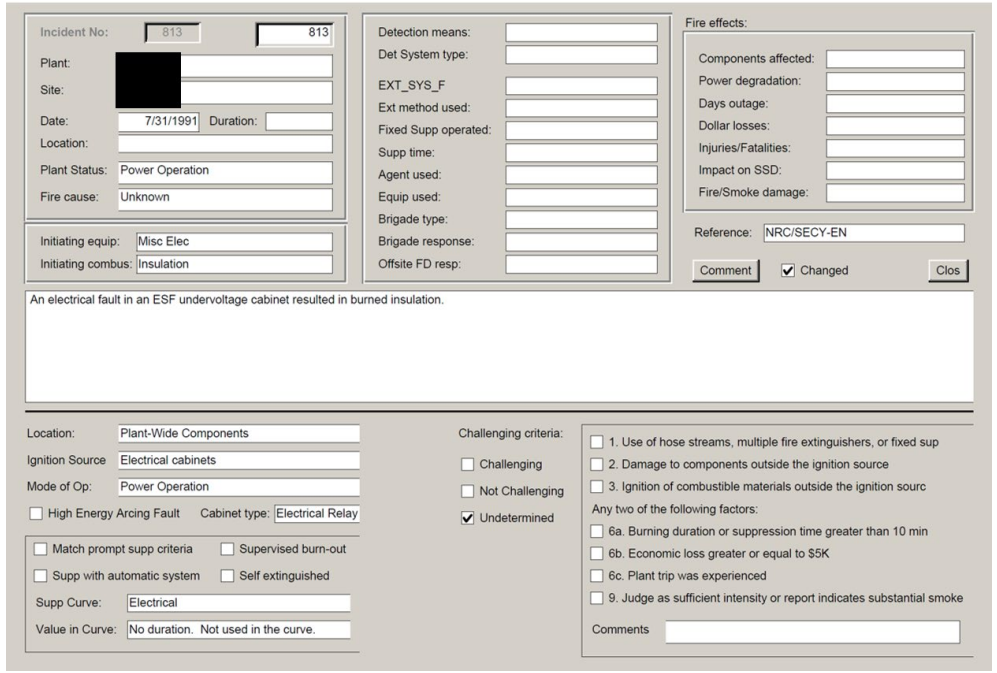
Historical Uses of Fire Event Data

- Fire ignition frequencies, *rate of ignition for a wide-range of fixed and transient sources*
  - Ignition source bin
  - Reactor years
- Manual non-suppression probabilities, *rate of personnel controlling or extinguishing the fire source*
  - Type of fire / ignition source / location
  - Time (minutes)
- Fire PRA demands many parameters, often dependent on each other to come up with meaningful risk insights
  - Operating experience has long been used for initiating frequencies
  - Deterministic and often conservative experimentation part of fire PRA data
  - Conservative fire PRA results necessitated the need to better harmonize operating experience

Database – Quality of Supporting Information

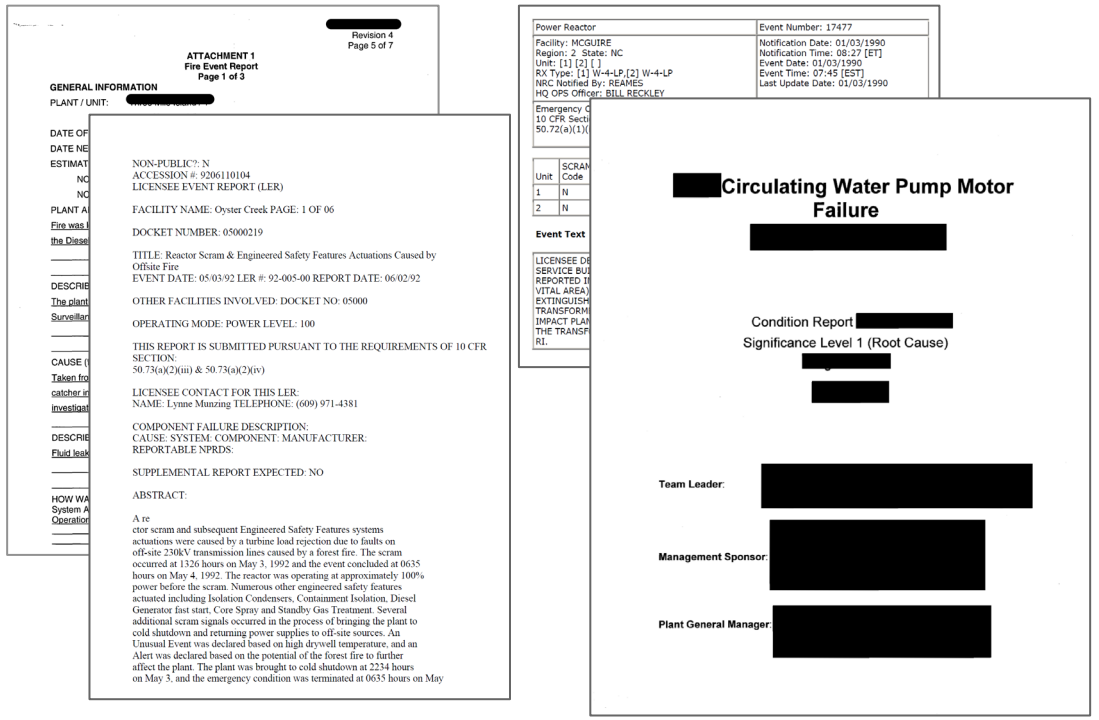
- Prior versions of EPRI Fire Events Database

