Wildfire Resilience

Risk Tolerance and Aversion for Compliance and Economic Efficiency

Introduction: Addressing Risks in the Utilities Sector

Electric and gas investor-owned utilities (IOUs) are heavily regulated and often face scrutiny from the media and stakeholders for their strategic and operational decisions. Most recently, IOUs must combat threats posed by a rapidly-changing climate. Notably, wildfires pose a significant threat, having increased in frequency and severity globally with an annual U.S. average of about 70,000 fires from 1983 to 2022. The California Public Utilities Commission (CPUC) reports that wildfires from utility infrastructure accounted for 42 percent of damaged acreage in California from 2014 to 2017, emphasizing the urgency of risk management.[1]

Consequences from such events generally include human life and property losses, health effects, environmental damage, service loss, and financial and economic impacts. Utilities face other safety risks, e.g., gas pipeline ruptures, cyber-attacks, dam failures, and workforce safety concerns. In response, CPUC introduced a Risk-based Decision-Making Framework (RDF), previously called the Safety Model Assessment Proceeding (S-MAP), to ensure comprehensive disclosure and management of safety risks by major IOUs through a regulatory review process named the Risk Assessment and Mitigation Phase (RAMP) designed for the major Investor-Owned Utilities (IOUs) of California: Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and Southern California Gas Company (SoCalGas). It ensures these IOUs comprehensively disclose and manage safety risks associated with their operations, aiming for transparency, consistency, compliance, and economic efficiency.

RAMP filings are integrated into the regulatory process, acting as a prerequisite for the IOUs' General Rate Case (GRC) applications. The decision takes into factors such as safety, reliability (measured by indices like System Average Interruption Duration Index and System Average Interruption Frequency Index), costs, and the impacts within the context of legal, insurance, and economic frameworks. This process aims to balance public and private interests transparently and requires a formal approach to determine risk tolerances and attitudes for meeting these aims.

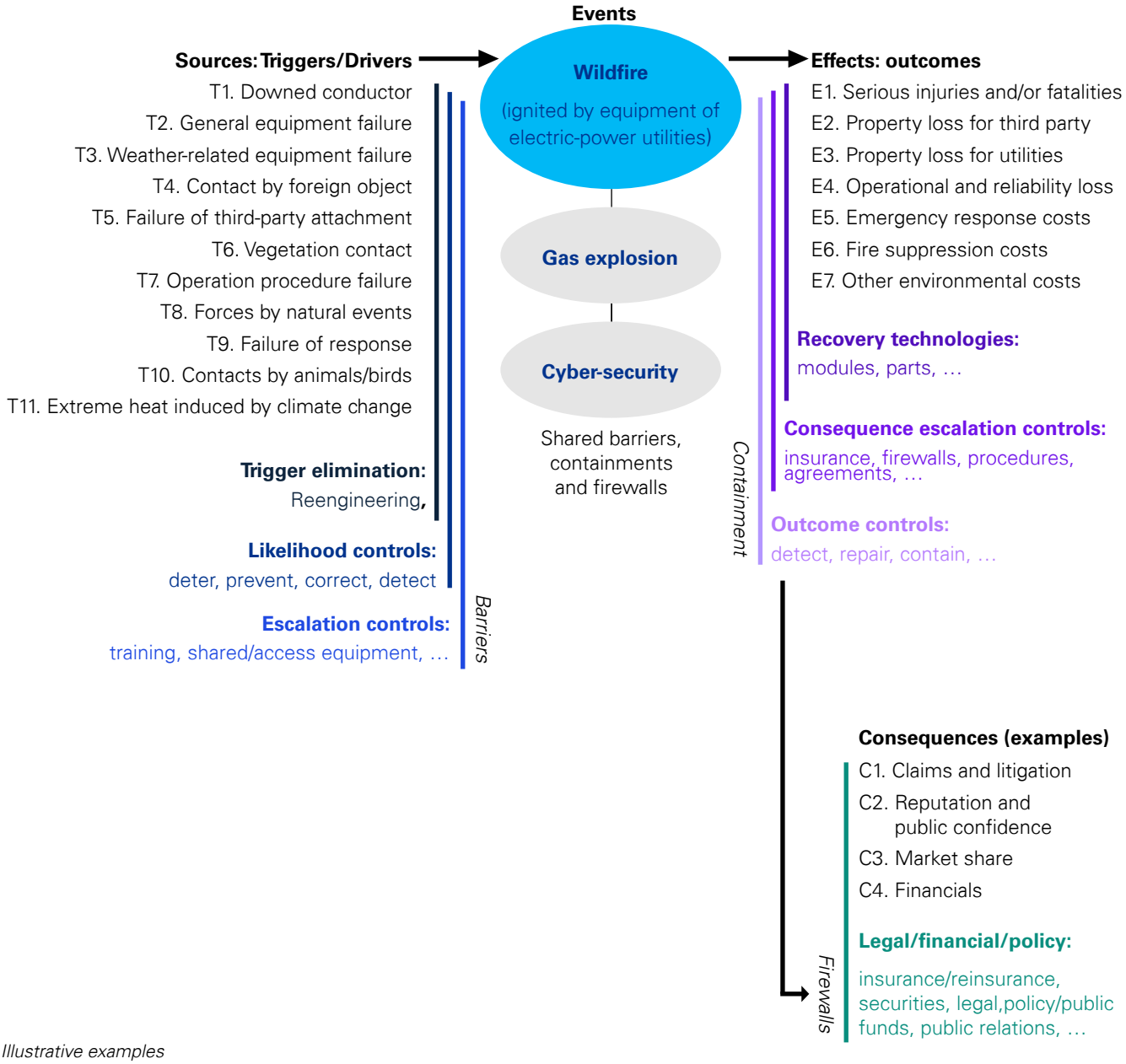
Understanding Risk and Aversion in Enterprises

