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HIGH WIND PRA KEY INSIGHTS AND UNCERTAINTIES

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September 26, 2017

INTRODUCTION

- The three major elements of a High Winds PRA (HWPRA) are:
  - The wind hazard analysis
  - The fragility analysis of the plant SSCs
  - The PRA model, which incorporates the wind hazard and fragility analyses
- Recently there has been significant developments in relation to high wind probabilistic risk assessments (PRAs)
- Several Nuclear Power Plants have built and successfully peer reviewed state of the art high wind PRAs
- In each of these high wind PRAs the risks associated with straight winds, tornadoes, and hurricanes were evaluated
- This presentation describes several assumptions and uncertainties based on recent High Wind PRAs

INTRODUCTION

- A key assumption is one that is made in response to a key source of model uncertainty in the knowledge that a different reasonable alternative assumption would produce different results, or an assumption that results in an approximation made for modeling convenience in the knowledge that a more detailed model would produce different results.
- A key source of uncertainty is one that is related to an issue in which there is no consensus approach or model and where the choice of approach or model is known to have an impact on the risk profile (e.g., total CDF and total LERF, the set of initiating events and accident sequences that contribute most to CDF and to LERF) such that it influences a decision being made using the PRA.

KEY ASSUMPTIONS AND UNCERTAINTIES

- The following assumptions/uncertainties are generally utilized during High Wind PRA Hazard development:
  - The site data generally doesn't include peak gust measurements for wind. Without peak gust data at the site other data near the site must be utilized.
  - Tornado reporting including the count and magnitude/wind speed of tornadoes is believed to be under-reported especially in earlier years.
  - Use of the entire plant safety envelope to define tornado strike which is conservative versus other assumptions such as the NUREG/CR-4461 definition of tornado strike (based on 200 ft x 200 ft building).
  - The association of wind speed with tornado intensity is considered one of the largest uncertainties in tornado hazard analysis.
  - Tornado frequencies for F5 tornadoes are extrapolated when the plant area has not experienced this level of tornado.
  - Extrapolation of straight wind hazards to very low exceedance probabilities.

KEY ASSUMPTIONS AND UNCERTAINTIES

- The following assumptions/uncertainties are generally utilized during the High Wind PRA fragility development:
  - SSCs behind vulnerable openings in Class I structures are included in the wind missile analysis and assumed to fail if a missile impacts the opening. This is conservative as the missile perforating the opening may not actually fail the SSC.
  - Rain is assumed to fail equipment inside of a building if the wall or roof cladding is failed.
  - SSCs located inside a building are assumed to fail if the building is failed. This is conservative since failure of the building may not always result in failure of all of the equipment inside.
  - Components are assumed to fail based on simplified damage criteria for SSCs.
  - Due to CAFTAs limitation of dealing with the point estimate the number of fragility calculation points for quantification can have a significant impact. Having a limited number of intervals can be significantly conservative.
  - Missile inventory counts over various time periods such as outages including missiles generated from building failures.
  - Missile trajectory and velocity when impacting SSCs.
  - Limitations of code based fragility analysis.

KEY ASSUMPTIONS AND UNCERTAINTIES

- Depending on the plant and its vulnerabilities these high wind PRA fragility assumptions/uncertainties can have a significant impact on the CDF and LERF.
  - As an example, the table below estimated high wind CDF for a plant with SSCs vulnerable to rain intrusion, which uses a code based fragility approach (Rain is assumed to fail equipment inside the building if the wall or roof cladding is failed), versus an explicit structural and rain modeling approach for the same SSCs

Code based CDF	Explicit High Wind Modeling CDF	Percent Decrease
7.26E-05	1.78E-05	75.5%

- As seen the more refined modeling provided a significant decrease in CDF

KEY ASSUMPTIONS AND UNCERTAINTIES

- Another example is shown in in the table below which compares a single fragility with area modeling versus refined missile modeling including an SSC damage impact assessment.

