REPORT

RISK MODELING WORKING GROUP SUMMARY REPORT, PHASE II

Summary of Discussions from 2023

PREPARED FOR

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Revision Record Summary

Revision	*Revision Summary*
0	Initial issue

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Acronyms and Terms

BLM:	Bureau of Land Management
BVES:	Bear Valley Electric Service
CalAdvocates:	CPUC Public Advocates
CAL FIRE:	California Department of Forestry and Fire Protection
Cal OES:	California Office of Emergency Services
CalTrans:	California Department of Transportation
CPUC:	California Public Utility Commission
DHS:	Department of Homeland Security
Energy Safety:	Office of Energy Infrastructure Safety
EPA:	Environmental Protection Agency
GPI:	Green Power Institute
IOUs:	Investor-Owned Utilities
JH:	Jensen Hughes, Inc.
L4:	Level 4 Ventures, Inc.
LU:	Liberty Utilities
MGRA:	Mussey Grade Road Alliance
NWS:	National Weather Service
PC:	PacifiCorp
PG&E:	Pacific Gas & Electric
RCP:	Representative Concentration Pathways (Climate Change)
RFW:	Red Flag Warning
RMWG:	Risk Modeling Working Group
SCE:	Southern California Edison
SDG&E:	San Diego Gas & Electric
SMJU:	Small Multi-Jurisdictional Utilities
USFS:	United State Forest Service
WSAB:	Wildfire Safety Advisory Board

Executive Summary

The Office of Energy Infrastructure Safety (Energy Safety) formed the Risk Modeling Working Group (RMWG) in 2021 with the stated goals to:

- Develop a more consistent approach to wildfire risk modeling
- Improve collaboration among the electrical corporations on wildfire risk modeling
- Provide an environment for stakeholders and academic experts to provide input on wildfire risk modeling methods
- Increase transparency in electrical corporation approaches to wildfire risk modeling

The group met approximately monthly since 2021 to discuss a variety of topics. These discussions are organized into annual phases (except for Phase I which included meetings that occurred in both 2021 and 2022). This report summarizes the discussions from Phase II, which occurred in 2023. The topics discussed in these meetings are summarized in Table 1.

Table 1. List of Phase II (2023) RMWG meetings

Date	Topic
Jan 11	Finalizing Session Topics for RMWG 2023
Feb 15	Coordination of Government Wildfire Plans with Utility Wildfire Mitigation Plans
Mar 15	Creating and Maintaining an Out-Year Fuelscape
Apr 12	Wildfire Consequence Modelling – Conflagration Risks
May 10	Approaches to Factoring Suppression into Fire Models
Jun 14	Approaches to Factoring Ingress and Egress into Fire Models
Jul 11	Approaches to Modeling Long Duration, High Intensity Wildfires
Aug 9	PSPS Planning Models
Sep 14	Avoiding Bias in Wildfire Probability Modeling
Oct 11	Standardized Wildfire Risk Type Classifications and in situ Wildfire Risk Assessment
Nov 8	Model Maintenance and Data Collection
Dec 13	Review of Wildfire Related Operational Models

The general structure of the meetings was similar to Phase I meetings, with the Office of Energy Infrastructure Safety (Energy Safety) providing the electrical corporations with a series of prompts prior to the meeting and asked to prepare a short presentation to guide the discussion. In some meetings, an external speaker presented on a related topic for discussion.

After finalizing the topics for 2023 in January, the first technical discussion in February discussed the coordination between electrical corporations and various government stakeholders at the local, state, and federal levels. The electrical corporations use data from many different federal resources as part of their planning and operations modeling efforts. Collaboration at the state level focuses more on specific planning activities as well as emergency response planning. Coordinating permitting for implementation of mitigation activities is done at the local level.

The next five workshops focused on specific aspects of modeling the consequences of a wildfire within a service territory. The discussion in March focused on best practices in maintaining and updating the electrical corporation's database of fuels across their respective service territories. The stakeholders discussed accounting for regrowth of vegetation in previously burned areas, long-term changes in land use (e.g., desertification, urbanization, agricultural development), and the methods used to conduct these updates. The April workshop focused on the ignition of buildings and the extent to which the electrical corporations consider the potential for building-to-building (i.e., conflagration) fire spread in their risk models. At this time, conflagration is not used in risk models due to a lack of data and data quality. Electrical corporations requested that a single entity manage a state-wide repository of structural data should conflagration risks be considered in the future.

