Rulemaking (R.) 20-07-013: Phase 4
Workshop #2: November 20, 2024

Overall Residual Risk, Risk Tolerance and Simple Optimization

California Public
Utilities Commission

Carbon Monoxide Safety

- “more than 150 people in the United States die every year from accidental nonfire-related carbon monoxide poisoning” (CPSC)
- Install and ensure good maintenance of carbon monoxide detectors at home.
- Ensure proper ventilation of fuel-powered appliances.
- Understand symptoms of CO poisoning.

Workshop #2 Agenda: Nov. 20th

Introductions	10:00 – 10:10 am
Opening Remarks: Commissioner Reynolds	10:10 – 10:15 am
Overall Residual Risk: SPD Presentation	10:15 – 10:25 am
Overall Residual Risk Discussion	10:25 – 10:35 am
Risk Tolerance (Probability Distributions): SPD Presentation	10:35 – 10:55 am
Risk Tolerance (Probability Distributions) Discussion	10:55 – 11:15 am
Break	11:15 – 11:25 am

Workshop #2 Agenda (Cont.)

Risk Tolerance (Tail Average Risk): SPD Presentation	11:25 – 11:35 am
Risk Tolerance (Tail Average Risk) Discussion	11:35 – 12:00 pm
General Discussion	12:00 – 12:30 pm
Lunch	12:30 pm
Risk Tolerance (Cont.) and Simple Optimization	November 21
Simple Optimization (Cont.) and General Discussion	November 22

Review of Phase 4 Timeline

Phase 4 Timeline

Definition of Scoped Work	Overall Residual Risk, Risk Tolerance and Simple Optimization	RMAR	Proposed Decision
Oct. 30th	Nov. 20th	Dec. 18th	Spring 2024

PURPOSE & EXPECTED OUTCOMES OF THE WORKSHOP

Purpose & Outcomes for Workshop #2

- Overall Residual Risk (Nov. 20th)
- Risk Tolerance (Nov 20th & 21st)
  - Probability Distributions
  - Average and Tail Risk
  - Risk Tolerance Working Group
- Simple Optimization (Nov 21st & 22nd)
  - Mitigation Portfolios
- Provide feedback on whether the Commission should provide guidance regarding:
  - The integration of overall residual risk into the RDF
  - Requiring the utilities to make risk tolerance explicit in RAMP and GRC filings
  - Requiring the presentation of optimal portfolios in RAMP or GRC filings

Staff Proposal for Overall Residual Risk, Risk Tolerance and Simple Optimization

Presenter: SPD Staff

Overall Residual Risk, Risk Tolerance and Simple Optimization

Safety Policy Division Staff

November 20, 21 & 22 2024

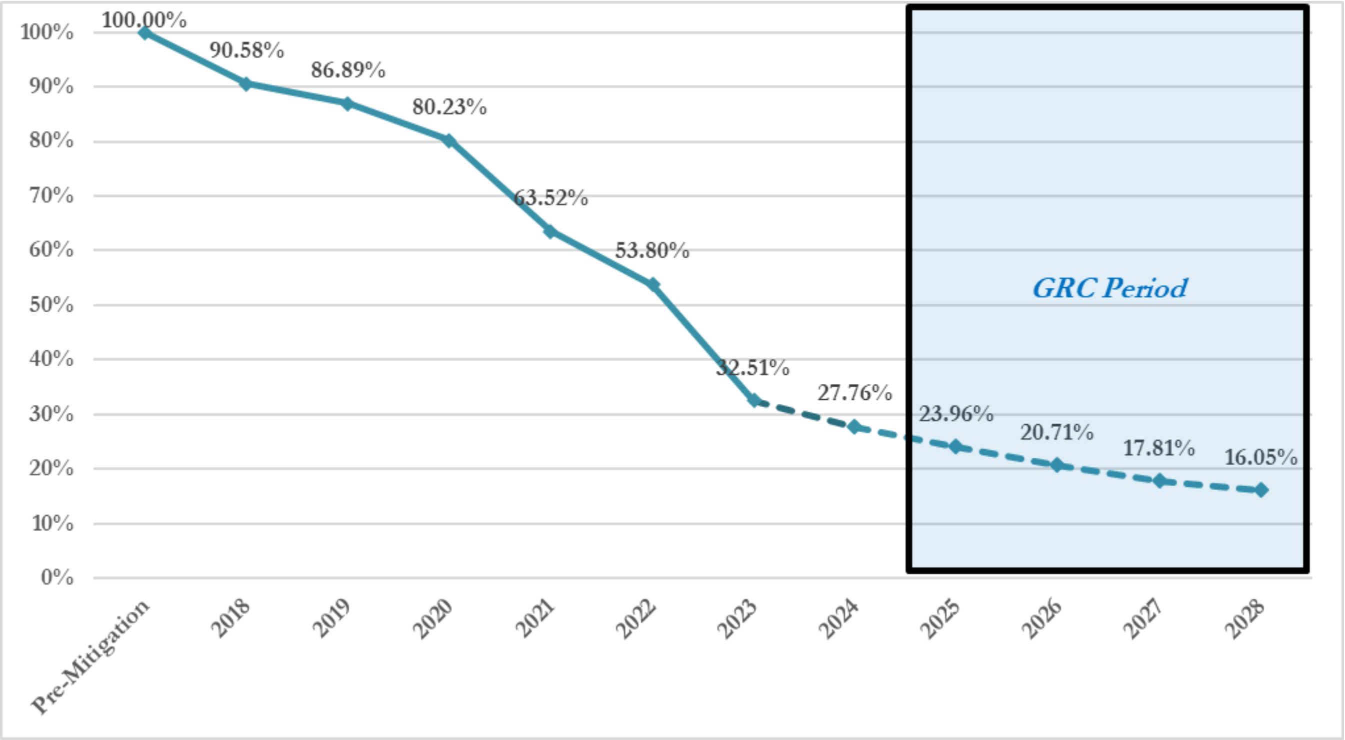
California Public Utilities Commission

Overall Residual Risk

November 20 2024

Overall Residual Risk

- Risk remaining after implementing the mitigation programs authorized by a GRC decision would be the <u>residual risk</u> only within the scope of that GRC application.
- Overall residual risk would include all of the risk on the utility's assets or systems after taking account of the historical progress of risk reduction for every GRC cycle to date.
- IOUs must report overall residual risk for decision-makers to evaluate a utility's progress towards a risk tolerance standard.



SCE Wildfire Risk Remaining After Grid Hardening and Fast Curve Settings (2018-2028)
A.23-05-010, TURN-12-E Clean at 21

Overall Residual Risk: Changes to the RDF

- Overall Residual Risk: all of the risk on the utility's assets or systems after taking account of the historical progress of risk reduction for every GRC cycle to date.
- Residual Risk: Risk remaining after application of Mitigations, including Mitigations classified as Controls for a given GRC cycle.

9.	Risk Assessment	The output of Step 2A, along with the input from stakeholders described in Row 12 below, will be used to decide which risks will be addressed in the RAMP. The output of Step 2A must include a calculation of Overall Residual Risk, along with a diagram and supporting workpapers demonstrating the change of Overall Residual Risk since the utility's first RAMP filing.

Clarifying Questions?

Discussion Question

- How does requiring the utilities to present diagrams and workpapers of overall residual risk help decision-makers and stakeholders determine if the utility's mitigation proposals in the RAMP and GRC reduce risk to levels that are tolerable for Californians?
- Should the Commission add the definition of overall residual risk to the RDF? Explain your answer.
  - What amendments, if any, would you make to the language changes recommended by the Staff Proposal?

Risk Tolerance

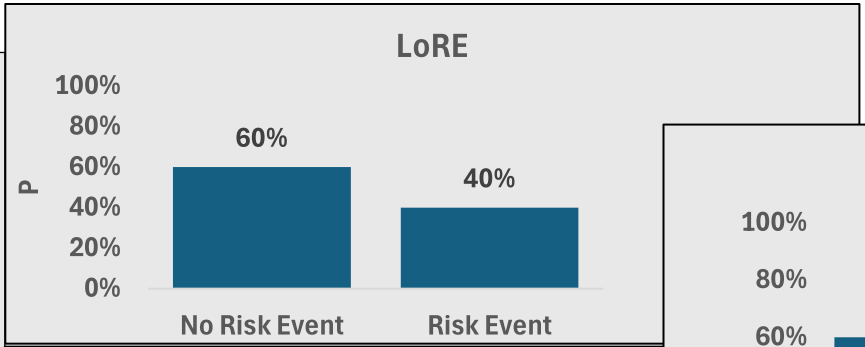
November 20-21 2024

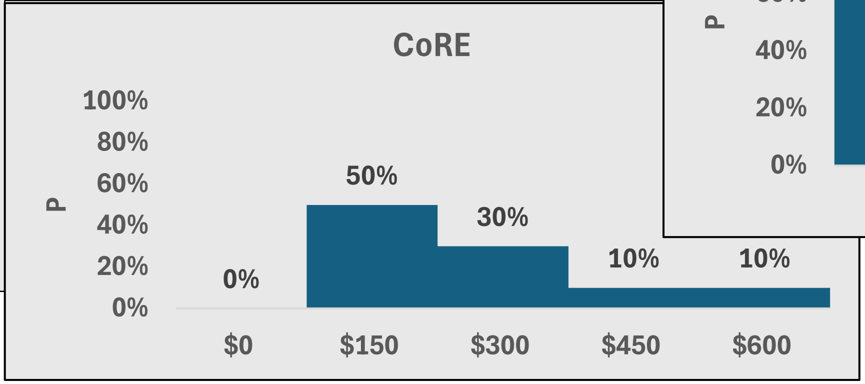
Probability Distributions

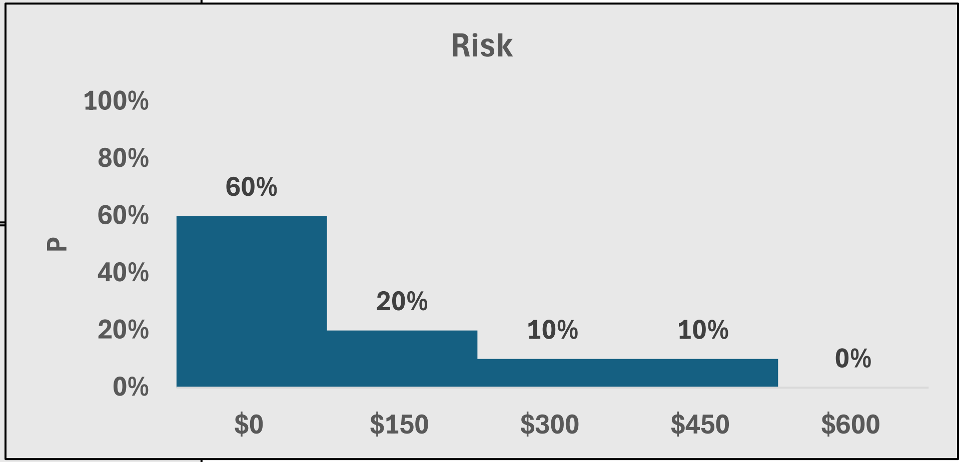
- Moving away from single number risk scores
  - The Flaw of Averages
    - Systematic errors from collapsing complex models into single numbers
  - The Flaw of Extremes
    - Aggregating the tail of a probability distribution into a single number can result in substantial over-investment
  - Likelihood of Simultaneous Failure
    - Impossible to evaluate interrelated risks if a single number is used
- Using probability distributions ensures proper results
  - Can still calculate single number representations of risk
    - Including average, the median, or any percentile of tail risk