Example of standard information in prior database



- Updated FEDB

Many fields plus full text supporting information



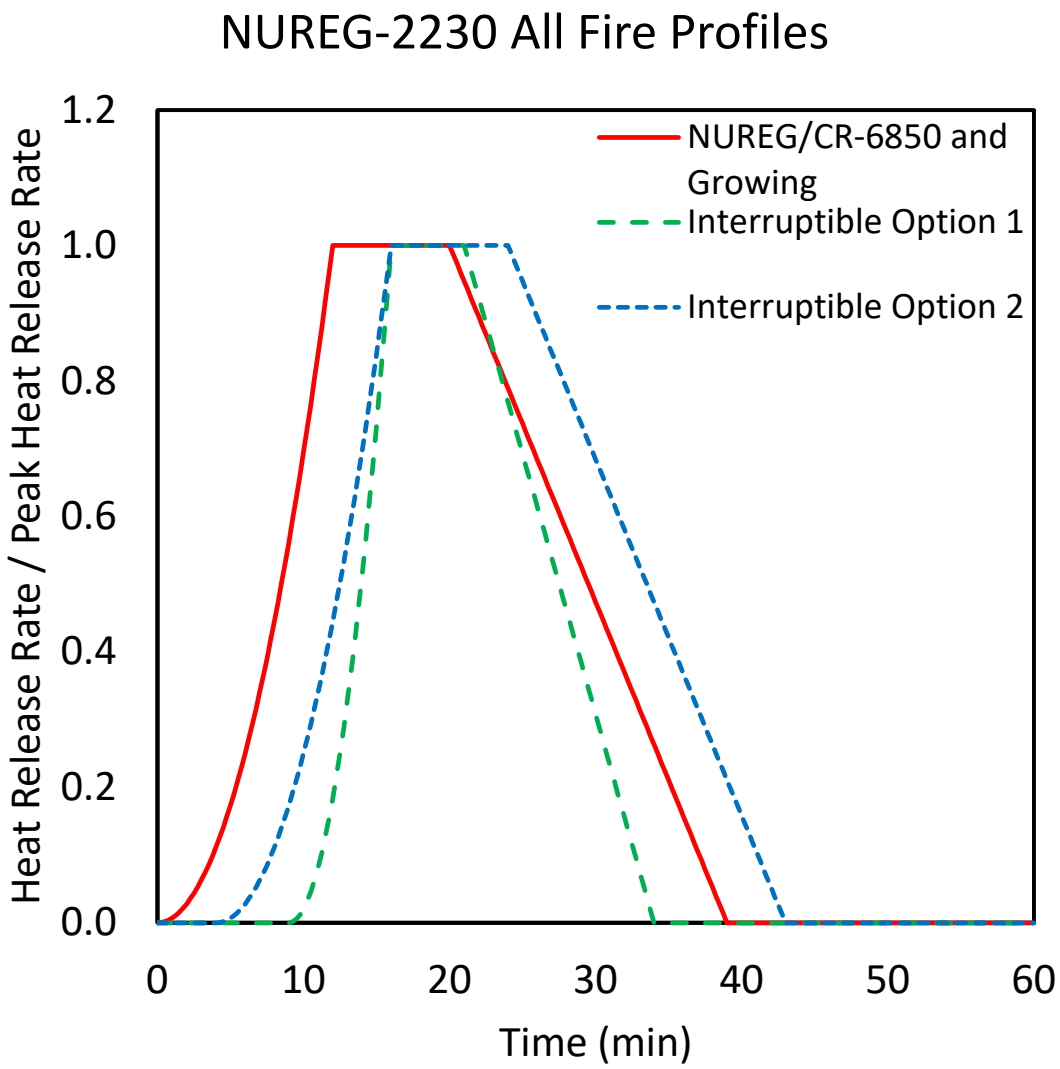
New FEDB allowed for insights and research beyond what was previously capable