The following two meetings continued the discussion on modeling the consequences of a wildfire with discussions on factoring in suppression (May) and ingress/egress (June). CAL FIRE provided an overview of wildfire suppression strategies to the RMWG and fielded questions on the topic. Most electrical corporations do not think that suppression should be included as a parameter in the models at this time, particularly in operational models where electrical corporations' do not have control over the outcomes, such as suppression. There was general agreement that future development could include suppression in the planning models; however, additional data, modeling methods, and validation efforts are needed before use in planning. For similar reasons, the electrical corporations generally agree that leveraging ingress/egress models or data for operational decision making is outside their scope of responsibility and not recommended at this time. However, all electrical corporations are considering egress in planning models to some extent. Additional discussion is needed on the data, indices, and how these can be used in the risk calculation.

The last meeting focused on wildfire consequences discussed approaches to modeling long duration wildfires. A guest speaker from the U.S. Forest Service provided a detailed presentation on research conducted by his team showing models that achieved similar statistical distributions for burned areas compared to historical fires. He also identified key challenges associated with modeling long-duration large fires based on fundamental issues with the data and modeling approaches. The electrical corporations presented simplified approaches to incorporate long duration wildfires into the modeling approaches. SCE provided a specific example case demonstrating that the relative risks across their service territory did not vary when based on 8-hour or 24-hour simulations. The general consensus was that the electrical corporations were using 8-hour simulations at the time and the benefits of extending models to long duration fires at this time were unclear as the results presented in the meeting indicated it does not affect which areas are the contributors to the highest amount of wildfire risk. However, this topic should be further studied because it will have an impact on the magnitude of the risk which informs the acceptable risk thresholds and cost benefit analysis.

The August meeting focused on planning models used for PSPS. Each participating electrical corporation presented its approach to establishing thresholds/criteria for PSPS informed by the modeling approaches. The discussion focused on the multi-attribute value functions (MAVFs) applied to the safety, reliability, and financial criteria required in the S-MAP process at the time of the meeting. There was variability in the approaches used, particularly in the calculation methods for reliability and financial criteria. The electrical corporations also discussed the historic lookback period used in these planning models, which varied by electrical corporation.

The September meeting focused on avoiding bias in wildfire probability models. A guest speaker from L4 presented at a high level about limiting bias in models, including a discussion of key sources of bias and defensive strategies that can be employed to combat these biases. The discussion from the electrical corporations on the topic focused on strategies to avoid systematic over and under prediction of risk factors. Members of the RMWG collectively identified a need for improved standards or guidelines on what validation activities and uncertainty assessments are necessary to mitigate these effects.

The October meeting discussed standardization of wildfire risk types and assessment. An external speaker from REAX provided a demonstration of the Pyregence tool, which was developed on behalf of the California Energy Commission Electric Program Investment Charge (EPIC) program. The electrical corporations discussed their level of engagement with the Pyregence tool at this stage. The weather station siting tool in particular had been used by several of the electrical corporations and was of particular interest. The electrical corporations also presented their categorization schemes for consequential fires, which varied from corporation to corporation. The electrical corporations requested a more standardized approach to categorizing consequential wildfires, in particular a working definition of a “catastrophic” wildfire from Energy Safety.

The discussion in November focused on the on-going maintenance (e.g., data collection, calibrations, verification, validation) required in both operational and planning models. The majority of the discussion focused on data governance processes employed by the electrical corporations and data that electrical corporations are willing to share with other stakeholders. In general, models and sub-models are updated annually or as needed as new data is collected or parameters change.

The last meeting of 2023 was a discussion focused on operational models. The electrical corporations noted the main difference between planning and operations is time. This includes both the time horizon of the projected event (hours or days vs. weeks to years) and the frequency of input updates. The electrical corporations use planning models to prioritize mitigations and operational models to guide immediate operational decisions. The electrical corporations noted that weather forecasts tend to under-predict the wind speeds in high-risk conditions with high winds. Due to the higher uncertainty in operational forecasts, the weather forecasts are considered as a data point in the operational decision-making process, but the final decision is up to the operators and is typically based on weather station data.