Arithmetic of Uncertainty: A High-Level Example

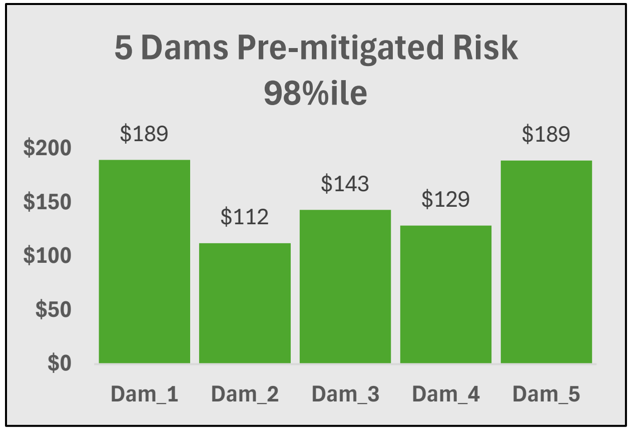
	LoRE	CoRE	Risk
Trial 1	0	$100	$0
Trial 2	**1**	**$200**	**$200**
Trial 3	0	$50	$0
Trial 4	**1**	**$350**	**$350**
Trial 5	0	$500	$0
Trial 6	0	$300	$0
Trial 7	0	$25	$0
Trial 8	**1**	**$150**	**$150**
Trial 9	**1**	**$100**	**$100**
Trial 10	0	$225	$0
Average	**40%**	**$200**	**$80**
90%ile		**$365**	**$215**





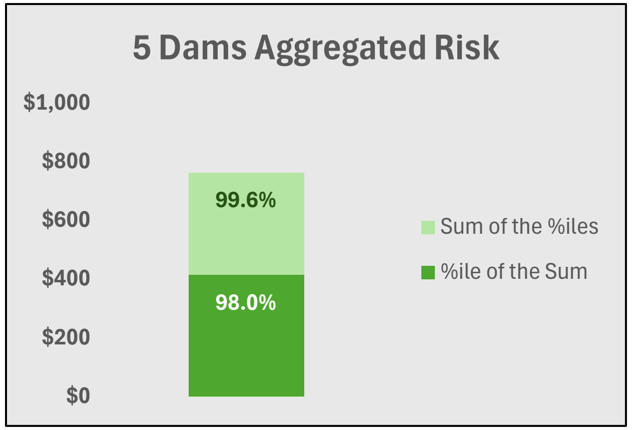


Flaw of Extremes:
Hypothetical Dam Safety Example



- Five independent dams
- Explore 98th percentile of risk at each dam
- Equivalent to a 1-in-50 year event

	Risk	Actual %ile	Frequency
Sum of 98%ile (a)	$762.37	99.6%	1 in 250 years
98 %ile of Sum (b)	$413.02	98.0%	1 in 50 years



- Light green bar: adds up the 98th percentile risk level for each dam
- Dark green bar: adds up the probability distributions of each dam and then takes the 98th percentile

- Approach (a) actually occurs once every 250 years
  - 99.6%tile
- Approach (a) results in a risk level that is overstated by 85%

Probability Distributions: Changes to the RDF

- Consequence (or Impact): the effect of the occurrence of a Risk Event. Consequences affect Attributes of a Cost-Benefit Approach and can be presented in the natural units of the attribute or monetized. Consequence is represented as a probability distribution.
- Likelihood or Probability: the chance that an event will occur, quantified as a number between 0% and 100% (where 0% indicates impossibility and 100% indicates certainty). The higher the Probability of an event, the more certain we are that the event will occur. Likelihood of an event will be represented in simulation models as a distribution of zeros and ones whose average is the chance that the event will occur.
- Probability Distribution: the range and chance that a set of outcomes occurs, as used within datasets and model results.
- Risk: The potential for the occurrence of an event that would be desirable to avoid, ~~often~~ expressed in terms of a combination of various Outcomes of an adverse event and their associated Probabilities. Risk is the product of LoRE and CoRE and represented as a probability distribution.

Probability Distributions: Changes to the RDF

10.	Identification of Potential Consequences of Risk Event	The identified potential Consequences of a Risk Event should reflect the unique characteristics of the utility and will be represented as a probability distribution. … For each enterprise risk, the utility must explain how they derived the probability distribution for Consequence of a Risk Event.

11.	Identification of the ~~Frequency~~ Likelihood of the Risk Event	The identified ~~Frequency~~ Likelihood of a Risk Event should reflect the unique characteristics of the utility and will be represented in simulation models as a distribution of zeros and ones. Likelihood of a Risk Event is the average of the distribution of the ones and zeroes. Frequency is the number of risk events over a defined period based on likelihood and can be presented for readability. … For each enterprise risk, the utility must explain how they derived the probability distribution for Likelihood of a Risk Event.

Probability Distributions: Changes to the RDF

13.	Calculation of Risk	For purposes of the Step 3 analysis for each enterprise risk assessed in the RAMP, pre- and post-mitigation risk will be calculated by multiplying the probability distribution representing Likelihood of a Risk Event (LoRE) by the probability distribution of Consequences of a Risk Event (CoRE) and be represented as a probability distribution. The CoRE is the sum of each of the ~~Risk-Adjusted~~ Attribute Values probability distributions monetized using the utility's full Cost-Benefit Approach.

Clarifying Questions?

Discussion Question

- Should the Commission require the utilities to use probability distributions for identifying and presenting the Consequence of a Risk Event (CoRE)?

- Should the Commission require the utilities to use probability distributions for identifying and presenting the Likelihood of a Risk Event (LoRE)?

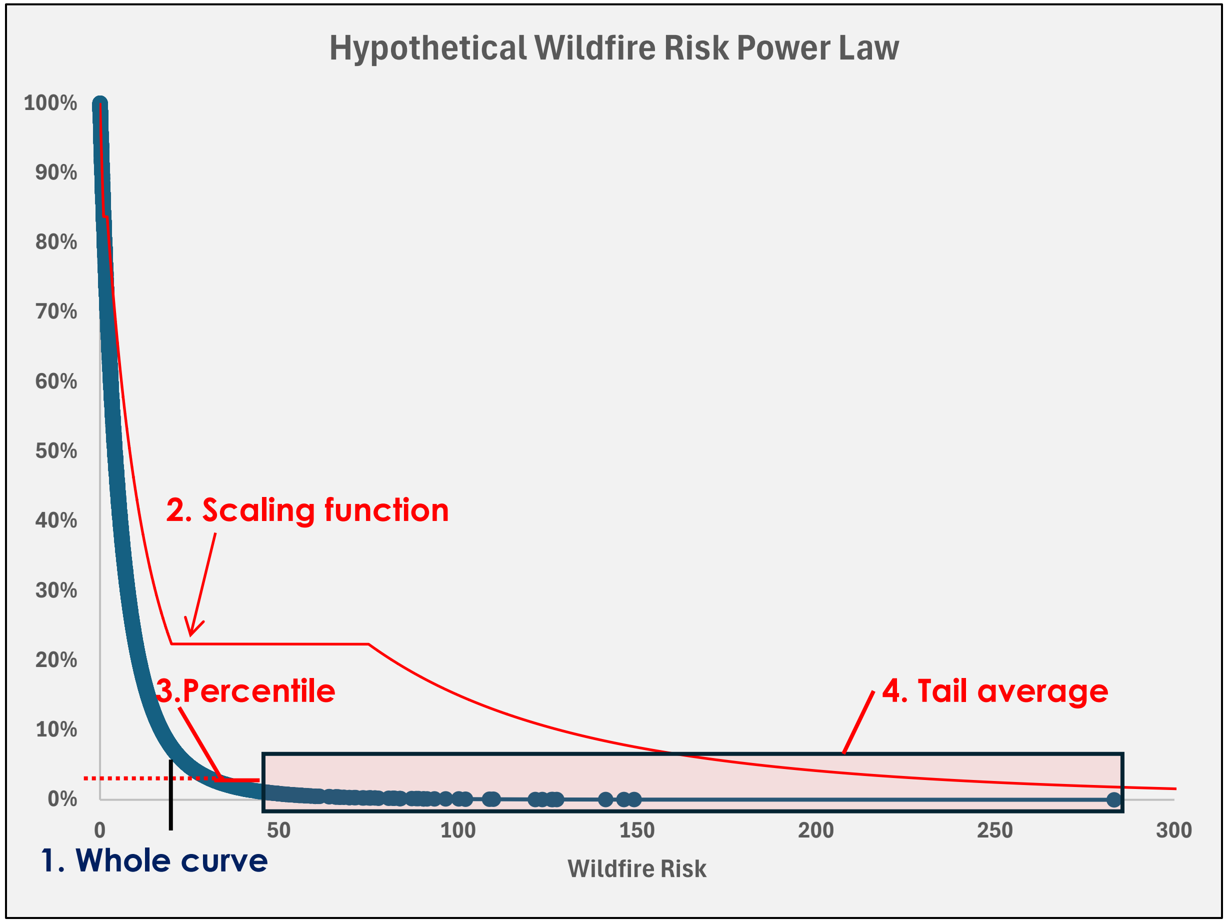
- Should the Commission require the utilities to use probability distributions to calculate and present pre- and post-mitigated risk?