Additional Uses of Industry Fire Experience Data

- Interruptible/growing electrical cabinet fires (NUREG-2230)
- Incipient detection (NUREG-2180 Supplement 1)
- Main control board model (NUREG-2178 Volume 2)
- High energy arcing faults (NUREG-2262)
- Transient fires (NUREG-2233)
- Plant trip probabilities (EPRI 3002016053)
- Oil fires (EPRI 3002020747)

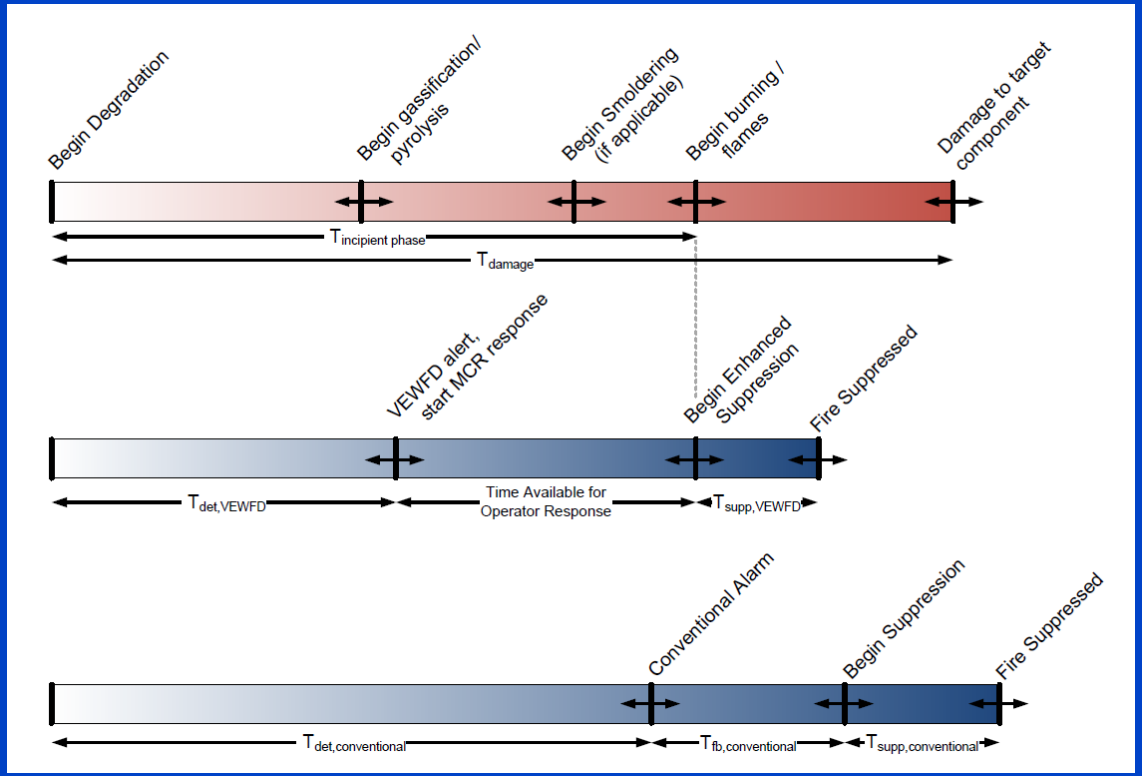
Interruptible and Growing Fires (NUREG-2230)