1.0 Introduction

1.1 BACKGROUND

The Office of Energy Infrastructure Safety (Energy Safety) formed the Risk Modeling Working Group (RMWG) in 2021 with the stated goals to:

+ Develop a more consistent approach to wildfire risk modeling
+ Improve collaboration among the electrical corporations on wildfire risk modeling
+ Provide an environment for stakeholders and academic experts to provide input on wildfire risk modeling methods
+ Increase transparency in electrical corporation approaches to wildfire risk modeling

The group has met approximately monthly since 2021 to discuss a variety of topics. These discussions have been organized into annual phases (with the exception of Phase I which included 2021-2022).

Phase I consisted of 13 meetings from October 2021 to December 2022. Table 2 provides a list of the topics discussed during Phase I of the RMWG. The discussions, outcomes, and takeaways from these meetings are summarized in the Phase I report[1] which was published on the Energy Safety docket[2] on June 15, 2023.

Table 2. List of Topics from Phase I

Date	Topic
10/5/2021-10/6/2021	Initial RMWG Presentations
10/27/2021	RMWG Organizational Conference
11/17/2021	Review of Consequence Models
12/8/2021	Risk Drivers, Probability of Ignition Models, and Data/Inputs
3/2/2022	Likelihood of Vegetation Risk Events and Ignitions
4/13/2022	PSPS Likelihood and PSPS Consequence, Reliability Analysis, and Impacts
5/25/2022	Modeling Algorithms, Part 1
6/15/2022	Wildfire Related Modeling Algorithms, Part 2
7/13/2022	Modeling Algorithms, Components, Linkages, and Interdependencies, Part 1
8/10/2022	Modeling Algorithms, Components, Linkages, and Interdependencies, and Climate Change, Part 2
9/14/2022	Lessons Learned, Guideline Improvements, Topics for the Next Session
12/14/2022	Comprehensive Accounting for Wildfire Smoke Consequences

This report documents the discussions occurring during Phase II (2023).

[1] Level 4 Ventures, Inc. *Risk Modeling Working Group Summary Report, Phase I*, 2023.
[2] Risk Model Group Docket, https://efiling.energysafety.ca.gov/EFiling/DocketInformation.aspx?docketnumber=Risk-Model-Group

1.2 RMWG SCOPE

The scope of the RMWG as documented in the Phase I summary report includes but is not limited to the following topics:[1]

- Data
  - Used in each model and model component
  - Sources and/or data sharing across electrical corporations
  - Quality, including updates and associated triggers, accuracy, and quality checks
  - Frequency of model input updates, including the basis for these updates
- Algorithms
  - Modeling components, linkages, and interdependencies
  - Physics and physical systems
  - Data-driven algorithms used in models (e.g., statistical, machine learning, or artificial intelligence)
  - Software design, implementation, and modularity
- Risk Considerations
  - Weighting of modeling inputs, components, and outputs
  - Impact of climate change on risk modeling results
- Substantiation
  - Confidence and uncertainties for each model and modeling components, including how confidences were determined
  - Verification of modeling inputs and outputs
  - Impact of uncertainty on model outputs
- Standardization
  - Identifying where consistency is infeasible or not necessary
  - Requirements for collaboration across electrical corporations

1.3 DOCUMENT SCOPE AND PREPARATION

The purpose of this document is to summarize the discussions from each meeting of the RMWG during Phase II (2023). At the time of preparation, Phase III of the RMWG (2024) has also been completed and Phase IV (2025) has started. The summaries presented herein focus on the discussions that occurred in 2023. The content of this document was prepared based on slides and detailed minutes provided to Jensen Hughes, Inc. (JH) by Energy Safety.

1.4 MEMBERSHIP OF THE RISK MODELING WORKING GROUP

The RMWG meetings are open to Energy Safety, electrical corporations, stakeholders, and technical expert members to allow for open dialogue. This process allows the group to dive into technical details among members who are committed to attending regularly. Interested parties can apply to be members of the working group by submitting an application to the Risk Model Group docket. Energy Safety staff review each application and admit approved applicants to the meeting group.

1.5 RMWG MEMBERS

The membership during Phase II of the RMWG is summarized in Table 3.

