# Risk Modeling Working Group Summary Report, Phase I

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# 1 Introduction

## 1.1 Background

During the 2021 Office of Energy Infrastructure Safety (Energy Safety) Wildfire Management Plan (WMP) evaluations, Energy Safety arrived at the following conclusions regarding the WMPs reviewed:[1]

- Utilities did not have a consistent approach to wildfire risk modeling; and
- While utilities operate under different circumstances due to (1) service territory characteristics, (2) data availability, and (3) risk model development stages, they face similar enough circumstances to warrant consistency in statewide approaches to wildfire risk modeling.

Energy Safety determined one possible way to reach greater consistency in wildfire risk modeling across utilities was to organize a conference with technical contributors, including utility risk management staff and stakeholders such as energy policy experts and public interest groups. The conference was named the “Risk Management Working Group” (RMWG) and was scheduled to meet regularly and discuss wildfire risk modeling topics with the goal of achieving the following objectives:

- Increase collaboration among utilities within their wildfire risk models,
- Provide an opportunity for stakeholders to comment on wildfire risk models, and
- Increase transparency in the approach used to develop wildfire risk models.

Energy Safety organized RMWG meetings to determine where electrical corporations can improve wildfire risk modeling efforts and adopt consistent practices.

Potential topic areas within the scope of the RMWG included:

- Data used in each model and model component, including sources or data sharing across utilities;
- Data quality, including updates and associated triggers, accuracy, and quality checks;
- Algorithms used in models, including machine learning;
- Modeling components, linkages, and interdependencies;
- Weight of components and inputs;
- Implementation of atomization;
- Frequency of modeling inputs, including the basis for inputs;
- Confidences for each model and modeling components, including how confidences were determined;
- Verification of modeling inputs and outputs, impact of uncertainty to models, impact of climate change;
- Identifying where consistency is infeasible or not necessary; and
- Potential collaboration requirements across utilities.

In October 2021, Energy Safety began hosting a series of RMWG sessions. The RMWG sessions were split into two phases. Phase I, (October 2021–December 2022) prioritized information sharing related to wildfire risk modeling across the various stakeholder groups, including the Investor Owned Utilities (IOUs), Small and Multi Jurisdictional Utilities (SMJUs), Energy Safety, the Wildfire Safety Advisory Board (WSAB), stakeholders, and others. The goal of Phase I was to gain an understanding of current risk modeling processes within each of the IOUs and SMJUs. Phase II will focus on identifying specific, actionable directions for improved risk modeling by the utilities.

Phase I has been completed and its objectives have been fully accomplished. The meetings provided a venue for experts to discuss and deliberate best practices moving forward. The RMWG also gathered risk modeling related information to understand the current risk modeling approaches adopted by the IOUs and SMJUs. This included cross-comparing different methodologies and identifying areas that need more research and understanding to advance.

The RMWG assisted in identifying certain areas that already had some consistency across IOUs and SMJUs, such as overarching bowtie methodologies with similar inputs and outputs.

During Phase I, an opportunity was identified to continue the work with a Phase II set of workshops. Phase II workshops will support the development of specific, actionable recommendations that can be incorporated into future WMP Guidelines.

The California Public Utilities Commission (CPUC) conducted a related series of Risk Spend Efficiency (RSE) Technical Working Group (TWG) workshops during 2022, leading to Decision 22-12-027, "Phase II Decision Adopting Modifications to the Risk-Based Decision-Making Framework Adopted in Decision 18-12-014 and Directing Environmental and Social Justice Pilots." The CPUC expects to continue this effort and begin implementation of Decision 22-12-027-related TWG workshops during 2023. Because coordination of Energy Safety and CPUC work in this area is beneficial to both organizations, the planned CPUC workshops are included in Chapter 4.

This report summarizes Phase I and establishes a foundation for Phase II work that will include workshops, topics of discussion, and areas of focus.

## 1.2 Membership of the Risk Modeling Working Group

For Phase I, interested parties could become RMWG members by submitting their resume to Energy Safety's Risk Model Group docket ("Risk-Model-Group"). Energy Safety staff then reviewed and approved applicants, checking for relevant expertise. This process allowed for conversations within the working group to dive into technical details and ensured that members were committed to attending regularly.

For Phase II, parties interested in joining should submit a resume to the Risk Model Group docket.

## 1.3 RMWG Members

| **SMJU:** | **IOU:** | **Vendor:** |
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| Bear Valley Electric Service<br>Liberty Utilities<br>PacifiCorp | Pacific Gas & Electric<br>San Diego Gas & Electric<br>Southern California Edison | Technosylva<br>Reax Engineering |
| **State Agency:** | **Stakeholder:** | **Advisory:** |
| California Public Utilities Commission<br>California Department of Forestry and Fire Protection<br>Office of Energy Infrastructure Safety<br>Wildfire Safety Advisory Board | Green Power Institute<br>CPUC Public Advocates<br>Mussey Grade Road Alliance | Level 4 Ventures<br>Lumina<br>Probability Management Institute |

## 1.4 Contributions

Energy Safety invited members of the RMWG to provide comments on the Summary Report. Members had 14 days to review, with comments due on March 20, 2023. The following individuals and organizations submitted comments:

- Joseph Mitchell, PhD, MGRA
- Zoe Harrold, PhD, GPI
- SDG&E

Level 4, in consultation with Energy Safety, evaluated these comments, concurred in some instances, and incorporated the comments into the Summary Report, including:

- Added “Role of overhead conductor and communications as possible egress risk should be evaluated." to section 3.1.5 (MGRA).
- Added additional rationale under PSPS risk in section 3.1.7 to account for safety and financial risk as well as accounting for PSPS thresholds (MGRA).
- Added “General loss of income results in lower life expectancy due to a wide range of life impacts. Rate increases planned to support wildfire mitigation can possibly have effects comparable to other harms under consideration.” to section 3.2.1 (MGRA).
- Added “IOUs and SMJUs should start evaluating how to integrate events missed due to PSPS into modeling, as suggested by MGRA. A good practice would be to consider the pros and cons and the accuracy. PG&E currently leads in this effort.” to the 12/8/2022 RMWG summary, topic: Risk Drivers, Probability of Ignition Models, and Data/Inputs (MGRA).
- Credited any contributions provided by Mussey Grade Road Alliance using the abbreviation MGRA (MGRA).