Break

11:15 – 11:25 am

Average Risk and Tail Average Risk

1. Whole Curve: same as using an infinite number of percentiles
2. Scaling function: shifts the curve to the right, increasing perceived risk
3. Percentile: A single value at a point on the curve
4. Tail average: all values above a chosen percentile are averaged



Average Risk and Tail Average Risk

1. The average includes the tail but does not adequately represent it.
2. The scaled average functions like the percentile approach, without exact percentile specified (i.e. 98.5 %tile).
3. Percentile may be the most stable measure of the tail but ignores risks above chosen percentile
4. Tail average captures the entire tail above the selected percentile and is stable if the number of data points changes

Wildfire Risk	
1. Average of entire risk curve	$7
2. Scaled Average	$41
3. 99th percentile	$50
4. Tail average above 99th percentile	$70

Tail Average Risk: Changes to the RDF

- Expected Value: the sum of all values in the probability distribution divided by the count of values in the probability distribution. Expected Value can be calculated for LoRE, Attributes of CoRE, and Risk.
- Tail Average: the sum of all the values in the probability distribution above a specified percentile divided by the count of values within that same specified percentile of the probability distribution. For example, Tail Average at the 95th percentile is the sum of all values above the 95th percentile in the probability distribution divided by the count of values above the 95th percentile in the probability distribution. Tail average can be calculated for Attributes of CoRE and Risk.
- Tail Risk: a measure of low probability, high consequence occurrences, which are represented in the extremities of the probability distribution, known as the tail. The tail is typically defined as the values above a specified percentile, such as the 95th percentile. Tail risk can be evaluated for Attributes of CoRE and Risk.

Tail Average Risk: Changes to the RDF

5.	Cost-Benefit Approach Principle 4 – Risk Assessment	~~When~~ Attribute Levels that result from the occurrence of a Risk Event are uncertain.~~, assess the uncertainty in the Attribute Levels by using expected value or percentiles, or by specifying well-defined probability distributions, from which expected values and tail values can be determined.~~ This uncertainty must be represented as a probability distribution and must be described by using the Expected Value of the probability distribution and can also be described using the tail average above a specified percentile of the distribution if the utility so desires. Monte Carlo simulations, other simulations (including calibrated subject expertise modeling), and output from machine learning models, among other tools, may be used to satisfy this principle.

Clarifying Questions?

Discussion Question

- Should the Commission require the utility to describe the uncertainty within a model of a risk event as the expected value of the probability distribution?
- Should the Commission allow the utility to describe the uncertainty within a model of a risk event as the tail average risk of the probability distribution?
- Are there any other ways that the utility should be allowed to describe the uncertainty within a model of a risk event?
- What are the benefits and costs of allowing the utility to describe the uncertainty within a model of a risk event using more than one calculation?

General Discussion

12:00 pm – 12:30 pm

Rulemaking (R.) 20-07-013: Phase 4 Workshop #2: November 21, 2024

Overall Residual Risk, Risk Tolerance and Simple Optimization

California Public Utilities Commission

Workshop #2 Agenda: Nov. 21st

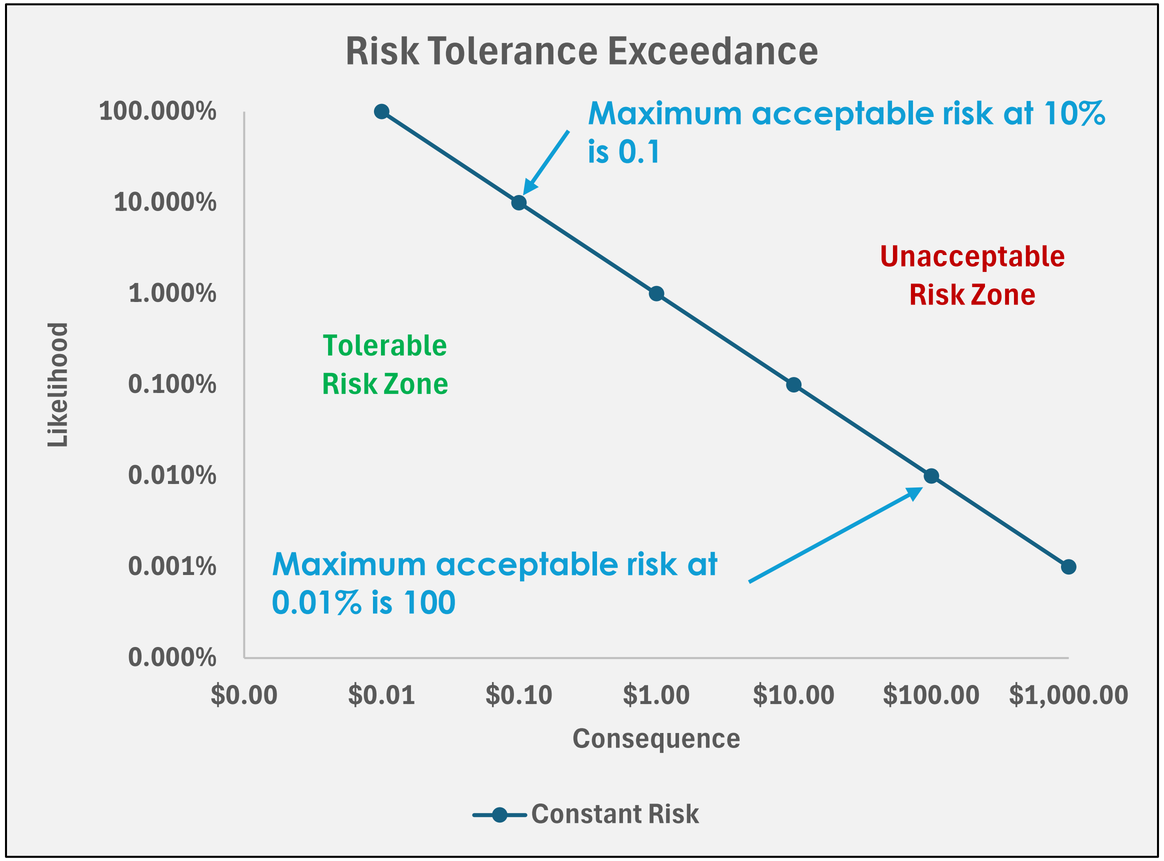
Introduction	10:00 – 10:10 am
Risk Tolerance (Exceedance Curves): SPD Presentation	10:10 – 10:35 am
Risk Tolerance (Exceedance Curves) Discussion	10:35 – 11:15 am
Break	11:15 – 11:25 am
Simple Optimization (Portfolios): SPD Presentation	11:25 – 11:40 am
Simple Optimization (Portfolios) Discussion	11:40 – 12:00 pm
General Discussion	12:00 – 12:30 pm
Lunch	12:30 pm
Simple Optimization (Cont.) and General Discussion	November 22nd

Risk Tolerance (Cont.)

November 21 2024

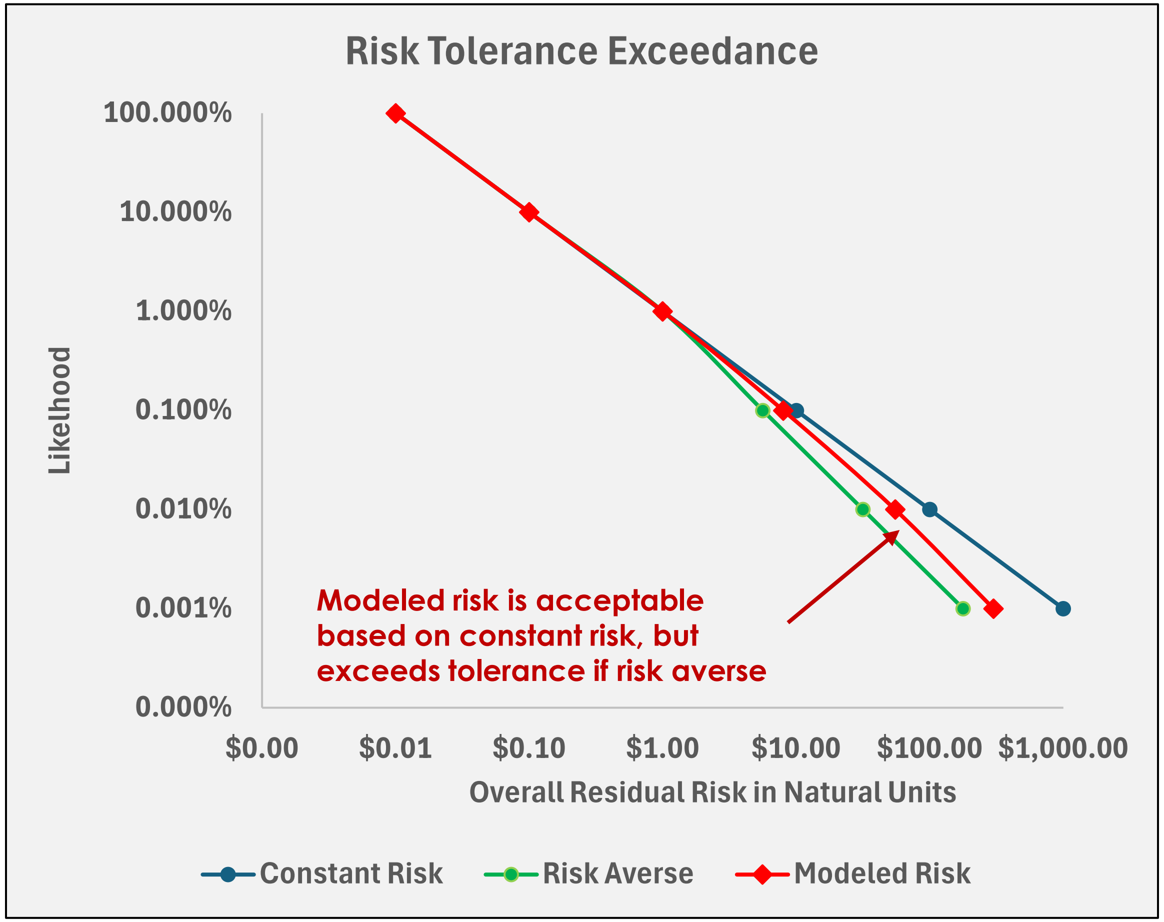
Conceptualizing Risk Tolerance

- Risk tolerance can be visualized with exceedance curves
  - Each point on the curve depicts the maximum level of acceptable risk for the associated probability
- Constant Risk Exceedance Curve
  - Each point on the curve represents the same risk ($0.01)



Risk Scaling and Risk Tolerance

- Risk scaling: a risk-averse function is multiplied against a risk-neutral curve (shift to the right)
  - Risk-averse scaling curve is convex
- Risk tolerance: the constant risk curve is divided by a risk-averse function
  - Risk-averse exceedance curve is concave