Table 3. RMWG Members During Phase II

SMJU: Bear Valley Electric Service (BVES) Liberty Utilities (LU) PacifiCorp (PC)	**IOU:** Pacific Gas & Electric (PG&E) San Diego Gas & Electric (SDG&E) Southern California Edison (SCE)	**Vendor:** Technosylva Reax Engineering
State Agency: California Public Utility Commission (CPUC) California Department of Forestry and Fire Protection (CAL FIRE) Office of Energy Infrastructure Safety (Energy Safety) Wildfire Safety Advisory Board	**Stakeholder:** Green Power Institute CPUC Public Advocates Mussey Grade Road Alliance	**Advisory:** Level 4 Ventures

1.6 CONTRIBUTIONS

Members of the RMWG during Phase II were invited to provide comments on this Summary Report. Members had 14 days to review with comments due on April 4, 2025. The following individuals and organizations submitted comments:

- Green Power Institute

2.0 Phase II Summaries

The following subsections provide a high-level summary of the discussions from Phase II of the RMWG occurring during the calendar year of 2023. Each meeting included a set of questions or prompts which electrical corporations were asked to address during the meeting. The discussions centered on these prompts, but the conversations were allowed to diverge from these prompts as the conversation evolved. In some meetings there was also an external speaker invited to provide a technical presentation related to the topic at hand.

The following sections provide the following information from the meetings:

+ Summary of external speaker's comments (if applicable)
+ For each question that was posed:
  - What are the electrical corporations doing the same? What are they doing differently?
  - What questions or parts of questions were not answered?
+ Other discussion:
  - What additional topics were covered that were not prompted?
  - What actions, suggestions, or recommendations for follow-up were mentioned? Were these addressed in a future meeting?

These sections provide high-level summaries of this information intended for public distribution.

2.1 01/11/23 – FINALIZING SESSION TOPICS FOR RMWG 2023

The focus of this meeting was to present a plan for the topics to be discussed for the remainder of the year and discussed with the RMWG for alignment. The floor was open to discussion from participants that could be invited to speak on various topics. Detailed minutes were not available for this session.

Table 4 provides a summary of the dates, topics, and prompts for each meeting occurring during Phase II. Note that the following dates, topic schedule, and prompts have been altered from the version discussed in January 2023 to match the final order of meetings and final discussion questions that were modified over the course of 2023.

Table 4. Summary of Phase II Topics and Prompts

Date	Topic
Feb 15	Coordination of Government Wildfire Plans with Utility Wildfire Mitigation Plans
Mar 15	Creating and Maintaining an Out-Year Fuelscape
Apr 12	Wildfire Consequence Modelling – Conflagration Risks
May 10	Approaches to Factoring Suppression into Fire Models
Jun 14	Approaches to Factoring Ingress and Egress into Fire Models
Jul 11	Approaches to Modeling Long Duration, High Intensity Wildfires
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2.2 02/15/23 – COORDINATION OF GOVERNMENT WILDFIRE PLANS WITH UTILITY WILDFIRE MITIGATION PLANS

This session focused on identifying the areas where electrical corporations collaborate and coordinate their wildfire mitigation plans with tribal, local, state, and federal government and agencies. The goal was to understand the current degree of data sharing and coordination to discuss whether improvements are needed in coordination with these groups. The guiding prompts provided to the electrical corporations on this topic were:

+ What government agencies, and related policies, have an impact on utility wildfire planning and mitigation? How are electrical corporations engaging with these agencies and policies currently?
+ What specific elements of the utility wildfire planning and mitigation modeling are impacted by these agencies and policies? In what way?
    - What coordination and/or data sharing currently takes place regarding these dependencies?
    - What new coordination and/or data sharing would offer value?
    - How should this coordination be implemented and managed?

Several similarities were noted in how the electrical corporations collaborate with government entities (the IOUs in particular). The IOUs described that they share data with local, state, and government agencies including Energy Safety, the CPUC, the California Office of Emergency Services (Cal OES), CAL FIRE, the United State Forest Service (USFS), the Department of Homeland Security (DHS), the Bureau of Land Management (BLM), the California Department of Transportation (CalTrans), and the National Weather Service (NWS). The individual electrical corporations also presented partnerships with tribal agencies, local fire and law enforcement, and stakeholders at critical infrastructure. Collaboration primarily includes coordinating and communicating risk mitigation efforts, obtaining policy-related materials (e.g., HFTD maps, red flag warnings, weather forecasts), and obtaining permits to conduct work. The majority of the electrical corporations use data from these various government sources indirectly through the use of Technosylva's wildfire model which sources some of its data from these collaborators.