- Reworded two paragraphs in the 9/14/2022 RMWG summary, topic: Lessons Learned, Guideline Improvements, Topics for the Next Session (GPI).
- Reworded a paragraph in the summary 12/8/2021 RMWG summary, topic: Risk Drivers, Probability of Ignition Models, and Data/Inputs (SDG&E).
- Reworded a paragraph in the summary 3/2/2022 RMWG summary, topic: Likelihood of Vegetation Risk Events and Ignitions (SDG&E).
- Reworded a paragraph in the summary 4/13/2022 RMWG summary, topic: Power Safety Power Shutoff (PSPS) Likelihood and PSPS Consequence, Reliability Analysis and Impacts (SDG&E).
- Reworded a paragraph in the summary 5/25/2022 RMWG summary, topic: Modeling Algorithms, Part 1 (SDG&E).
- Reworded a paragraph in the summary 8/10/2022 RMWG summary, topic: Modeling Algorithms, Components, Linkages, and Interdependencies, and Climate Change, Part 2 (SDG&E).

# 2 Phase I RMWG Summaries

Table 1 provides a summary of Phase I RMWG meetings. The information shared during these meetings will inform the work during Phase II (see Chapter 3). The collected information will then inform Energy Safety's coordination with the CPUC TWG (see Chapter 4).

The summaries also include takeaways from the Energy Safety team about what was discussed in the meetings. These include lessons learned and potential areas that may inform future WMP guidelines as well as future RMWG topics. Takeaways do not denote requirements for utilities at this time.

*Table 1: RMWG Phase I Summaries*

| **Date:** 10/5/2021 |
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| **Topic:** Initial RMWG, Day 1. |
| **RMWG Summary** |
| This RMWG focused on introducing the group's purpose, stakeholders involved, and participating organizations.<br><br>San Diego Gas & Electric (SDG&E), Pacific Gas & Electric (PG&E), Southern California Edison (SCE), PacifiCorp, Liberty, and Bear Valley Electric Service (BVES) presented a high-level overview of their risk models. Energy Safety discussed the objectives for improved consistency in wildfire risk modeling. Modeling details included components of the models, model inputs, modeling assumptions, and confidence in model outputs.<br><br>**Takeaways:** n/a |
| **Date:** 10/6/2021 |
| **Topic:** Initial RMWG, Day 2. |
| **RMWG Summary** |
| This RMWG focused on introducing the WSAB, including the organization's purpose, staff, objectives, and recommendations for risk assessments within utilities.<br><br>The WSAB was created as a legislative response to the increased risk of catastrophic wildfires, including utility-caused wildfires, in California. The board's purpose is "to ensure that broad expertise is available to develop best practices for wildfire reduction." (AB 1054, § 2)<br><br>WSAB Board Member expertise includes fire modeling, fire policy, safety, utility infrastructure, and risk modeling experts. The WSAB reviews and makes recommendations on wildfire mitigation plan requirements, a process to conduct safety culture assessments, and wildfire mitigation plan performance metrics. |

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| Parameters for participation in the meetings were disclosed. Working group meetings will include Energy Safety staff, utility staff, and qualified interested parties (determined through an approval process). To participate in the working group, interested parties must demonstrate experience in modeling, risk assessment, and/or wildfire risk.<br><br>**Takeaways:** n/a |
| **Date:** 10/27/2021 |
| **Topic:** RMWG Organizational Conference. |
| **RMWG Summary** |
| This RMWG focused on defining the RMWG phases, objectives, and administrative issues (e.g., logistics, confidentiality).<br><br>The value of collaboration between the IOUs was discussed, both in general and with respect to wildfire mitigation. The IOUs confirmed that they currently collaborate in areas including best practices, use of Technosylva services, PoI modeling, reviewing each other's RAMP filings after submission, model components, and consequence modeling.<br><br>**Takeaways:** Three key decisions were:<br>• General Non-Disclosure Agreements (NDAs) would not be used, so any specifics requiring confidentiality agreements must remain as narrow as possible and those items would need to be dealt with using specific NDA agreements covering just those items.<br>• Remote participation would be supported.<br>• Meetings would not be recorded. |
| **Date:** 11/17/2021 |
| **Topic:** Review of Consequence Models. |
| **RMWG Summary** |
| This RMWG focused on weather and fuel inputs to wildfire consequence models.<br><br>PG&E uses data sets including LandFire 2012 and 2016, a 13-year meteorology data set dated from 1990 to 2020; a 2020 snapshot data set showing fire scars; and a fuels layer data set that forecasts to 2030. Most of these data sets were sourced from Technosylva, a wildfire science, surveillance technology, and data services vendor for electric utilities.<br><br>SDG&E uses meteorology and climatology data sets like those used by PG&E. They have developed a two-kilometer resolution weather model to drive wind, temperature, and humidity with hourly temporal granularity. For fuel data they use Technosylva's FireCast.<br><br>SCE reports to be using datasets comparable to those in use by PG&E for weather and fuels modeling purposes. |

Utilities described the data sets used and how the data sets fit into a utility's fire modeling. Two major wildfire data vendors, Reax Engineering and Technosylva, were present and filled in gaps where needed. Reax Engineering offers utilities data packages for both operational and forecast modeling. Their forecast model uses fuel samples and machine learning to generate live fuel-moisture forecasts. Its planning data forecasts cover a 30-to-40-year span, including humidity, temperature, and windspeed. The Reax models are stochastic, so they can provide probabilities and confidence ranges. Technosylva generates current fuels data through remote sensing, field observation, and Light Detecting and Ranging (LiDAR).