Cost-Benefit Analysis and Risk Tolerance

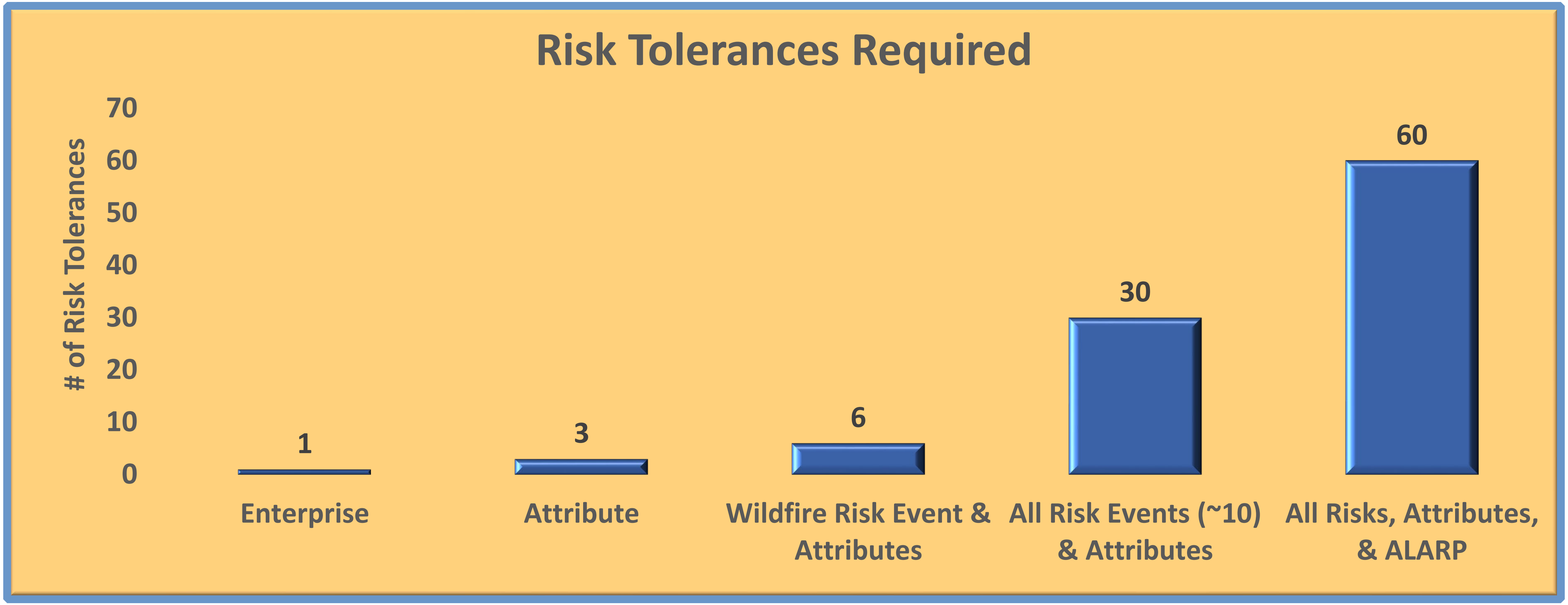
Portfolio-001	Average	Scaled Average	Tail Average
Risk Reduction	$80	$150	$320
Cost	$100	$100	$100
BCR	**0.80**	**1.50**	**3.20**

- Hypothetical BCR threshold=1
- BCR=.80, reassess portfolio
- Scaled Average or Tail Average BCR will always create the illusion of high cost-efficiency
- BCRs only make sense if the benefits (numerator) are based on average risk reduction

Risk Tolerance for Californians

- Need a forum of key stakeholders whose consensus on risk tolerance would represent the residents of California.
  - The California Utility Risk Tolerance Stakeholder (CURTS) Working Group.
- The CURTS Working Group should be engaged by each utility during the preparation for filing its RAMP Report.
  - Determine which tolerances are needed
  - Determine how to set tolerances for average risk and tail average
- SPD recommends that risk tolerance be set both in aggregated dollars for overall residual risk and at the consequence attribute level for each utility

Establishing Risk Tolerance for Californians



Risk Tolerance: Changes to the RDF

- Constant Risk Exceedance Curve: the curve that results in the same Expected Value of Overall Residual Risk for every probability. For example, for an Expected Value of $10 risk, the Constant Risk Exceedance Curve would include the points 10% Likelihood of $100 Consequence; 1% Likelihood of $1,000 Consequence; and 0.1% Likelihood of $10,000 Consequence.
- Exceedance Curve: A function that depicts the maximum level of acceptable Consequence for an attribute for a given probability that the Risk Event will occur.
- Risk Tolerance: Maximum amount of Overall Residual Risk that an entity or its stakeholders are willing to accept after application of risk Control or Mitigation. Risk tolerance can be influenced by legal or regulatory requirements.

Risk Tolerance: Changes to the RDF

6.1	Cost-Benefit Approach Principle 6: Attribute Exceedance Curves	Establish a Constant Risk Exceedance Curve for each attribute relevant to a given risk event. Each Attribute Level Constant Risk Exceedance Curve must depict the *maximum* level of acceptable Consequence for the associated probability that a given Consequence occurs. Each point on the curve represents the same Expected Value of risk. It will inform the establishing of the Constant Risk Exceedance Curves for Risk Events in Row 13.1.

7	Cost-Benefit Approach Principle 6 – Applying ~~Risk~~ Scaling Function to the Attribute Exceedance Curves	~~Apply a Risk Scaling Function to the Monetized Levels of an Attribute or Attributes (from Row 6) to obtain Risk-Adjusted Attribute Levels.~~ For each enterprise risk included in the RAMP, the utility may apply a Scaling Function reflecting Risk Attitude to the Attribute Level Constant Risk Exceedance Curve (from Row 6.1) to obtain a Scaled Attribute Exceedance Curve. The Scaled Attribute Exceedance Curve (which represents Risk Tolerance, see Row 13.1) is obtained by dividing the Attribute Level Constant Risk Exceedance Curve by the Scaling Function. …

13.1	Risk Tolerance	Utilizing the Attribute Level Constant Risk Exceedance Curves from Row 6.1, establish a Constant Risk Exceedance Curve for each enterprise risk assessed in the RAMP. The Constant Risk Exceedance Curve must depict the *maximum* level of acceptable Risk for the associated probability that a given Risk Event occurs. Since each point on the curve represents the exact same level of risk, it is called the Constant Risk Exceedance Curve. The goal of the RDF is to reduce Attribute Consequence Levels below each Risk Tolerance, which is the Scaled Attribute Exceedance Curve. No later than one month after the utility's pre-RAMP workshop, the utility must present its preliminary Attribute Level Exceedance Curves and Constant Risk Exceedance Curve for each enterprise risk assessed in the RAMP to the California Utility Risk Tolerance Stakeholder (CURTS) Working Group. Within 21 days of the CURTS Working Group discussion, stakeholders of the CURTS Forum should make recommendations to the utility for ensuring that the Attribute Level Exceedance Curves and Constant Risk Exceedance Curve appropriately represent the risk tolerance of the residents of California. The utility must submit these recommendations with its RAMP Application along with a justification explaining why the utility did or did not integrate the CURTS Forum recommendations into its RAMP Application.

13.2	Test Year Risk Tolerance	The utility must determine how much risk can be reduced in the next GRC cycle to approach the Constant Risk Exceedance Curve or Scaled Exceedance Curve for each enterprise risk assessed in the RAMP filing.

Clarifying Questions?

Discussion Question

- How does requiring the utilities to explicitly state their risk tolerance help decision-makers and stakeholders determine if mitigation proposals in the RAMP and GRC are an appropriate strategy for reducing risk to acceptable levels?
- In the context of a RAMP and GRC filing, should the Commission require the utilities to present how much risk can be reduced in the next GRC cycle to bring overall residual risk in line with risk tolerance?
  - Should the utilities also present how much time it will take for them to bring overall residual risk in line with risk tolerance?

Discussion Question

- Should utilities be allowed to apply a scaling function to express a risk-averse tolerance? Why or why not?
- Should risk tolerances be established at the overall residual risk level in dollars? Should tolerance be set at the attribute level, in natural units and/or dollars? Explain your answers.

Discussion Question

- Should the Commission establish a forum of key stakeholders whose consensus on risk tolerance would represent the residents of California and inform the utilities' RAMP and GRC filings?
- Should the Commission require utilities to explicitly state their risk tolerance for each risk event?
  - If yes, explain if the Commission should immediately or gradually require the utility to establish a risk tolerance for every risk submitted to a RAMP filing.
    - If gradually, for which risks should the utilities first establish a risk tolerance?
  - If no, why not?

Break

11:15 – 11:25 am

Simple Optimization

November 21-22 2024

Establishing Portfolios: Interrelated Mitigations

- Mutually exclusive
  - Mitigations that cannot work together to reduce risk
  - Ex: undergrounding and covered conductor on the same electric grid asset
- Synergistic
  - Mitigations that work together to decrease the amount of risk.
  - multi-factor authentication and security awareness training can create a more robust defense against cyber-attacks than either alone.
- Diminishing returns
  - Mitigations that reduce risk together, but as investment in one increases, the need for the other mitigation is reduced.
  - Reducing the risk of dam failure by increasing spillway capacity and raising the height of the dam is likely to have diminishing returns, since the success of one reduces the risk that needs to be addressed by the other.

Building Portfolios

No Mutually Exclusive Mitigations

Portfolio	Mitigations
Port_1	M1
Port_2	M2
Port_3	M3
Port_4	M1, M2
Port_5	M1, M3
Port_6	M2, M3
Port_7	M1, M2, M3

Mutually Exclusive Mitigations (M1, M2)

Portfolio	Mitigations
Port_1	M1
Port_2	M2
Port_3	M3
Port_4	M1, M3
Port_5	M2, M3

- Cost and benefit are calculated at the portfolio level.
- Portfolios can be evaluated against each other and the best one chosen.
  - With N number of mitigations, can create 2^N-1 portfolios
- Most portfolios do not need to be constructed or evaluated
  - Optimization can reduce this to a manageable set
- Utilities must continue to present benefits and costs by program and activity in RAMP and GRC filings

Mitigation Portfolios: Changes to the RDF

- Mitigation Portfolio: a collection of one or more risk mitigations for reducing the risk of a given enterprise risk. Costs, benefits, and benefit-cost ratios can be calculated for each portfolio, and portfolios can be compared to one another.

- Mitigation Group: the combining of two or more mitigations that exhibit either synergy, meaning the mitigations result in mutually reinforcing risk reduction efficiency, or diminishing returns, meaning as one mitigation reduces risk it limits the efficiency of the other mitigation to reduce risk.

Mitigation Portfolios: Changes to the RDF

25.1	Portfolios of Risk Mitigations	Utilities must construct portfolios of risk mitigations for each Risk as identified in Row 8. Mitigations in each portfolio should account for interrelationships between them, such as mutual exclusivity, synergies, and diminishing returns. • Mutually exclusive mitigations must be avoided, only one or the other can exist in the same portfolio. • Synergies and diminishing returns can be captured by combining two or more mitigations, called a mitigation group. Synergies or diminishing returns can be calculated for the mitigation group. For example, a wildfire mitigation portfolio could include for a given circuit segment: covered conductor as mitigation, vegetation management as a mitigation, or covered conductor with vegetation management as a mitigation—but not covered conductor and vegetation management as separate mitigations since their benefits are not additive (re: may exhibit diminishing returns).