The primary differences in collaboration with government entities were between the IOUs and the SMJUs. The smaller electrical corporations have a more limited breadth of collaboration with various groups. This is, in part, due to outsourcing larger parts of their risk modeling efforts to vendors compared to the IOUs which have dedicated teams allocated to wildfire risk modeling. In addition, the SMJUs are earlier in the development of their risk models and approach which limits the current scope of existing collaborations. Across the IOUs and the SMJUs there were differences in how the integration of planned activities from other agencies is used in the risk forecasts. This is due to uncertainties in the timeliness of planned work and the potential for priorities of the collaborators shifting. The electrical corporations expressed concerns that crediting risk mitigation from other groups is not desirable due to these implementation challenges.

While the electrical corporations touched on most of the questions that were posed in the prompts, most of the discussion was at a high level. Aside from HFTD maps and weather data, it was not clear to what extent data received from the collaborators is used within the electrical corporation risk models. Some examples that were mentioned include:

+ Data on egress/ingress from CalTrans was mentioned as a potential source, but the data are not representative of traffic patterns during emergencies.

- Data on CAL FIRE’s response time to fires in various areas was also mentioned, but it was unclear how this is used in the wildfire consequence models.
- Updates to fuel loads based on USFS planned mitigation activities and prescribed burns were also mentioned. However, the challenge on crediting risk mitigation from other groups was not resolved in this discussion.

Similarly, it was not clear to what extent government collaborators consider the electrical corporation WMP in deciding on specific projects to implement within their sphere of influence. The electrical corporations mentioned several challenges associated with expanding the use of collaborators data:

- Various agencies sometimes have conflicting definitions and/or policies. Examples include AFN definitions, reportable fire criteria, “catastrophic fire”, and assignment of responsible party for evacuations.
- The majority of data received from external agencies had limited usefulness because it was not designed or formatted with wildfire risk analysis in mind. This often results in missing attributes necessary for modeling.
- Even data from a reliable agency may reflect lags in data collection or incomplete collection, so electrical corporations may still be cautious to use data from agencies, stakeholders, or other electrical corporations.

The stakeholders noted a few groups and areas which were not mentioned by the electrical corporations but may be important for future collaboration. One such group that was mentioned was the Environmental Protection Agency (EPA), which may be important but was not mentioned. Evacuation planning was also absent from the collaboration lists discussed by the electrical corporations. A representative from SDG&E noted that this responsibility is held by local jurisdictions. This topic is discussed further in the June meeting on Ingress in Egress (see Section 2.6).

There were several actions, suggestions, and recommendations for follow-up mentioned during the discussions.

- Streamlining planning and permitting processes would improve ability to implement plans. Mitigation projects can experience delays due to requesting permissions from local and state agencies.
- The electrical corporations requested the creation of a common data repository where various agencies could host data. This is expected to result in the following benefits:
    - Remove the need for each electrical corporation to independently validate the same data
    - Reduce data acquisition costs, especially for smaller electrical corporations
    - Improve the preprocessing of data into a format more conducive to wildfire risk mitigation analysis
- There are several key terms and objectives that were undefined. Clarifying these aspects would improve the ability to collaborate. Some examples which were mentioned include:
    - No definition for “catastrophic fire”
    - No definition for acceptable risk tolerance threshold
    - No clear end goal for wildfire risk mitigation. There needs to be recognition of the cost-benefit. A “no risk” approach is not possible as there will always be some risk.
- The electrical corporations requested that absolute and relative risk be recognized as distinct concepts.