Level 4 commented that fuel class definitions used within the LandFire model are unclear; this may impact how utilities update, validate, and tune models to improve their predictive capability.

**Takeaways:**

- IOUs' existing approach to meteorology and climatology data sets differ in granularity, although many of the aspects are similar, such as evaluating wind, temperature, and humidity.
- All three IOUs rely on Technosylva at least in part to perform consequence risk modeling. This includes Technosylva's in-house fuel characterization and data collection, as well as data integration and modeling of socioeconomic/static vulnerability characteristics, egress, and terrain difficulty.
- The RMWG needs more granular data on consequence risk models to fully evaluate them and understand what is being modeled; this data may require greater transparency from data vendors than what is presently offered.

**Date:** 12/8/2021

**Topic:** Risk Drivers, Probability of Ignition Models, and Data/Inputs.

**RMWG Summary**

This RMWG focused on what defines a "risk event" and what data IOUs and SMJUs are using as an input to their ignition risk models.

PG&E reported roughly 15,500 outages per year, and roughly 1,500 damage reports per year. Most of these events do not result in ignitions; however, PG&E is using a model to interpret the likelihood an outage results in an ignition. PG&E uses a model developed by its meteorology team to determine which events qualify for a Power Safety Power Shutoff (PSPS) response. This model uses historical records to identify historical conditions that would have justified a PSPS (e.g., an outage turning into an ignition event). The model applies both probabilities of ignition and consequences of ignition (e.g., with and without damages). The consequences (i.e., damages) side of the modeling plays a small role because PG&E does not have adequate data.

SCE uses its outage data as part of its ignition risk evaluations. SCE's ignition risk model is also equipment-specific, starting with distribution conductors in 2018 and moving through equipment types based on ignition count.

SDG&E's training data sets are more on the outage side. They look for evidence of heat in any outage event, regardless of ignition, and utilize that feedback in Probability of Ignition (PoI) models. SDG&E validates models through cross validation statistics. These models are then used to weigh the wildfire risk versus the PSPS consequence. SDG&E's policy is to initiate a PSPS event when the wildfire risk is greater.

**Takeaways:**

- IOUs and SMJUs should start evaluating how to integrate estimates for PSPS prevented consequences into modeling, as suggested by MGRA. A good practice would be to consider the pros and cons and the accuracy. PG&E currently leads in this effort.
- IOUs and SMJUs should also evaluate how to translate outage and near-miss data into ignition risk data, if not already doing so, including overcoming outage location extrapolation through language processing and machine learning.
- Likelihood of ignition models need further evaluation to understand the impact from certain drivers such as balloon and vehicle contacts, and the sort of bias that may play on understanding risk in the planning and operational models.
- IOUs and SMJUs should move toward equipment-specific failure models, with most of the utilities already modeling conductors and are moving toward modeling additional equipment. This modeling is dependent on accurate equipment inventories and data.

**Date:** 3/2/2022

**Topic:** Likelihood of Vegetation Risk Events and Ignitions.

**RMWG Summary**

This RMWG focused on vegetation data collected during vegetation inspections and inventories, the frequency of data collection, and the granularity of the collected data. The data being is critical to the development of proper "fuelscapes" (i.e., plans for treating varying fuels before and during cases of fires and proximity to fires.

SDG&E's vegetation management strategy involves a robust tree inventory database, not hyperspectral/LiDAR data. The GIS-based tree inventory database is the record system for vegetation management activities including pre-inspection, tree trimming, pole brushing, and auditing. SDG&E follows a vegetation management process that involves an annual master schedule of activities within 133 Vegetation Management Areas for their service territory. The process flows from pre-inspection, to pre-inspection audit, to trimming/removal, to post-trim audit. SDG&E observes that LiDAR accuracy and usability is dependent on flight frequency and data processing. While SDG&E believes that LiDAR may augment how it conducts vegetation management inspections, it does not believe that it can replace ground-based inspections by trained workers. However, SDG&E continues to research practical applications to operationalize technologies such as LiDAR and satellite imagery.

SCE uses LiDAR for transmission inspections and compliance and has not launched satellite imagery activities for risk modeling. SCE is currently using Normalized Difference Vegetation Index (NDVI) hyperspectral for PSPS applications and to find dry areas. They have observed a correlation between the likelihood of an ignition event and tree species and genus. SCE's strategy for vegetation management does not involve managing trees at the individual tree level and they do not collect tree density data. However, they do manage a database of 1.5 million trees, including tree species, and they are currently working on linking that data to outage data for greater risk management utility. Currently, both the tree database and the outage database separately feed into the risk models. The risk models are then used to determine physical inspections. Trees within high-risk circuits are a priority for inspection.