- **Scope:** Electrical cabinet fires (Bin 15)
- **Motivation:** Operating experience (OPEX) suggests that a majority of fires do not generate damage outside the ignition source
  - Fire PRA methods may be overestimating the growth and damage rate of electrical cabinet fires
- **Use of OE:** Reviewed fire event experience and binned experience into two categories (interruptible and growing)
- **Summary:** Two different fire growth behaviors (fast/slow) and new timing profile
  - Additional refinements for crediting plant personnel suppression were made to better match OE with fire PRA modeling approaches



Incipient Detection (NUREG-2180)

- **Scope:** Electrical cabinet fires (Bin 15)
- **Motivation:** Need to determine fraction of fires that exhibit incipient behavior and could be detected by an incipient detection system
- **How OE was used:** Reviewed electrical cabinet experience to determine type of cabinet (power versus control) and circumstances leading to fire (if it experienced detectable incipient behavior)
- **Summary:** Alpha factor used in NUREG-2180 event tree that provides analyst a split fraction for events that are likely to exhibit incipient behavior

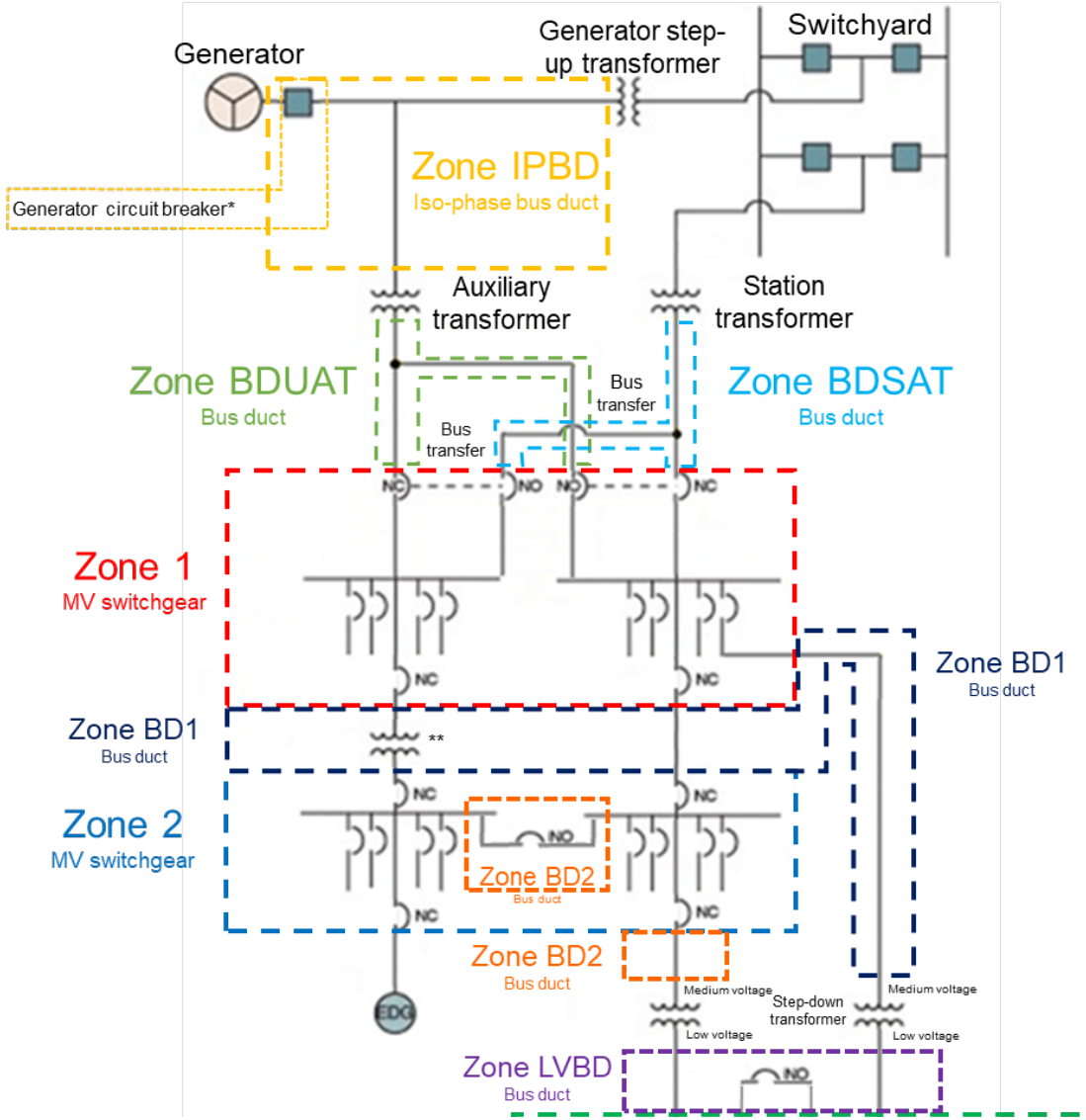


New Main Control Board Model (NUREG-2178 Vol. 2)

- **Scope:** Main Control Board
- **Motivation:** Limitations with Appendix L model and limitations on modeling fire spread within the main control board
- **How OE was used:** Used to determine fraction of main control board fires that were limited to single subcomponent