2.3 03/15/23 – CREATING AND MAINTAINING AND OUT-YEAR FUELSCAPE

This session discussed the approaches used to modify the fuelscape across a service territory for use in long-term risk mitigation planning. The fuelscape is expected to change over time as new urban areas develop (i.e., housing), vegetation grows (i.e., seasonal wetness and regrowth of burn scars) and changes (i.e., invasive species, climate effects, new burn scars), climate changes (i.e., average temperature and drought), fire scars, and other factors. Wildfire mitigation plans may need to consider these long-term effects and incorporate likely changes to the fuelscape over time into models. This session discussed current strategies to adapt fuelscapes to changing conditions. The guiding prompts provided to the electrical corporations on this topic were:

+ What fuelscape related elements are conducive to forecasting for improved out-year analysis?
+ What future fuelscape forecasting is currently performed by electrical corporations? Is that conducive to standardization?
+ What future fuelscape forecasting that is not performed would offer significant value? Who would develop those models?
+ What is a reasonable duration for the forecasts (e.g., how far into the future)?
+ If scenarios rather than forecasting is applicable, how should future-state fuelscape scenarios be incorporated into existing risk models?

Most of the electrical corporations understood the prompts in this section to be asking what fuelscape related elements would improve future out-year analyses rather than what elements are currently used for these analyses. Each electrical corporation considers the following factors in long-term forecasts:

+ Burn scars (and, in most cases, associated regrowth)
+ Projected urbanization and agricultural development

The main changes made to the fuelscape by the electrical corporations for near-term planning is to adjust the fuel models for regions which have recently burned to be representative of the likely condition after regrowth. All electrical corporations use a 2030 (10-year) fuelscape with most using the fuelscape provided by Technosylva. Some electrical corporations also use 2050 or 2080 scenarios; however, these use the same fuels as the 2030 data with the main difference being the climate effects. When these longer-term scenarios are considered, they are for information purposes only and not for risk mitigation at this time.

It was unclear based on the discussion how the specific fuelscapes are developed by the various stakeholders; however, there was some discussion on the development approaches:

+ SCE noted that their current timeline assumes 7-10 years for a burned area to be able to burn again, with a 20-year growth assumed to reach max burning potential.
+ USFS approach to translating one layer of fuel to another layer of fuel over time (when an area is completely burned, it will restart as grass, then translated into shrub, then small trees, etc.).
+ Technosylva uses a similar approach which uses a machine learning model to predict regrowth into 6 classes dependent on density of buildings and type of vegetation around buildings.

There was a general consensus that it would be helpful to standardize these approaches, with some caveats. Some of the areas of suggested standardization were:

- **Future Year Basis**: GPI asked about expanding to a further future design-basis year (e.g., 2035) or having a rolling basis. The electrical corporations noted that this can be done, but there is high uncertainty in these fuelscapes and there is not much confidence in the difference between 2030 vs 2035.
- **Future Fuelscapes**: SDG&E noted that each of the electrical corporations are independently doing the same adjustments, and it would make sense for a fire agency to lead the development of future fuelscapes across the state.
- **Worst Case**: Development of a standard "upper bound" scenario (e.g., 2030 climate, high population growth) along with characterization of the uncertainty associated with the scenario. Some of the electrical corporations requested that prescribed modeling requirements allow for flexibility and experimentation with scenarios as it is not yet known what standard would work for all service territories.
- **Climate Change**: Guidance on translating future severe drought periods expected from future climate change projections to fuelscapes (e.g., how to convert drought size into fuel layer data). Ideally the CA Climate Assessment teams could centralize the development of these scenarios rather than the IOUs.

There were also some differences / unique methods in how the electrical corporations are using future fuelscapes in their analyses:

- SCE projects future fuel moistures based on climate change and anticipated precipitation levels.
- PacifiCorp focuses on wind driven and fuel/terrain driven wildfires and treats them as distinct categories. PacifiCorp suggests that the fuelscape is not as important for wind driven fires due to ember cast and high fireline intensity.
- PG&E uses the fuel type as part of the probability of ignition calculation. SCE only considers urban vs. non-urban in the probability of ignition calculation.

The RMWG also discussed areas for future development which could provide significant value in future fuelscapes. The key recommendations from this discussion were:

- Projected change in land use/land cover in areas adjacent to the wildland urban interface/intermix regions, including:
  - Vegetation patterns (e.g., desertification, and/or agricultural development)
  - Population growth (e.g., suburbanization)
- The electrical corporation agreed that a Statewide authoritative source develop future fuelscapes and scenarios would be useful. These can be vetted by the IOUs and CAL FIRE prior to incorporation in applications or proceedings to ensure alignment between Energy Safety and other filing requirements.
- City governing bodies are approached years in advance for construction approvals. Engagement of electrical corporations earlier in the construction process would allow the models for population growth and land use to be predictive rather than reactive.
- Future research is necessary to investigate how climate change impacts the rain/growth seasons and related fuel loads.
- Limit projections in fuelscapes for risk planning to a decade forecast due to uncertainties in future conditions.