PG&E's strategy for vegetation management includes the collection of a wide variety of data fields to produce grid maps. Technologies used include LiDAR data, which is used specifically to inspect all High Fire Threat District (HFTD) lines. Fields include street tree count, tree height, and dry fuels. A dedicated team translates LiDAR data into useable attributes for risk modeling. PG&E has noted correlations between the likelihood of events and humidity, moisture, soil health, etc.—but not tree health directly.

BVES contracts out tree density surveying and looks at the reduction of tree density as a metric for fire risk. BVES is unaware of the methods their contractor uses to obtain tree density data.

**Takeaways:**

- Evaluation of tree species/genus is useful in determining vegetation risk, and databases should move toward accurate and granular species information as part of risk evaluations.
- The RMWG should conduct further evaluation to determine which factors contribute to likelihood of events, including temporal factors such as climate and climate change.
- The RMWG should conduct further evaluation to understand how to integrate LiDAR and NDVI data within modeling data sets, including the pros and cons of such, as well as correlations to identifying risk events.

**Date:** 4/13/2022

**Topic:** PSPS Likelihood and PSPS Consequence, Reliability Analysis, and Impacts.

**RMWG Summary**

This RMWG focused on PSPS data and measures used for PSPS planning, including historical lookback for affected areas, retroactive application prior to PSPS implementation, and climate projections.

The PG&E PSPS planning and operational models use a similar configuration, using 31 years of weather and fuels data with a 10-year lookback period. The models are optimized based on the most recent 4-year period. PG&E's analysis confirmed that a 10-year lookback period would be capable of predicting the number of PSPS events, size, and impact factors.

The SCE PSPS operational model has a 2020 base year, and hindcasts starting from 2021. It compares 2020 experience to 2021 and calculates events in both years to estimate the impact of grid hardening and expedited grid hardening. The current model configuration uses weather station references.

The SDG&E PSPS model hindcasts 30 years of data to 1984, but SDG&E does not specifically derive PSPS risk directly from this historical data, as PSPS risk inputs are subject matter expert (SME) driven and assembled by meteorology.
Neither Liberty nor BVES have had any PSPS events in the past, and they have not performed a historical lookback analysis for risk modeling purposes. They are exploring the use of historic weather patterns to predict events where PSPS is necessary.

**Takeaways:**

- IOUs have primarily built-out operational PSPS models based on historical backcasting from previous PSPS events as well as retroactive interpolation prior to PSPS.
- This area may benefit from data sharing given the large variances between number of events for IOUs and SMJUs.
- The RMWG should conduct further evaluation on the balance between PSPS risk and wildfire risk for both the planning and operational models.

**Date:** 5/25/2022

**Topic:** Modeling Algorithms, Part 1.

**RMWG Summary**

This RMWG focused on discussing how to select between physics- and data-driven models, including whether any data-driven models (such as statistical or machine learning-based) are being used as sub-models within physics-based models.

PG&E states that data should be in the physics models and physics should be in the data models, thereby not leaving a clear cut between the two. Specific failure mode models are more physics-based, but are often statistics-based. PG&E uses Monte Carlo and simulation experiments, as well as a machine learning tool. PG&E also uses sensitivity models to understand covariates and how to weigh factors.

SCE agrees that physics-based models alone will not provide full optics or visibility, and that statistics-based and physics-based models should agree given that they are modeling the same situation. SCE uses natural distributions to evaluate how individual features affect model outputs, and receiver operating characteristic curves for sensitivity.

SDG&E states that understanding the problem space and available data is key, with imbalance of class data being a common issue for risk modelers given the small amounts of data available.

SMJUs discussed the need for suitable data for application and are still evaluating what data is available and whether it is suitable.

During this meeting, Energy Safety also led a discussion on the formatting of the RMWG meetings and sought more documentation via slides from IOUs and SMJUs every week, as well as sending prompts to provide responses in advance.

**Takeaways:**

- Understanding how IOUs are using the models is critical. Design basis is critical in an engineering system, but it is difficult due to the broad uncertainty in environmental impacts.
- More evaluation and understanding on the interplay of co-factors across various portions of modeling is key, with wind being an important example given the effects on both ignition and consequence.
- Model verification, validation, and sensitivity performance is key in understanding covariates and causalities relating to risk. Part of this should involve data sharing across utilities regarding outages and ignitions to increase data set sizes and useability.

**Date:** 6/15/2022

**Topic:** Wildfire Related Modeling Algorithms, Part 2.

**RMWG Summary**

This RMWG focused on presenting IOU wildfire modeling algorithms, including inputs, outputs, and model applications.

PG&E presented their weather model, which produces a 30-year climatology. PG&E validates the outputs from each case against hundreds of weather stations and uses the most accurate Weather Research and Forecasting (WRF) configuration for operational testing.

SCE's weather model is deterministic and applies one core model and one configuration model. The weather modeling team consists of both internal experts and vendors. One of the weather modeling vendors tests many configurations and then ranks the best performing configurations.

SDG&E uses a weather modeling approach similar to SCE. SDG&E selects modeling schemes based on an analysis of test cases through simulations. The development of the SDG&E model has involved collaboration with universities and government agencies. Many test cases generated in the research are now available for public review. A vendor is currently refining the weather prediction model for use as an operational model. The current weather prediction model supports operational, short-term, and long-term applications, including climate change simulation.