  - 7 of the 9 events (78%) describe a fire that was not a significant source of heat and the damage was isolated to the initial subcomponent
  - The remaining 2 events (22%) describe fires that caused damage beyond the initial subcomponent
- **Summary:** Fire event experience was used as an essential split fraction in the new main control board model

High-Energy Arcing Faults (NUREG-2262)

- **Scope:** HEAF-related ignition sources
- **Motivation:** Existing methodology for HEAF was simplistic and aluminum oxidation issue was discovered in testing
- **How OE used:**
  - Operating experience provided invaluable insight into the types, frequency, and attributes of events
    - Low voltage sustainability
    - Generator fed faults
  - Plant design provided input on electrical distribution system designs and crucial fault clearing time ranges
- **Summary:** New HEAF model provides realistic and practical guidance and impact on risk is plant-specific (can either result in risk increase or decrease)



Transient fires (NUREG-2233)

- **Scope:** Transient (not fixed) ignition sources
- **Motivation:** Transient HRR distribution not directly tied to NPP operational experience
- **How OE was used:** To select fuel packages and ignition methods based on transient fire experience
  - 99 fuel packages selected for testing
  - Testing results were used to develop new HRR distribution
- **Summary:** New transient HRR that reflects NPP OE and better parameters for detailed fire modeling