26	Mitigation Strategy Presentation in the RAMP and GRC	The utility's RAMP filing will provide a ranking of all RAMP Mitigations by ~~Cost-~~Benefit-Cost ~~r~~Ratios. Additionally, the utility must present a set of optimal portfolios for reducing each enterprise risk. Mitigation Groups defined in Row 25.1 can also be ranked within each portfolio. The utility must justify the portfolio selection, optimization, and structure of Mitigation Groups. … In the GRC, the utility will provide an updated presentation of a set of optimal portfolios for reducing each enterprise risk if an update is necessary. Any differences in the set of optimal portfolios from the RAMP filing must be clearly explained by the utility in its GRC filing. In the RAMP and GRC, the utility will clearly and transparently explain its rationale for selecting Mitigations for each enterprise risk and for its selection and optimization of its ~~overall~~ portfolio of Mitigations for each enterprise risk. The utility must explain how the Benefit-Cost Ratio constraint and other constraints factored into the utility's portfolio selection. ~~The utility is not bound to select its Mitigation strategy based solely on the Cost-Benefit Ratios produced by the Cost-Benefit Approach.~~ Mitigation selection and Mitigation Portfolio optimization can be influenced by Benefit-Cost Ratios and other factors including, but not limited to, funding, labor resources, technology, planning and construction lead time, compliance requirements, Risk Tolerance thresholds, operational and execution considerations, and modeling limitations and/or uncertainties affecting the analysis. In the RAMP and GRC, the utility will explain whether and how any such factors affected the utility's Mitigation selections. In the RAMP and GRC, the utility must also implement and justify a transparent and systematic way to integrate these other factors into the optimization of its Mitigation Portfolios. …

Clarifying Questions?

Discussion Question

- Should the Commission require the utilities to construct portfolios of risk mitigations for each risk event addressed in a RAMP or GRC filing? Why or why not?
    - If yes, since the portfolio may include two or more mitigations, should the utility identify the mitigations as having a relationship that is synergistic or exhibits diminishing returns? Explain your answer.

General Discussion

Rulemaking (R.) 20-07-013: Phase 4 Workshop #2: November 22, 2024

Overall Residual Risk, Risk Tolerance and Simple Optimization

California Public Utilities Commission

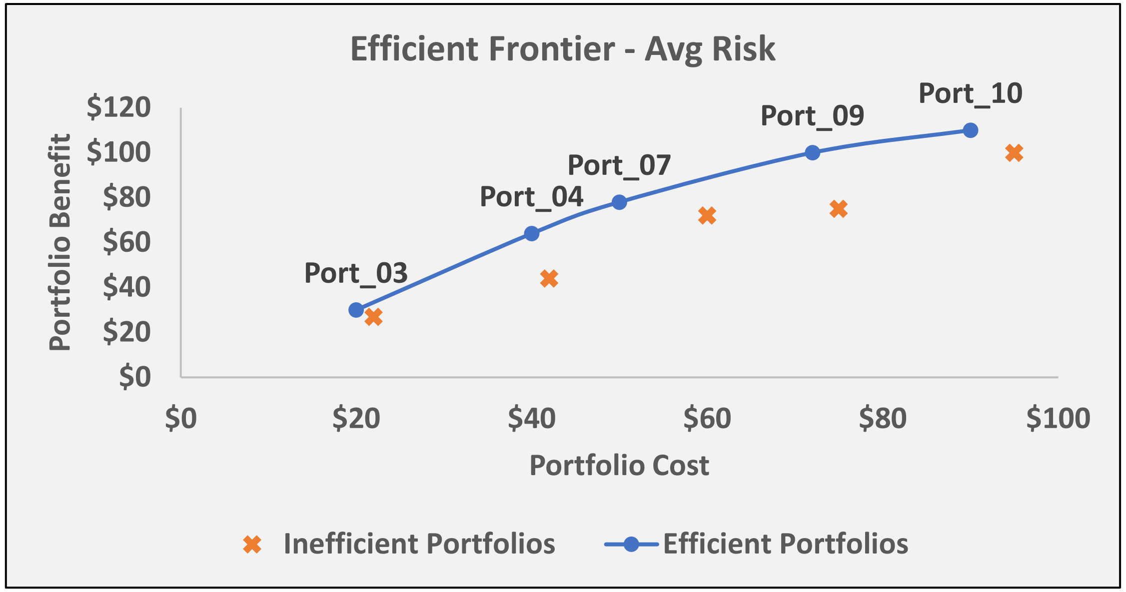
Workshop #2 Agenda: Nov. 22nd

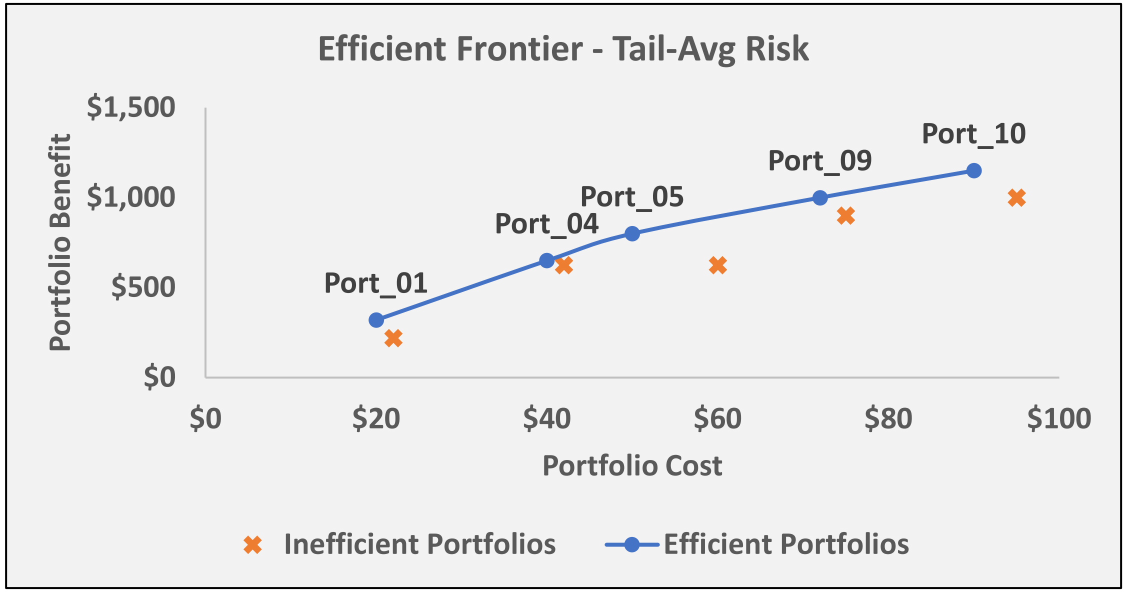
Introduction	10:00 – 10:10 am
Simple Optimization (Linear Programming): SPD Presentation	10:10 – 10:30 am
Simple Optimization (Linear Programming) Discussion	10:30 – 10:50 am
Break	10:50 – 11:00 am
General Discussion	11:00 – 12:25 pm
Close-Out and Next Steps	12:25 – 12:30 pm

Simple Optimization (Cont.)