**Takeaways:**

- The RMWG should conduct further evaluation to identify the difference between the probability of ignition and the probability that such ignition turns into a catastrophic wildfire.
- IOUs and SMJUs should be clear about the processes for validation, including the uncertainty percentages at each aspect of its model to understand

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| compounding uncertainty. Validation should also include comparison to real-world data including weather station data. |
| **Date:** 7/13/2022 |
| **Topic:** Modeling Algorithms, Components, Linkages, and Interdependencies, Part 1. |
| **RMWG Summary** |
| This RMWG focused on discussing machine learning biasing procedures when used to reduce the risk of ignition or PSPS, risk model validation/verification methodologies, and described how each IOU charts wildfire and PSPS risk model components—such as inputs, outputs, and variables.<br><br>The PG&E process begins with historical in-house data and data sets produced by a vendor. PG&E merges the data sets and uses them to train a probabilistic model. The model then goes through a Quality Assurance (QA)/Quality Control (QC) process. The historic data is then segmented, and the model is initially trained with those partial data sets represented by each segment. PG&E runs this process in parallel with the former models to help identify any bias in the machine learning. The results may indicate a need to retrain a machine learning model, or to use another method for forecasting such as logistical regression. At the end of the process, the PG&E team validates the machine learning models using current procedures, and a panel of experts review the models before implementation.<br><br>SDG&E applies a similar approach in the development of machine learning models. The process to bias machine learning models involves selecting only observations for which a wind speed step occurred and historic observations within a specific data range. SDG&E also intentionally introduces bias into machine learning models by removing outliers in regression models, selecting time windows used to calculate maximum observed wind gust, and through random sampling of non-event cases.<br><br>SCE follows a model biasing process that involves training vendor models with about 6-months of weather data. SCE removes unintentional bias in these models by using random forest mode predictors and by using weather station point locations that have predictors weighted differently to cut errors, such as root mean square error.<br><br>PacifiCorp, Liberty, and BVES currently do not incorporate machine learning into their forecasting models.<br><br>PG&E, SDG&E, and SCE share commonalities in how they substantiate each model and component. These methods include model validation, performance metrics, SME review, and industry best practices.<br><br>PacifiCorp follows a mostly qualitative approach to validate risk and weather models, BVES uses vendors to validate the models, and Liberty’s approach involves a qualitative and quantitative approach. |

**Takeaways:**

- The RMWG should conduct further evaluation to understand the various types of machine learning models currently used, including validation and tactics to understand potential biases.
- Data use is key as inputs to machine learning models and could benefit from cross-utility sharing, particularly for SMJUs.

**Date:** 8/10/2022

**Topic:** Modeling Algorithms, Components, Linkages, and Interdependencies, and Climate Change, Part 2.

**RMWG Summary**

This RMWG focused on reviewing schematic charts for IOU wildfire risk models and PSPS risk models. The schematics presented connections between inputs/outputs, variables, sub-modules, and other models.

SDG&E's wildfire planning model is a weighted-sum model and does not apply conditional probability. The model instead uses weighted factors to adjust the ignition rate and then normalizes the top-down values per historical ignition counts. SDG&E uses marginalization in its model. Circuit-segment annual ignition rate is calculated from the global annual rate. Their wildfire operational model does not use marginalization.

Regarding conditional accounting, and balancing conditional probabilities and biases, PG&E interprets these inquires as related to covariance between conditions contributing to event causes and event consequences. Regarding probabilities, their model covariance structure will vary by cause, sub-cause, and equipment type. The PG&E team trains separate subset models accordingly. These models represent different causal pathways with drivers of such causes embedded in the estimates for each subset and revealed in the importance of specific covariates.

PacifiCorp currently uses a combination of qualitative SME and quantitative inputs to account for and balance ignition-related risks and consequences.

**Takeaways:**

- There is variability across the Global Climate Model (GCM) followed by all IOUs in their current efforts to address climate change impact on their risk models, with some guidance from CPUC's Climate Change Adaptation Order Instituting Rulemaking (OIR) and CalAdapt.
- There is also much variability in how GCMs isolate climate change impact.
- Regarding climate change preparedness as of today, the IOUs are focusing on infrastructure hardening and system resilience as well as determining the necessary timing for hardening based on forecasted events.

**Date:** 9/14/2022

**Topic**: Lessons Learned, Guideline Improvements, Topics for the Next Session.

**RMWG Summary**

This RMWG focused on IOU climate change impact modeling and approach. SDG&E, SCE, Liberty, PacifiCorp, and BVES presented.

PacifiCorp, Liberty, and BVES look to consultants/vendors, and SDG&E, PG&E, and SCE for treatment and inclusion of climate change impact. They plan to expand their modeling capabilities within these areas.

All three SMJUs expect further guidance from CalAdapt, the fifth climate assessment, and the Pyregence project,[1] among other sources. Current climate change impact models used by SMJUs forecast up to the year 2050 using data gathered from vendors. Data collected includes variables such as fuels, weather, and regional trend data.

Modular risk modeling and its advantages over the current standard of monolithic enterprise risk modeling was covered at a high-level. The advantages discussed included scalability, reusability, a framework, and reduced maintenance costs.

SDG&E noted that the RMWG illustrated many areas of data and modeling overlap between the IOUs and suggested potential opportunities for collaboration and standardization. SDG&E also emphasized the importance of balancing the cost of modeling, and model/data improvement, with the value of those improvements to management decisions.

Multiple RMWG members suggested that in Phase II the RMWG meetings should transition from primarily discussing current modeling approaches to collaborating on potential improvements and best practice modeling approaches.

Stakeholders (MGRA, GPI, and Sam Savage) pointed out that flattening wildfire risk scores into single composite risk score values (e.g., by averaging consequence scores or combining multiple risk driver scores (equipment, Contact from Object, vegetation, etc.), introduces potential errors and/or results in a loss of probabilistic assessment. For example, if wildfire consequence results are not normally distributed (i.e., they are skewed or bimodal), flattening by averaging prevents stochastic modeling from capturing tail risk (an unlikely but very high impact risk) or confidence levels. Also, flattening prevents capturing when variables are interrelated such as risk event driver and weather, or environmental conditions that affect consequence (e.g., wind).