Full PPE bag

~ 110 to 180 kW

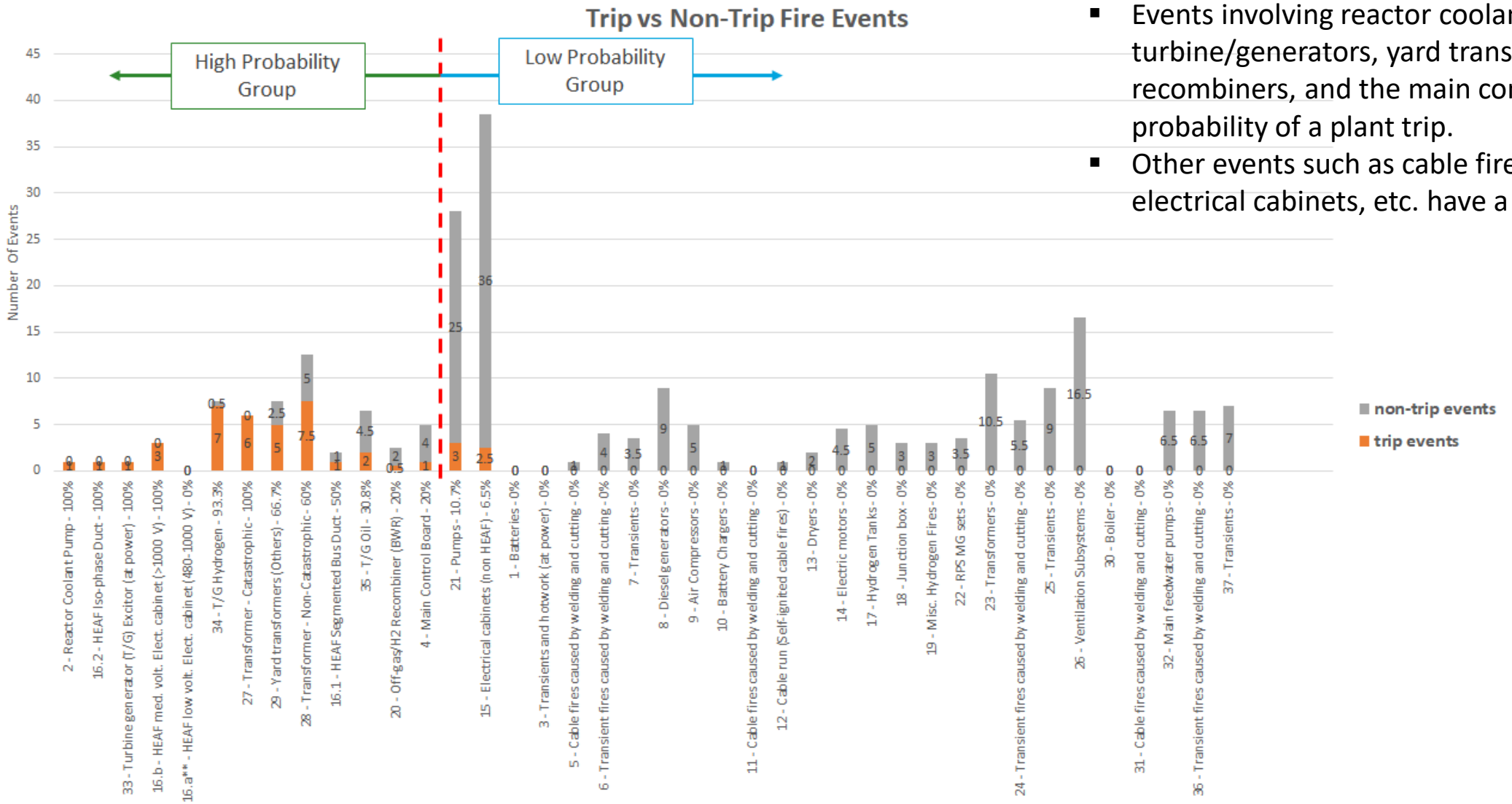
FR plastic tarp folded

~ 80 kW

Plant trip probabilities (EPRI 3002016053)

- **Scope:** All ignition sources
- **Motivation:** Not all fires result in a plant trip, yet the fire PRA assumes a plant trip
- **How OE was used:**
  - Reviewed 280 at power fire events from 1990-2009 to determine if a plant trip occurred
  - Binned ignition sources into low or high trip group based on overall trip percentage from OPEX review
    - ≥ 20% = high probability trip group
    - < 20% = low probability trip group
- **Summary:** 18% of fires resulted in a plant trip, with most trip events clustered around a handful of ignition source bins (see next slide)

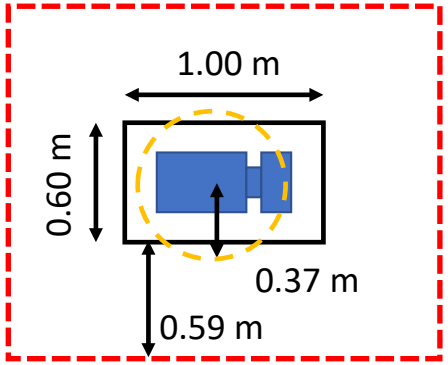
Plant trip probabilities (EPRI 3002016053)