Risk is defined differently across sectors. In banking and finance, it is defined as the effect of uncertainty on objectives. In technology and engineering, it is the potential loss from exposure to a hazard. In microeconomics, risk is defined as a situation with uncertain outcomes with known probabilities uncertain outcomes and known probabilities.

In enterprise risk management, risk appetite is the willingness to pursue specific risk types for potential returns. Risk tolerance is defined as the manageable loss amounts, post-risk treatment, within legal or regulatory bounds. Risk preference is a behavioral concept focusing on variance in payoffs (from an economic standpoint) or propensity for risk-taking behavior (from a psychological standpoint). And crucially, risk attitude is an analytical approach to risk preference, which includes three broad mindsets of risk aversion, risk-seeking, and risk neutrality. Risk-aversion is contingent on risk acceptance, the degree of risk a decision maker is willing to accept under certain circumstances. Utility functions describe the relationship between preferences and value, highlighting the concept of risk aversion through a diminishing marginal utility of value.

[1] ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering Volume 10, Issue 2

Risk Management Methodology: Bowtie Framework and Economic Valuation



Illustrative examples

A bowtie framework like the one detailed above can be used to define and evaluate risk comprehensively. The full process looks something like the following: defining the context for the wildfire (getting a geographic profile and analyzing causes), devising a bowtie analysis, monetizing losses for cost-benefit analysis, and addressing residual risks.

1. Context and system definition

2. Wildfire bowtie: scenario-based triggers and system states

3. Monetization for benefit-cost analysis

4. Risk management: risk tolerance and residual risk

Discretization of spatial system (e.g., wildland urban interface and electric power)

Event and fault trees

California wildland-urban interface (2013)

Wildfire

Effects: outcomes in native units

E1. Serious injuries and/or fatalities
E2. Property loss for third party
E3. Property loss for utilities
E4. Operational and reliability loss
E5. Emergency response costs
E6. Fire suppression costs
E7. Other environmental costs

Consequence types in native units

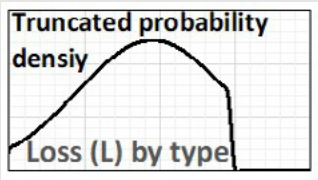
C1. Claims and litigation
C2. Reputation and public confidence
C3. Market share
C4. Financials

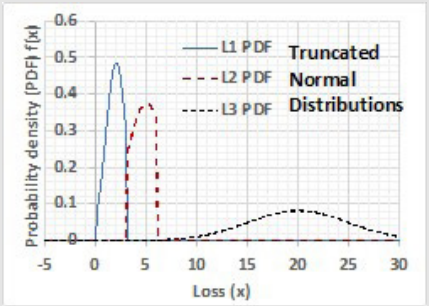
Economic valuations: willingness to pay

Effects monetized: E1 to E7

Consequences monetized: C1 to C4

Example: Loss monetized





Risk attitude and aggregation

- **Calibration, verification, validation and qualification**
- **Expert-opinion elicitation**

Attitude multipliers

Illustrative examples

Composite panel: (on left) 2013 California Wildland-urban interface (WUI) https://apps.revealnews.org/wui/, and (on right) California Energy Commission Map of Transmission Lines, https://www.vox.com/energy-and-environment/2019/10/22/20916820/california-wildfire-climate-change-blackout-insurance-pge (accessed 01-21-2023)

Risk tolerance is key to address residual risks and have effectual decision-making. Risk tolerance is the amount of loss by risk type after applying risk treatment for achieving objectives within established legal or regulatory bounds. The Bounded Value at Risk (bVaR) is the expected value of losses in the range from the Value at Risk (VaR), defined as a single-valued, i.e., threshold-like loss associated with an exceedance probability. It is also related to the Conditional Value at Risk (cVaR); with an infinite maximum possible loss bVaR approaching to the same value as cVaR.