Multiple RMWG members pointed out that operational and planning models are very different even when talking about the same risk or mitigation (e.g., PSPS), and that a differentiation should explicitly be made in the discussions of these models going forward.

PG&E pointed out a need for third party Independent Verification and Validation (IV&V) alignment of risk models, and standardizing approaches to handling the transition from probabilities to deterministic units. They also pointed out a need for standardized approaches to measuring risk model performance.

[1] Pyregence project. Available at: https://pyregence.org/

Liberty pointed out that Energy Safety guidance documents and reviews should keep in mind that SMJUs may not have the resources (financial or personnel), or the large ratepayer bases, to support wildfire mitigation modeling, planning, and mitigation tools and activities that the larger IOUs can justify.

Stakeholders (MGRA, GPI, and Sam Savage) raised several items for consideration during Phase II, including the necessity of defining risk planning standards or thresholds (e.g., 1-in-2-year, -10 year, or -100-year wildfire event) that will inform risk model design as well as risk model-informed mitigation selection; and potential improvements in ingress-egress modeling, such as accounting for choke-points.

**Takeaways:**

- IOUs noted the commonalities present in their risk models, development methods, and data use will allow for greater collaboration going forward; they want the RMWG to move from organizing discussions to facilitating action.
- Due to the complexity of the risk models used, any proposed changes should be evaluated for potential benefits to ensure the change and downstream effects are worth the cost.
- IOUs noted that the RMWG should once again cover planning and operational models but at a greater depth than what occurred in Phase I. Additionally, going forward, a distinction should be made between the two types of models whenever a discussion on risk modeling occurs.
- SMJUs noted that it’s critical for Energy Safety to consider that smaller utilities do not have the customer base to justify the cost of implementing the mitigation research, planning, tools, and practices of large IOUs.

**Date:** 12/14/2022

**Topic:** Comprehensive Accounting for Wildfire Smoke Consequences.

**RMWG Summary**

Topics covered included the value and feasibility of extending wildfire consequence models to include the impact of smoke on air quality (and hence, health) and the social cost of wildfire related carbon-dioxide (Co2) emissions with respect to climate change. SDG&E has attempted to incorporate this approach into their models by assigning an assumed total effective cost per acre burned, but in general this is not a mature or widely used aspect of current modeling.

**Takeaways:**

The IOUs seem receptive to extending the way they calculate the consequence of fire to incorporate the impact of smoke and greenhouse gases, with the following caveats:

- IOUs would like the model and parameters to be provided to them, rather than developed by them.
- IOUs would like the model to be simple and compatible with the existing wildfire modeling parameters, so either of the following would be reasonable:
    - An assumed cost per acre burned.
    - An assumed cost per acre burned, adjusted based on geographic regions, like the HFTD map. The regional breakdown would presumably account for both typical vegetation, typical wind directions, and proximity

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| | to population centers. For example, the impact of wildfire smoke in some regions may be more detrimental than an equivalent number of acres burned in a different region. |

# 3 Phase II RMWG Topics

Phase I of the RMWG was primarily used for information gathering and understanding how to more effectively organize and arrive at concrete solutions that can improve how IOUs and SMJUs conduct, validate, and report fire risk modeling. Phase II is intended to review topics that were not thoroughly covered or not covered at all in Phase I. In addition, the intention of Phase II is to improve how the RMWG generates and distributes best practices in fire risk modeling.

Section 3.1 contains potential Phase II topics and on-going areas of work that were identified during Phase I. The topics have been assigned a priority rating using stakeholder input: high, medium, and low.

Phase II topics directly involving climate change and community vulnerability may be added based on the scoping meetings resulting from Energy Safety's 2022 Wildfire Mitigation Plan reviews.

## 3.1 Planned Phase II Topics

1. Wildfire Consequence Modelling – Conflagration Risks:
    - Priority: High
    - Description:
        - Structure-to-structure spread, or conflagration, is a critical element of high consequence wildfires.
        - Separate from plume driven long-range spotting, the other phenomenon that has driven California's very high consequence wildfires is structure-to-structure ignition or conflagration.
        - Conflagration occurs when a wildfire directly ignites homes on the wildland-urban interface, which then generate heat and embers that ignite homes located adjacent to them.
    - Rationale:
        - This RMWG may explore best practices in modeling conflagration risk and how conflagration risk can be standardized and factored into wildfire modeling.
        - Without a better understanding of how conflagration risk is incorporated into modelling, it is difficult to understand where and which mitigations will prove most effective.

2. Approaches to Factoring Ingress and Egress into Fire Models:
    - Priority: High
    - Description:
        - Considerations of limited or threatened ingress (i.e., emergency personnel) and egress (i.e., evacuation of civilians) can have significant impact on the potential consequences of a wildfire, and hence, on the risk mitigation strategy and priority for some circuits.

        - Role of overhead conductor and communications as possible egress risk should be evaluated.
    - Rationale:
        - This RMWG may explore relevant geolocated ingress and egress related data, ways to incorporate that data into wildfire operational and planning models, and standardizing and incorporating ingress/egress data.

3. Approaches to Modeling Long Duration, High Intensity Wildfires:
    - Priority: High
    - Description:
        - Current approaches to modeling the likely impact of wildfires uses a combination of utility specific ignition models and Technosylva's 8-hour models of growth.
    - Rationale:
        - This RMWG may help provide guidance for modelling long duration (>8 hours) wildfires.
        - Existing models may fail to account for the risks associated with long duration (measured in days or weeks) and large (>10,000 acre) fires, therefore missing extended risks as observed in previous catastrophic fires.