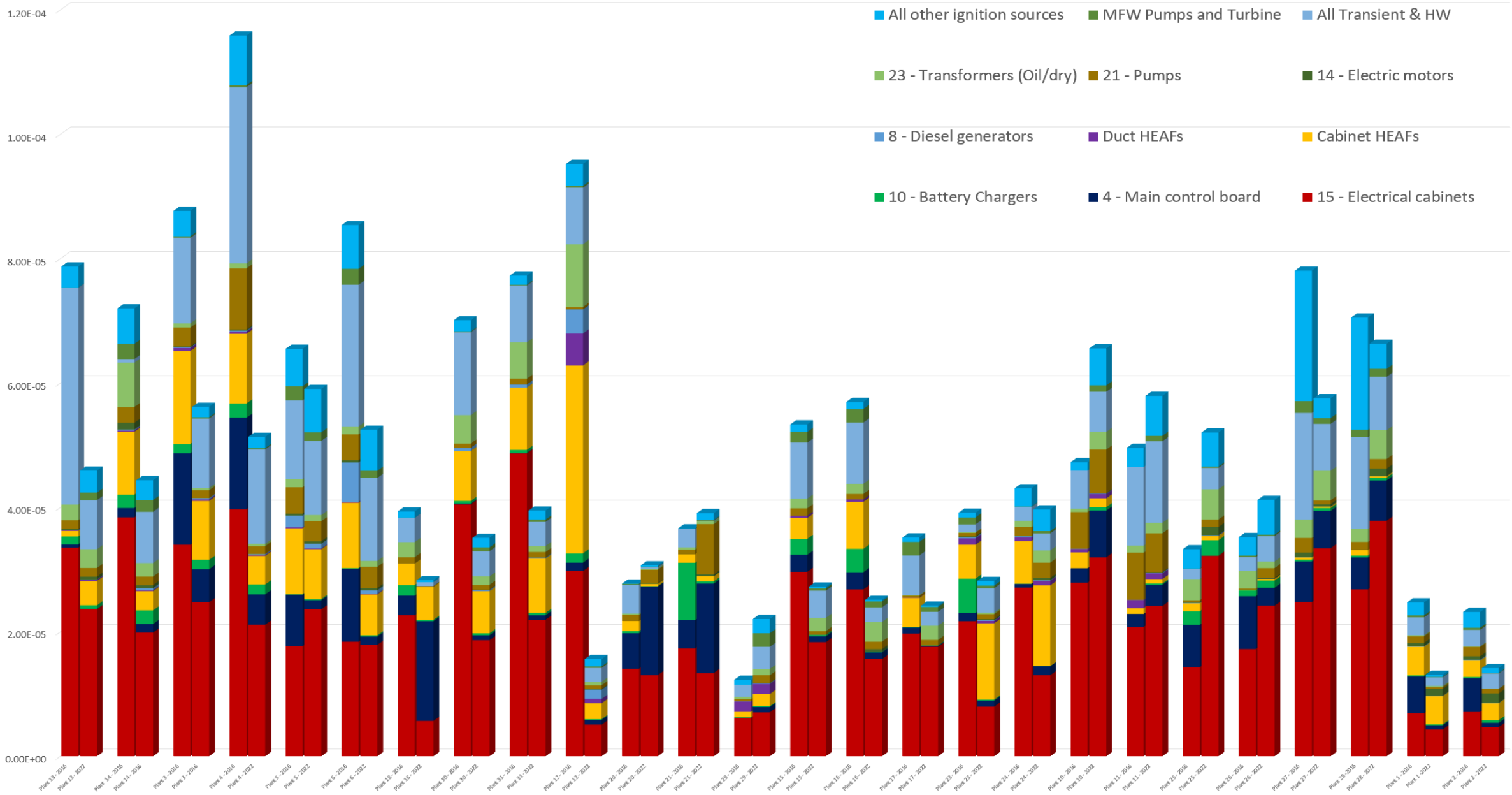
- Events involving reactor coolant pumps, HEAFs, turbine/generators, yard transformers, off-gas/H_2 recombiners, and the main control board have a high probability of a plant trip.
- Other events such as cable fires, transient fires, electrical cabinets, etc. have a low probability

Oil fires (EPRI 3002020747)

- **Scope:** Ignition sources with oil (excluding transformers)
- **Motivation:** Existing references model oil fires as large spills resulting in pool fires
  - Instantaneous spill followed by ignition would result in brief burning duration (~1 min), but average suppression time is ~11 minutes
- **How OE was used:** Reviewed ~160 oil related fire events to understand fire type and burning characteristics
- **Summary:** New bin specific oil fractions developed and found that majority of oil related events are spray fires (as opposed to pool fires)



Changes in fire risk (2016 to 2022)



Conclusions

- More recent fire PRA methods have made use of insights from reading the supporting references on fire events
- Beyond fire ignition frequencies and manual plant personnel suppression rates include:
  - Split fractions
  - Insights on fire growth and behavior
  - More detailed modeling approaches (e.g., event trees) where risk-significant requires additional detail / realism
  - Inform testing programs
  - Inform methods on plant configurations
- Updated FEDB allows us to examine and obtain details in a completely new and different way
  - Eliminate conservatism and methods closer to realism

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