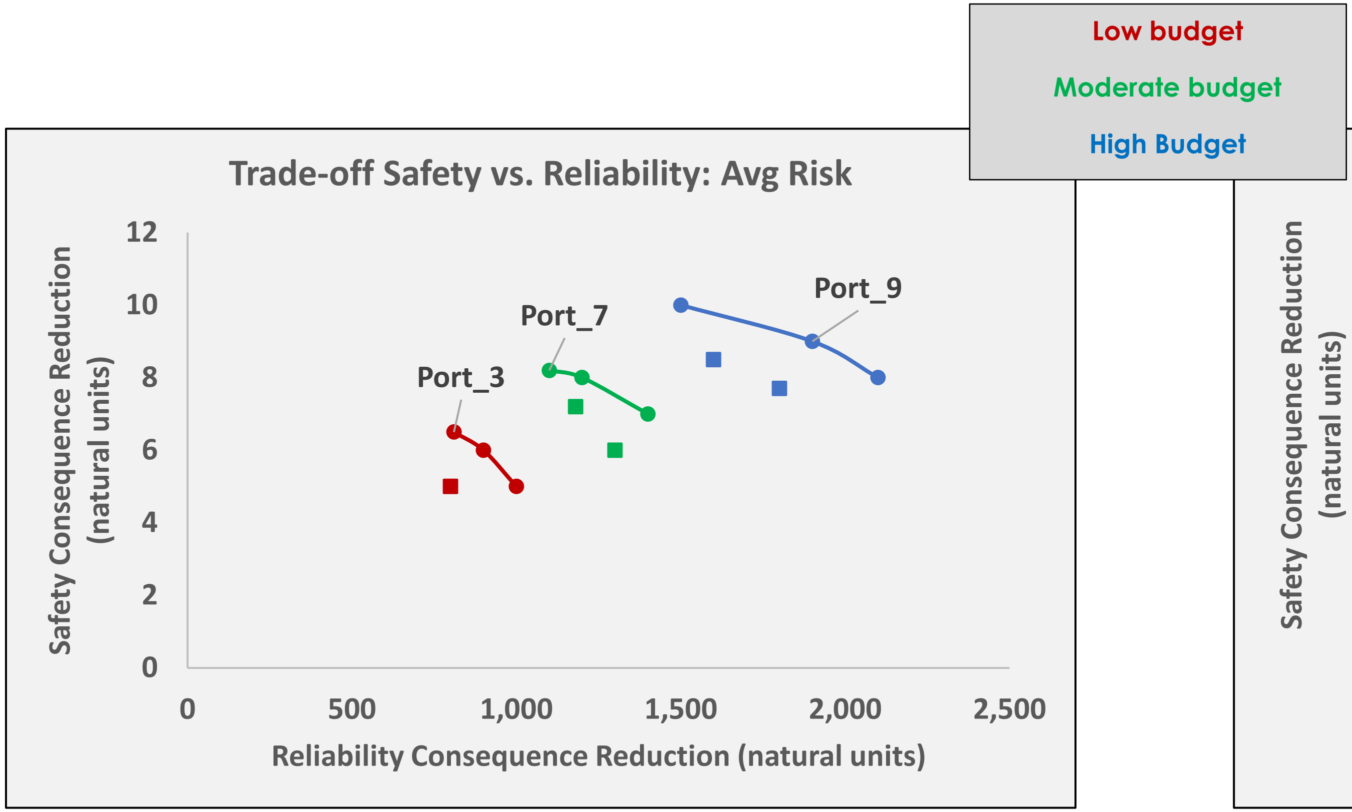
November 22 2024

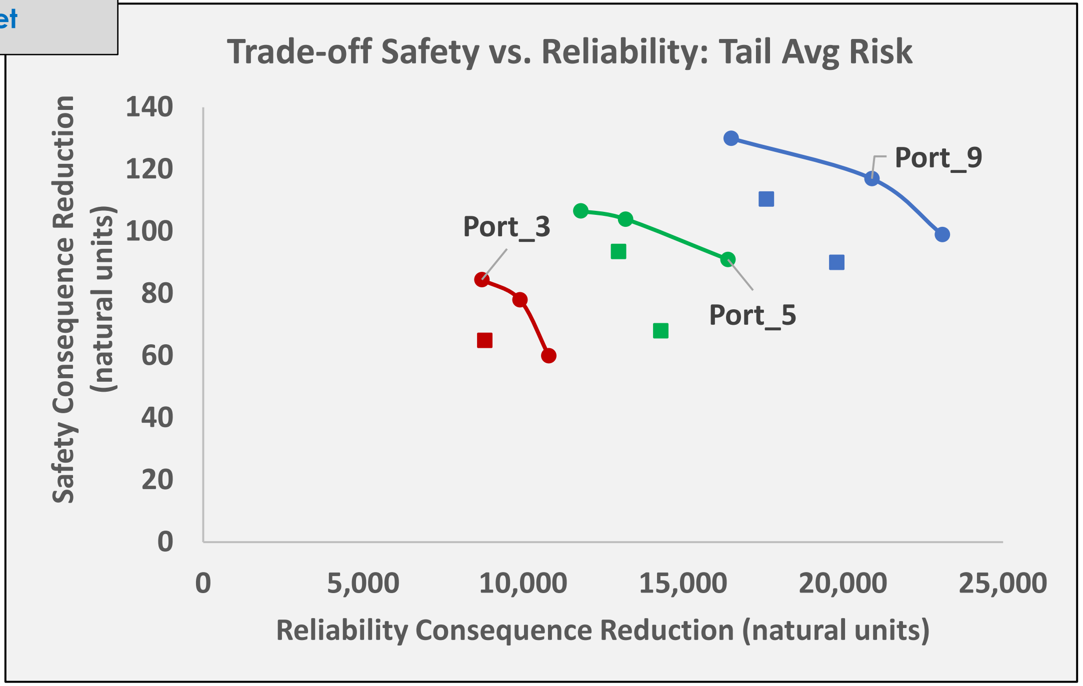
Efficient Frontier of Mitigation Portfolios