4. Coordinating State and Utility Wildfire Planning and Initiatives:
    - Priority: High
    - Description:
        - Utility wildfire mitigation work may impact overall wildfire risk within California and its initiatives to reduce wildfire risk may impact utility risk consequence modelling, hence affecting utility risk prioritization.
        - This topic will explore ways for utilities and State agencies to coordinate and share risk-related data with organizations such as CalFire and federal forest management agencies.
    - Rationale:
        - This RMWG may explore synergies between stakeholders that are participating in wildfire risk reduction throughout California.
        - There may be opportunities for data and model sharing between stakeholders.

5. Creating and Maintaining an Out-Year Fuelscape:
    - Priority: Medium
    - Description:
        - Wildfire mitigation plans are impacted by fuelscape maps.
        - Fuelscape maps incorporated into risk models may be static depicting moment-in-time conditions, or may depict more current conditions depending on how often the map is updated.
        - A fuelscape map changes over time due to various factors such as development incursion (e.g., new housing), vegetation regrowth, the

        - impact of climate change on average temperature and drought, past wildfires and fire scars, and other factors.
    - Rationale:
        - This RMWG may explore approaches to incorporating improved fuelscape inputs into existing risk models.
        - Incorporating likely changes in the fuelscape over time into risk models has the potential to optimize long term wildfire mitigation plans.

6. Approaches to Factoring Suppression into Fire Models:
    - Priority: Medium
    - Description:
        - Current fire models do not factor in fire suppression (firefighting). Fire suppression is not uniformly effective. Different terrains, proximity to suppression resources, vegetation types, time of day, weather conditions, and other conditions impact the effectiveness of fire suppression.
        - Understanding and modeling fire suppression may impact both wildfire planning and operational models, such as PSPS models.
    - Rationale:
        - This RMWG may review fire suppression modeling needs, current models and data, and future strategies.
        - Factoring suppression into the models will hopefully help create more effective deployment of preemptive and live mitigations, given the more accurate parallels observed in-field and the potential significant impacts of suppression.

7. PSPS Planning Models:
    - Priority: Medium
    - Description:
        - The objective will be to validate that current utility PSPS planning models are optimized to balance safety and wildfire risk versus reliability and consequences associated with PSPS events.
        - While not a direct wildfire risk impact, PSPS impacts impose other safety risks that utilities must consider as part of planning and mitigation selection.
    - Rationale:
        - This RMWG may focus on current utility PSPS planning models and look for opportunities to standardize or improve PSPS planning models across the utilities.
        - Utilities need to demonstrate that PSPS risk analysis includes both cascading safety and financial risks.
        - Utilities also need to demonstrate how PSPS risk is considered when deploying mitigations and applying future reduction of PSPS events, including determinations of thresholds for PSPS events based on applied mitigations.

8. Avoiding Bias in Wildfire Probability Modeling:
    - Priority: Medium
    - Description:
        - Wildfire modeling may include built-in bias, which should be identified and understood for potential output impacts.
        - For example, if any circuit that is experiencing winds of 75+ mph is shut down, then a wildfire ignition model might conclude that high wind conditions are very low risk from an ignition perspective because there are no ignition events once winds reach this value.
        - For instance, the aggressive use of PSPS for impacted circuits can reduce a utility's ignited wildfire risk, but as an unintended consequence, models that are adjusted based on ignition data may become biased.
    - Rationale:
        - This RMWG may explore ways to remove bias from wildfire planning models.
        - Utilities need to demonstrate an understanding of various biases across models to accurately balance, account for, and adjust model outputs accordingly to decrease inaccuracies or unintended overscoring of certain risks.

9. Review of Wildfire Related Operational Models:
    - Priority: Medium
    - Description:
        - Previous RMWG meetings focused primarily on planning models in terms of discussion, with some discussion of operational models mixed in.
        - Operational models should be used to inform various aspects of operations, such as PSPS, protective device settings, resource deployment, and responding to potential risk events.
    - Rationale:
        - This RMWG may explore how utilities can validate that the models are optimized for safety and will look for opportunities to standardize or improve models.
        - This meeting may facilitate explicit and a clear time to discuss best practices and components of operational models.

10. Model Maintenance and Data Collection:
    - Priority: Medium
    - Description:
        - Both operational and planning models require ongoing maintenance (calibrations, extensions, etc.) that typically requires data to validate and update the models.
        - Models need accurate data, including refinements and updates, to provide useful and reliable outcomes, particularly when using machine learning within models.

- Rationale:
  - This RMWG may explore approaches to standardizing and enhancing model maintenance, including data collection and calibration.
  - Accurate and sufficient data is a major key to the success of models, whether this means minimizing data gaps, updating frequently as new information becomes available, or scrubbing for inaccuracies. Without obtaining proper data sources and upkeep, model outputs would not be reliable.
  - Through previous RMWG meetings, utilities have shown that sharing data can increase modeling potentials, especially for SMJUs that have smaller territories and therefore fewer self-collected data sources.

11. Standardized Wildfire Risk Type Classifications and *in situ*[2] Wildfire Risk Assessment Models:
    - Priority: Medium
    - Description:
      - Most discussions of wildfire risk in a utility setting deal with utilities as sources of wildfires (transmitted risk). Utilities, however, are also receivers of wildfire risk. Wildfires can damage generation, transmission, and distribution equipment (assets), which threatens reliability.
      - The California Energy Commission (CEC) is currently funding an ongoing project under the Electric Program Investment Charge (EPIC) program to develop open-source wildfire risk models (in situ models) to assess wildfire threats to the electric power systems in California.
    - Rationale:
      - This RMWG may review work in this area, propose standardized wildfire risk type classifications, and develop recommendations for modeling and mitigating received wildfire risk.
      - Understanding and defining wildfire risk is necessary outside utility-caused ignitions, particularly when considering mitigations meant for loss prevention.