SSC Area Modeling for single component (CDF)	Detailed Missile Modeling for single component (CDF)	Percent Decrease
1.97E-05	1.78E-05	9.6%

- As seen the more refined modeling provided a significant decrease in CDF.

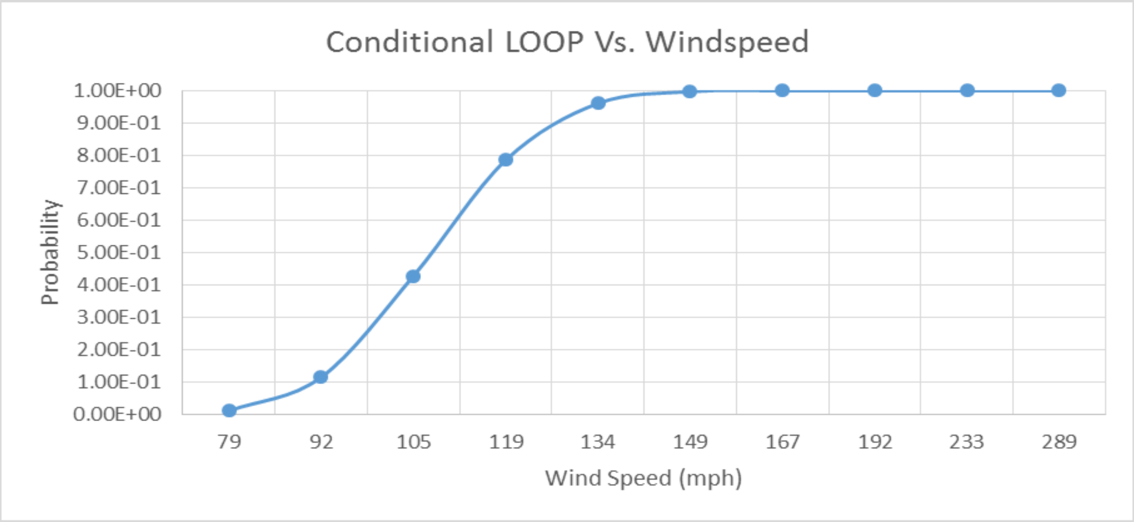
KEY ASSUMPTIONS AND UNCERTAINTIES

- There are a number of uncertainties that can have a significant impact on the HWPRA results. The table below shows the summary of estimated maximum failure frequency calculation errors for a few examples.

Item	Number	Error	Comment
1. No. of Windspeed Hazard Intervals	5	~ 100%	Variable spacing is suggested.
	10	~ 35%	
	15	~ 10%	
2. Windspeed Range		negative	Always produces underestimation error. Range from 50 to 300+ mph is suggested.
3. Modeling Separate Wind Hazards vs Combined Wind Hazard		< 10%	Does not include errors from CAFTA approximations.
4. Use of Derived Mean vs Integration of Family		<15%	Generally overestmation error based on 4 SSC fragilities analyzed herein. Could be negative, however.
5. Negatively Correlated Failure Modes	10	-34.9%	Maximum Theoretical Error
	100	-36.6%	
	1000	-36.8%	
6. Positively Correlated Failure Modes	10	900%	Maximum Theoretical Error
	100	9900%	
	1000	99900%	

KEY ASSUMPTIONS AND UNCERTAINTIES

- The figure below gives a representation of the conditional LOOP probability versus the wind speed.
  - Given the results in the figure below, assumptions made regarding offsite power in the low wind speed range can impact the results.
  - Not crediting recovery of offsite power can have a significant impact on the high wind PRA results



LESSONS LEARNED

- Several lessons learned during the performance of High Wind PRAs can be used to optimize the completion of additional High Wind PRAs.
  - The high wind equipment list should be detailed enough to provide the SSC, location, and relevant PRA failure modes in a context that the fragility analysts can understand
  - Fully understanding the estimated impact of the assumptions/uncertainties utilized in high wind PRA models can facilitate the correct decisions are made when building the high wind PRA model.

QUESTIONS?

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