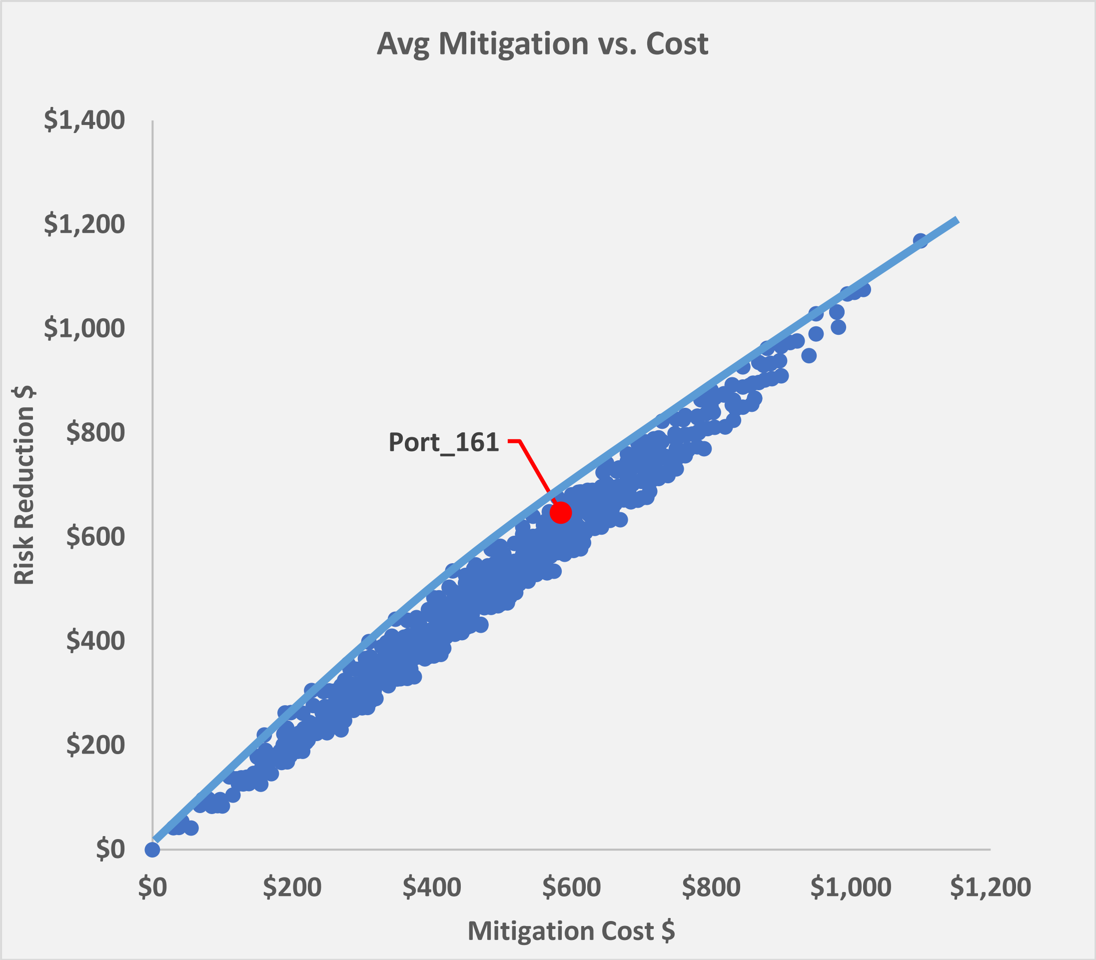


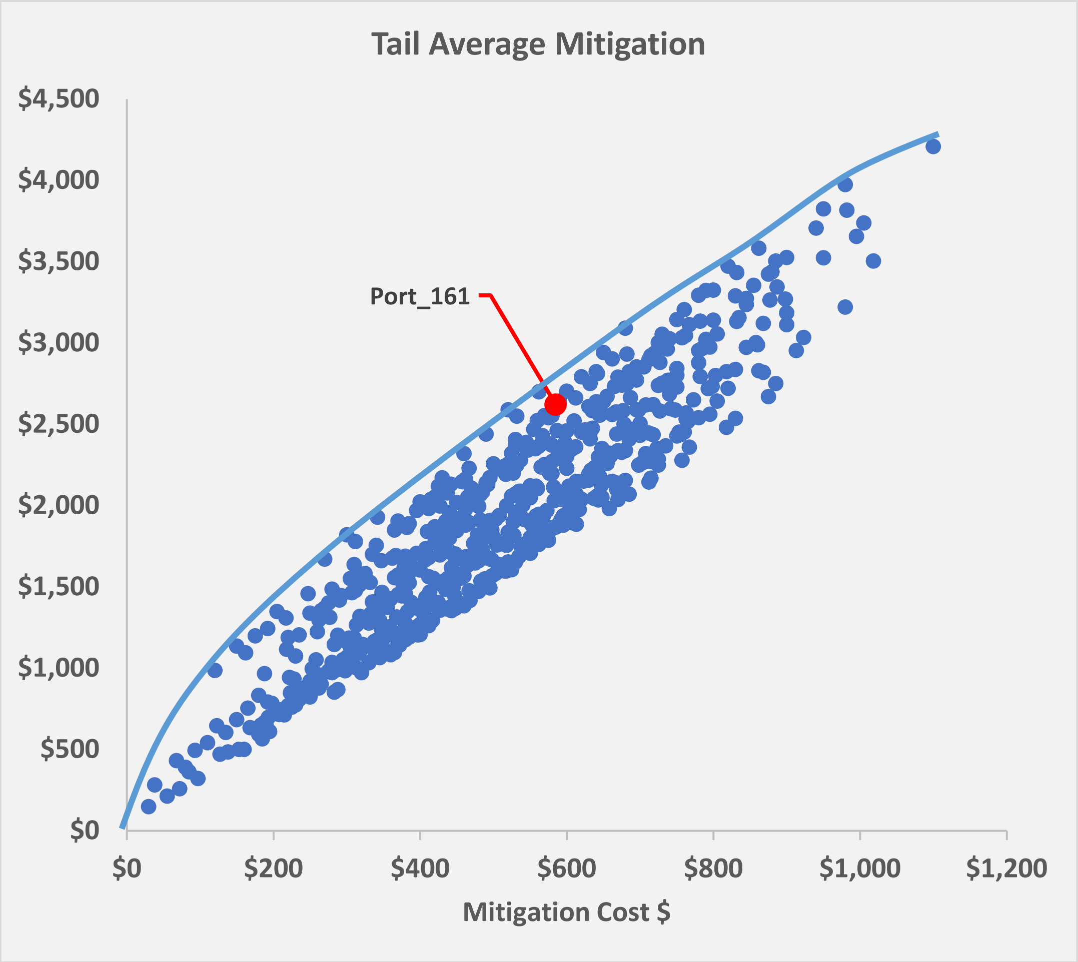
Trade-Offs across Mitigation Portfolios



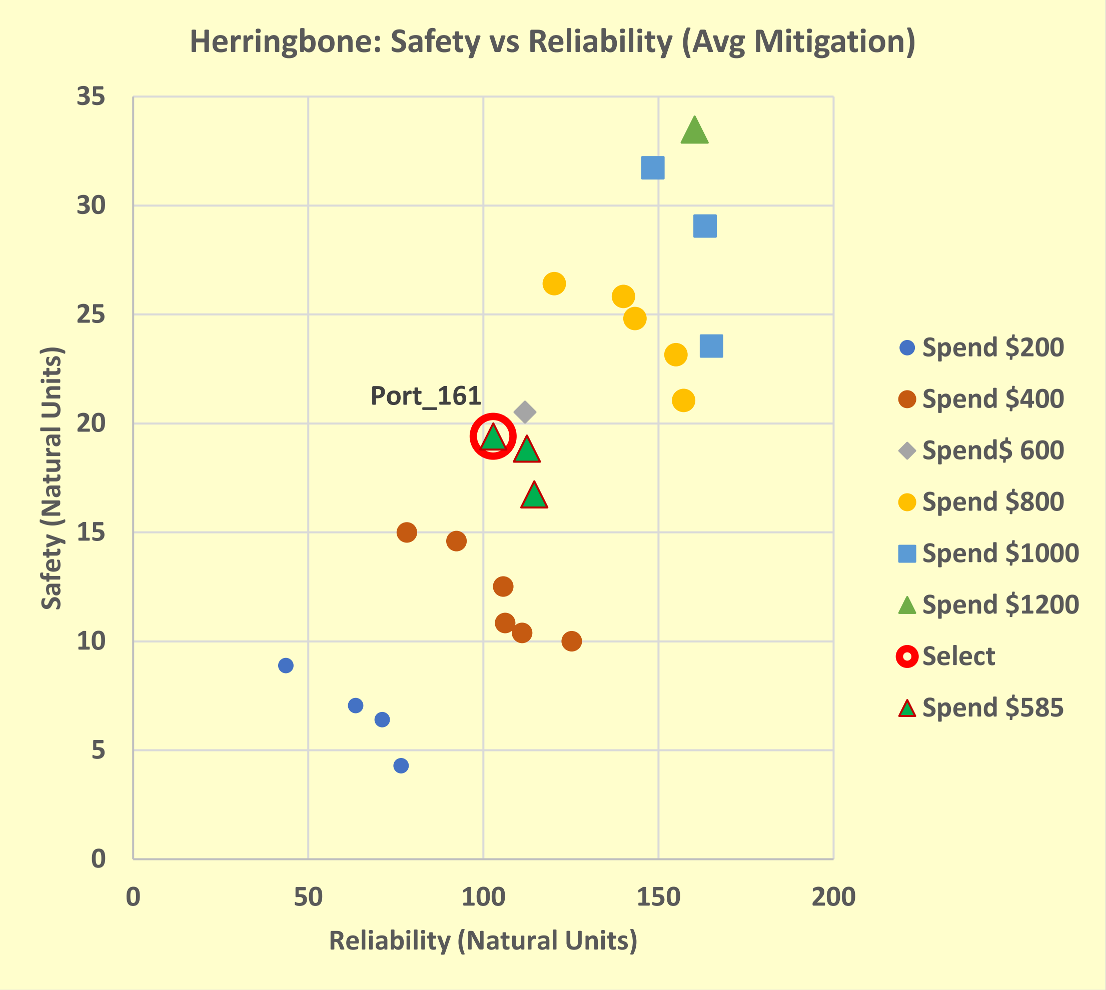


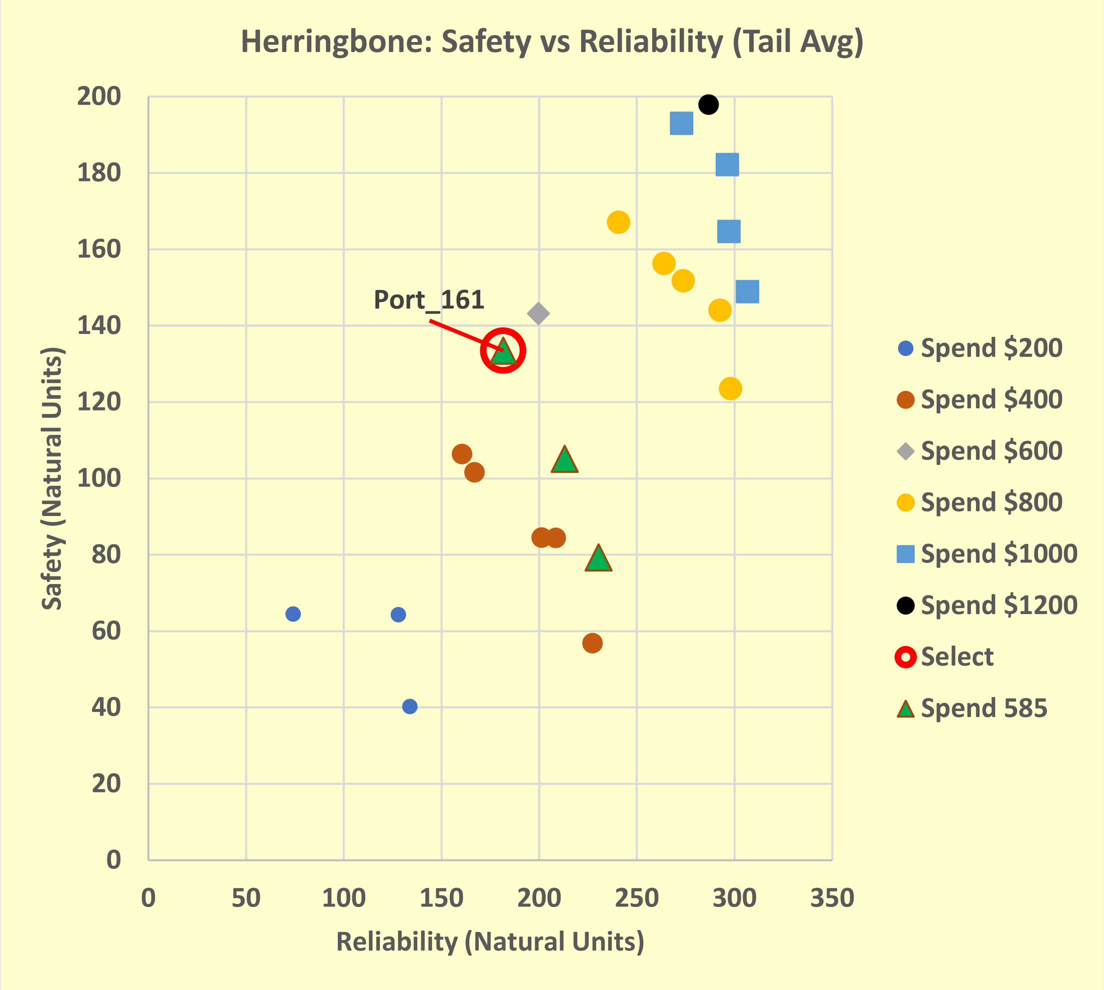
Optimizing Large Numbers of Portfolios





Optimizing Large Numbers of Portfolios





Evaluating an Optimal Portfolio

		Average	Tail Avg @95%
A	**Pre-mitgated Risk**	$1,364	$4,716
B	**Mitigation Benefit**	$646	$2,621
C=A-B	**Overall Residual Risk**	**$718**	**$2,095**
D	**Risk Tolerance - Neutral**	$800	
E	**Risk Tolerance - Averse**	$700	$1,800
	BCR of Mitigation Benefit	**1.11**	

- The acceptability of this portfolio depends on whether a utility is risk-neutral or risk-averse
- For a utility that chooses to be risk averse, this portfolio requires further mitigation
- Portfolio BCR exceeds 1, so can consider increased budget to achieve risk-averse threshold
    - Impact on affordability?

Non-prescriptive Approach to Optimization

- Many approaches to optimizing portfolios of mitigations.
- The goal is minimizing overall residual risk towards Californian's risk tolerance.
- Any approach to optimization must consider affordability constraints.
- ALARP could be a future approach
  - Requires establishing extra exceedance curves

Clarifying Questions?

Discussion Question

- Should the Commission require the utilities to present a set of optimal portfolios for reducing the risk of each risk event addressed in a RAMP or GRC filing? Why or why not?
    - If yes, should the utilities be required to provide a justification for its portfolio selection and approach to optimization in a RAMP or GRC filing? Why or why not?
- Is taking account of tail risk an important way to optimize portfolios of risk mitigations? If so, what methods can be used to address both expected value and tail risk when determining the optimal selection of risk mitigations? If not, why not?

Discussion Question

- Should the Commission provide explicit guidance instructing the utilities how they should conduct the simple optimization of portfolios of risk mitigations? Why or why not?
  - If yes, should the utilities be required to use linear programming to optimize their portfolios of risk mitigations? Why or why not?

General Discussion

11:00 am – 12:25 pm

CPUC Close and Next Steps

12:25 pm – 12:30 pm

Next Steps

1. Workshop Recording on Youtube (3-4 days)

   https://www.youtube.com/user/CaliforniaPUC

2. Commission Files Post-Workshop Proposal (November 27)

3. Workshop #2 Opening Comments (December 17)

4. Workshop #2 Reply Comments (December 24)

Thank you!