## 3.2 Other Topics:

The topic areas below are important and may be integrated in Phase II topics covered during separate, parallel tracks outside of the RMWG or potentially as part of future RMWG work.

1. CPUC HFTD Map Update Process and Current Status
2. Climate Change Impact on Models

[2] In this context, *in situ* refers to wildfires where the utility is a receiver of wildfire risk (i.e., where the wildfire ignition was not utility caused).

# 4 Coordination with CPUC TWG

In tandem with Energy Safety's RMWG, the CPUC hosts "Technical Working Group" (TWG) workshops. The solutions that are sought by both groups—CPUC's TWG and Energy Safety's RMWG—have a high degree of synergies. Energy Safety will continue to coordinate with the CPUC regarding conference topics and outcomes.

# 5 Conclusion

The RMWG was formed to improve consistency across utilities in terms of risk modeling, data sets used, methods applied, and to identify and promote best practices for modeling in areas such as:

- the likelihood of ignitions;
- the consequences of ignitions; and
- the extent to which varying mitigation alternatives impact the frequency and duration of PSPS events.

The RMWG has increased transparency of utilities’ models and provided a conduit for information exchange between utilities, stakeholders, and outside experts.

# 6 Acronyms

| | |
|---|---|
| BVES: | Bear Valley Electric Service |
| CEC: | California Energy Commission |
| CFO: | Contact From Object |
| Co2: | Carbon-Dioxide |
| CPUC: | California Public Utilities Commission |
| Energy Safety: | California Office of Energy Infrastructure Safety |
| EPIC: | Electric Program Investment Charge |
| ESJ: | Environmental and Social Justice |
| GPI: | Green Power Institute |
| HFTD: | High Fire Threat District |
| ICE: | Interruption Cost Estimate |
| IOU: | Investor-Owned Utility |
| LiDAR: | Light Detecting and Ranging |
| MAVF: | Multi-Attribute Value Function |
| NDA: | Non-Disclosure Agreement |
| NDVI: | Normalized Difference Vegetation Index |
| NPV: | Net Present Value |
| O&M: | Operations and Maintenance |
| OIR: | Order Instituting Rulemaking |
| PG&E: | Pacific Gas & Electric Company |
| POET: | Power Outage Economic Tool |
| PoI: | Probability of Ignition |
| PSPS: | Public Safety Power Shutoff |
| QA: | Quality Assurance |
| QC: | Quality Control |
| RMWG: | Energy Safety's Risk Modeling Working Group |
| ROC: | Receiver Operating Characteristic |
| RSE: | Risk Spend Efficiency |
| SCE: | Southern California Edison |
| SDG&E: | San Diego Gas & Electric Company |
| SME: | Subject Matter Expert |
| SMJU: | Small and Multi-Jurisdictional Utility |
| TCO: | Total Cost of Ownership |
| TWG: | CPUC's Technical Working Group |
| UC: | University of California |
| WMO: | Wildfire Management Overlay |
| WMP: | Wildfire Mitigation Plan |
| WRF: | Weather Research and Forecasting |
| WSAB: | California Wildfire Safety Advisory Board |

# 7 Glossary

Conflagration: A large fire often started through structure-to-structure spread.

Deterministic Model: A model that allows for the exact calculation of future events when all the necessary data for an exact calculation is available.

Environmental and Social Justice: Fair treatment and meaningful involvement of all people with respect to the development, implementation, and enforcement of environmental regulations.

Egress: A plan, route, or means to exit an area during a fire emergency.

Fuelscape: Plans for the treatment of varying fuels before and during cases of fires and proximity to fires.

Ingress: A plan, route, or means to enter an area during a fire emergency; a concern for law enforcement and fire departments.

LiDAR: Light Detecting and Ranging; a remote sensing method used to examine the surface of an area.

MAVF: Multi-Attribute Value Function; a model being applied by utilities to assess wildfire ignition probabilities and estimated consequences.

Net Present Value: The difference between two sequences of dollar amounts; dollars in and dollars out, each amount in each sequence discounted by their applicable interest rate depending on how far into the future the dollar amount will be received or spent.

Probability of Ignition: A model for rating the likelihood that a fire will ignite on specific areas and grow based on local fuels.

Open-source: Usually a software project or methodology where the original code or formulas used are openly available at no cost in the interest of creating a dedicated community of contributors who improve the software or methodology.

Operational Model: Model used in day-to-day and real-time utility operation.

Optimization: The action of making the best or most effective use of a resource (e.g., optimizing risk for dollars spent).

Planning model: Models used to forecast risks and need for mitigation; years, decades, and longer-term (such as climate change mitigations).

Risk Bowtie: A schematic, usually a diagram, that graphically presents the relationship between sources of risk, controls, escalation factors, events, and consequences.

Risk Spend Efficiency (RSE): The benefit to cost ratio for risk reduction programs, calculated by dividing the net present value of risk reduction scores by the net present value of program costs.

Risk Taxonomy: A comprehensive list of risk categories commonly used in enterprise risk identification.

Standardization: The process of conforming to a standard (e.g., conforming to a standard fire model, a standard consequence model).

Stochastically: Doing something by means of a process involving a randomly determined sequence of events.