Both loss aversion (avoiding or reducing loss) and risk aversion (ensuring a certain level of gain) must be considered when determining risk attitudes and risk tolerance.

Risk-aversion amplification factors are a way to reflect the extent of risk aversion based on market-related measurements and psychological considerations. These factors help in adjusting the expected net benefits by considering risk-aversion premiums associated with losses and any associated gains.

Public Library and Electric Utility Examples

Case studies from the NIST's EDGe$ software tutorial guide and an electric utility highlight the practical application of risk aversion factors.

Public Library Example[2]

The library example explores options for resilience against wildfires, considering costs, benefits, and externalities. The Ronald Reagan Presidential Library (RRPL) is located in Simi Valley, CA, a high Fire Hazard Severity Zone, indicating a significant chance of experiencing a wildfire within the next 30 to 50 years. Historical incidents like the Easy Fire of 2019 have already caused substantial damage to the library.

To enhance resilience, two options are illustratively considered: (1) retrofitting the current library with fire-resistant materials, and (2) constructing a new library in Oxnard. The decision-making process involves comparing these options against inaction, factoring in a 50-year planning horizon, a 40-year wildfire recurrence, a 5 percent discount rate, and a $7.9 million value for mortality reduction.

The costs and benefits of each option are quantified. Option 1 involves a mix of direct and indirect costs totaling $10.74 million, while Option 2 encompasses direct historic value costs, property resale gains, and operational savings, cumulatively resulting in significant financial considerations for Simi Valley. Benefits include reduced losses and mortality, with additional co-benefits like asset value increase, noise reduction, and energy savings. Notably, constructing a new library in Oxnard might introduce negative externalities for Simi Valley, such as lost library access and tourism.

Furthermore, the study incorporates risk aversion factors, specifically for content loss and mortality reduction, and applies loss amplification factors for direct property loss and mortality, varying these from a baseline to measure their impact on economic indicators like Net Present Value (NPV), Benefit-to-Cost (BTC) Ratio, Return on Investment (ROI), and Internal Rate of Return (IRR). The comprehensive analysis, including these risk considerations and economic indicators, aims to guide decision-making amidst the complexities of political and fiscal constraints.

Electric utility example

The electric utility example illustrates risk tolerance measurement, categorization of potential losses, and the integration of risk aversion factors in decision-making.

Risk tolerance is measured by identifying different types of risks and the maximum potential losses (quantified in dollar values) they could incur. Losses are distributed across a range, and this distribution can be represented by truncated probability distributions. These distributions only consider values within a certain range, ignoring extreme values that are deemed improbable.

Losses are categorized into different ranges (e.g., L1, L2, L3) based on their severity, with L1 representing retained risks, L2 covering risks mitigated by insurance, and L3 involving catastrophic losses typically covered by CAT bonds or similar instruments. These categories help in setting respective risk tolerance levels. Some loss ranges are considered tolerable without intervention, while others require risk treatment measures to reduce them to acceptable levels.

Risk attitudes of decision makers are factored into the management of tolerable losses. This involves adjusting the expected net benefits based on risk neutrality and market-related considerations, such as willingness-to-pay amounts. Loss aversion and risk aversion are considered by respective amplification factors informed by insurance, CAT bond and other markets.

Amplification factors must be considered as well, as they can adjust the premiums paid for risk aversion based on psychological and micro-econometric considerations. The net expected benefit, which has a defined formula, accounts for loss reduction or avoidance, added benefits, costs, and other impacts, each weighted by their respective risk-aversion amplification factors.

[2] Helgeson, J. F., D. Webb, and P. Lavappa. 2020. EDGe$ (Economic Decision Guide Software) online tool, software. Gaithersburg, MD: NIST.

Conclusion: Enhancing Decision-Making in Utilities

Electric and gas investor-owned utilities play a pivotal role in community wellbeing and resilience, while operating within a regulated environment, necessitating a structured approach to risk management. The paper discusses risk-aversion amplification factors and considerations when setting risk attitudes and risk tolerance.

This approach introduces the concept of risk-aversion amplification factors as a tool in economic and trade-off studies related to utilities and communities, offering a method that can be easily integrated into existing practices. It links risk aversion quantification and market mechanisms such as insurance and CAT bonds, which will help produce certainty-equivalent economic valuations. These valuations are crucial in conducting comprehensive benefit-cost and trade-off analyses.

The measures and proposals put forward aim to ensure that companies better understand risk and are able to enhance their overall decision-making process in utility and community contexts.

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