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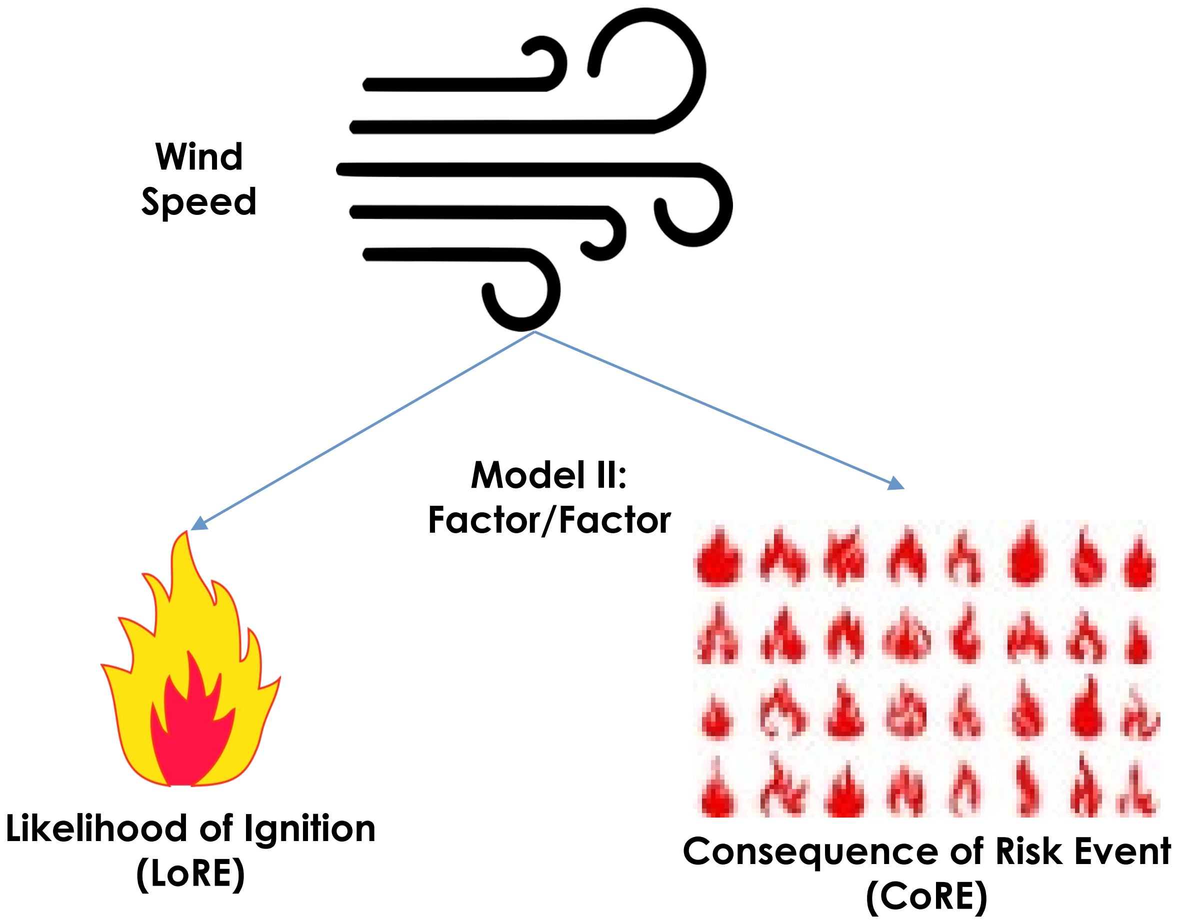
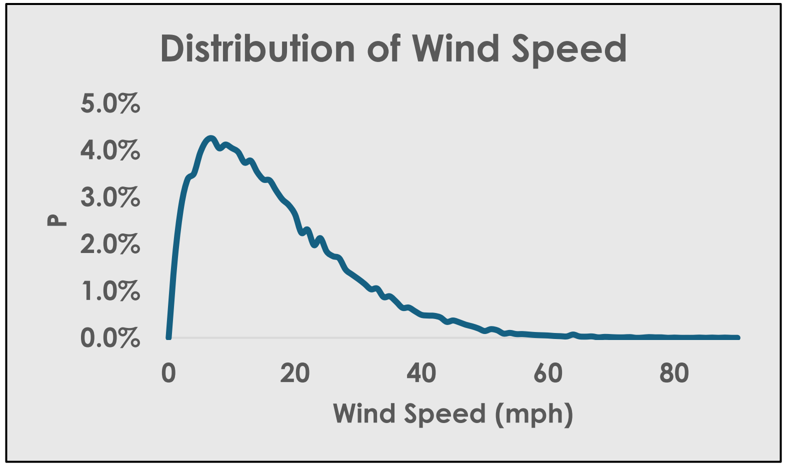
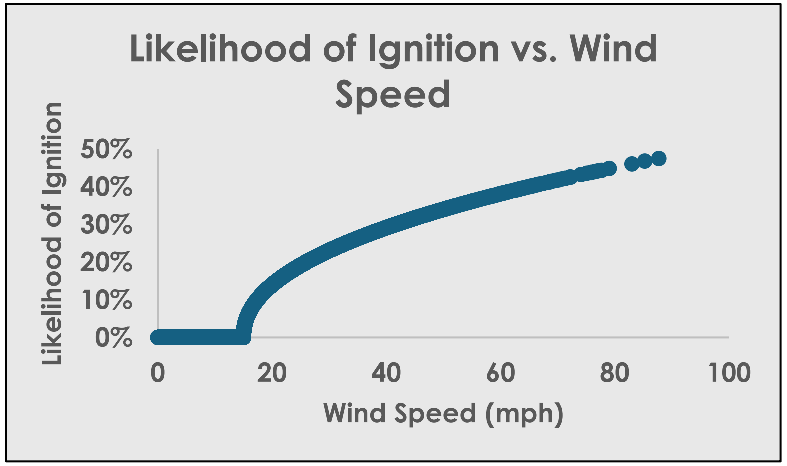
Appendix

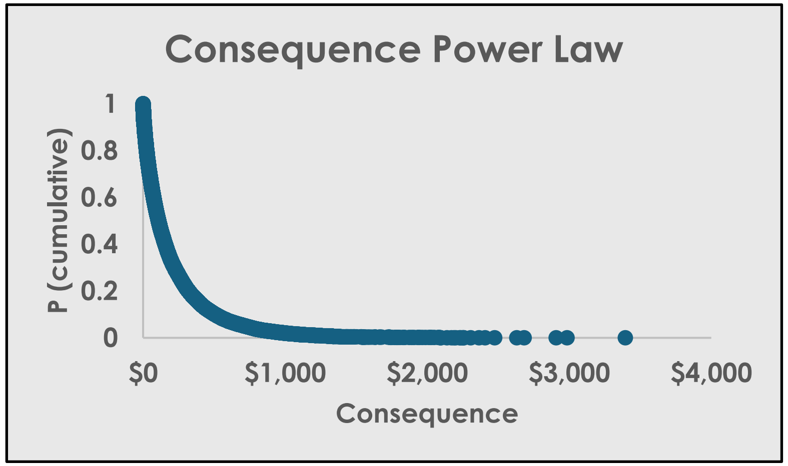
Flaw of Averages



Flaw of Averages: Hypothetical Wind Speed and Wildfire Example







Flaw of Averages:
Hypothetical Wind Speed and Wildfire Example

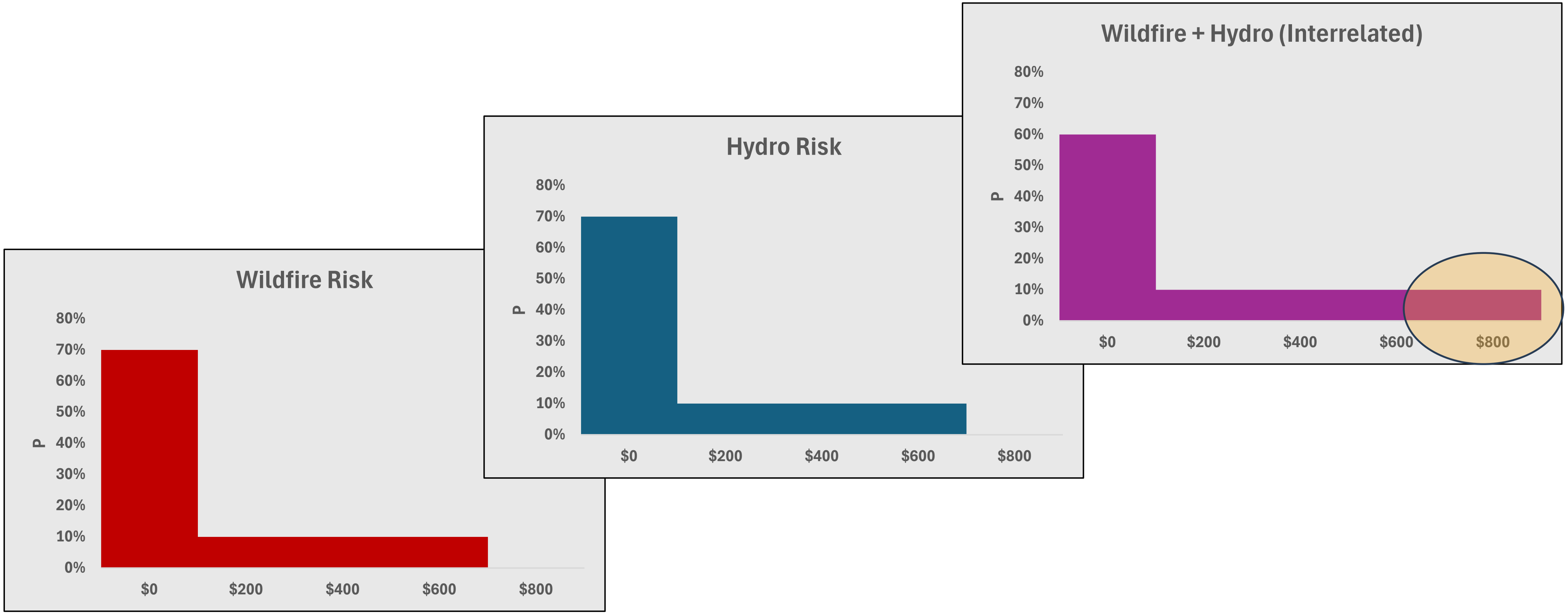
	Risk
Average	$30.56
Median	$0.00
92%	$24.97
95%	$202.05
99%	$753.57
99.5%	$985.88
99.9%	$1,489.40

- Until 92nd percentile, risk is zero
- Rapidly increases in the tail
- 99th percentile is 25 times the average

- Approach (a) uses average wind speed to determine LoRE*CoRE=Risk
- Approach (b) uses distributions of LoRE and CoRE but takes average to find Risk
- Approach (c) multiplies the distributions for LoRE and CoRE and takes average of new distribution for Risk

Risk Calculations	LoRE	CoRE	Risk
Single Number Input (a)	7.4%	$147.22	$10.86
Avg LoRE x Avg Core (b)	8.3%	$200.96	$16.58
Avg (LoRE*CoRE) (c)			$30.56

Likelihood of Simultaneous Failure: Hypothetical Wildfire and Dam Safety Example



Likelihood of Simultaneous Failure: Hypothetical Wildfire and Dam Safety Example

Independent Risks

	WF Risk	Cyber Risk	Total
Trial 1	$0	$500	$500
Trial 2	$0	$0	$0
Trial 3	$100	$0	$100
Trial 4	$0	$300	$300
Trial 5	$0	$0	$0
Trial 6	$500	$0	$500
Trial 7	$0	$0	$0
Trial 8	$300	$0	$300
Trial 9	$0	$0	$0
Trial 10	$0	$100	$100
Average	$90	$90	$180
90%ile			$500

Interrelated Risks

	WF Risk	Hydro Risk	Total
Trial 1	$0	$500	$500
Trial 2	$0	$0	$0
Trial 3	$100	$0	$100
Trial 4	$0	$0	$0
Trial 5	$0	$0	$0
Trial 6	$500	$300	$800
Trial 7	$0	$0	$0
Trial 8	$300	$100	$400
Trial 9	$0	$0	$0
Trial 10	$0	$0	$0
Average	$90	$90	$180
90%ile			$800

- Each risk:
  - occurs three times,
  - has average risk of $90
  - has a combined risk of 180
- Independent risks have a tail risk of $500
- Interrelated risks have a tail risk of $800

Risk Neutrality and Tail Risk

	Likelihood	Consequence A	Likelihood	Consequence B	Risk
Risk A	100%	$1,000	0%	$0	$1,000
Risk B	10%	$10,000	90%	$0	$1,000
Risk C	1%	$100,000	99%	$0	$1,000
Risk D	0.10%	$1,000,000	99.90%	$0	$1,000
Risk E	0.01%	$10,000,000	99.99%	$0	$1,000
Risk F	0.001%	$100,000,000	99.999%	$0	$1,000
Risk G	0.00001%	$10,000,000,000	99.9999900%	$0	$1,000

As Low as Reasonably Practicable (ALARP)

- Tier I. Risk exceeds maximum risk tolerance, mitigate immediately regardless of cost.
- Tier II. Risk level is within maximum risk tolerance, continue to mitigate if BCR is above a set threshold.
- Tier III. Risk level is at or below the accepted level of risk, no further action is taken (residual risk is accepted).