2.4 04/12/23 – WILDFIRE CONSEQUENCE MODELING – CONFLAGRATION RISKS

Conflagration is a critical element of high consequence wildfires and occurs when a wildfire directly ignites homes on the wildland-urban interface, which then generates heat and embers that ignite nearby homes. This phenomenon is separate from plume driven long-range spotting. There is a limited understanding of how conflagration risk is best incorporated into overall consequence modelling. This makes it difficult to predict where and how mitigations will be most effective. This session explored how modeling of conflagration (structure-to-structure spread) risk can be standardized and factored into wildfire modeling. The session began and ended with electrical corporations responding to prompts; however, there was an external speaker in the middle.

Guest speaker Sam Manzello discussed the role of firebrands in ignition of structures. The SME posed that the incidence of large outdoor fires in the WUI will only get worse, and electrical corporations have a key role to play in funding WUI fires research (particularly in the firebrand mechanism for building-to-building fire spread). The presentation started with an overview of the physical processes of firebrand generation, transportation, and heat transfer leading to ignition. One of the key limitations in understanding the role of firebrands is the lack of data from post fire investigations and the cost associated with large scale laboratory testing to simulate real-world exposures.

The speaker noted that the primary common building components that contribute to ignition by firebrands are roofing and walls. There have been workshops in recent years held by ASTM, IAFSS, and ISO to improve standard testing to work towards more resilient assemblies. Two published (or soon to be published) ISO standards from this work are:

- ISO/TR 24188:2022: large outdoor fires and built environment, overview of different approaches to standardization
- ISO Standard Firebrand Generator (ISO/DIS 6021) – dragon generator design passed draft international standard ballot

The discussion after the presentation focused on where the study of conflagration lies on the priorities for electrical corporations and the different approaches for mitigating building-to-building spread. The approaches for mitigating conflagration vary from building material scale to holistic community scale (building codes/materials, prescribed burns, and vegetation management). It was proposed that only a holistic approach would be effective.

Several electrical corporations mentioned that the current mitigation framework assigns standard building values to all structures so that higher-value areas are not skewed to a higher prioritization; the intent is to prioritize all customers, prioritize where the risks are, and actively deploy mitigations to address the risks. Electrical corporations primarily focus on preventing wildfires, specifically ones started by their assets, and building-to-building spread research and testing does not provide insights into what causes fires—therefore it is not a priority for electrical corporations to pursue. The SME maintained that understanding how wildfire firebrands are produced is important to have a better understanding of the best approach for prioritizing locations and strategies for risk spending. Especially understanding how vegetation produces firebrands, and how such firebrands ignite structures (i.e. the vulnerabilities), would lead to a better understanding of wildland-to-building fire spread. The stakeholders within the RMWG agreed with the speaker and reminded the group that the RMWG is a forward-looking effort. Realistically, electrical corporations will not change their current frameworks for mitigating wildfire in their territories, but it is plausible that conflagration risk can inform where an ignition started by their assets will create the most harm and therefore inform what areas to prioritize mitigation.

However, the RMWG collectively agreed that the current state of the available data is not sufficiently validated, at a sufficient quality, nor at a correct granularity for electrical corporations to directly use within modeling.

The guiding prompts provided to the electrical corporations on this topic were:

+ What is the best available science on how structure type, preparation, and arrangement impact structure to structure spread during a high intensity wildfire?
+ What data is available regarding key conflagration variables (e.g., structure arrangement, structure age, roof type) with respect to HTFDs? If not available, how might data be acquired regarding key conflagration variables?
+ How might this data be incorporated into consequence modelling?
+ How might approaches to collecting data on and incorporating conflagration risk into risk models be standardized across IOUs?

The discussion on this topic generally noted that conflagration is an important factor in the overall consequence of a wildfire. However, there is limited data available and existing methods that are not well validated for this application currently. SCE pointed out that, while fire may spread from structure-to-structure and via ember cast, that type of data is generally not available so it’s very difficult or impossible in most cases to know how the fire spread to destroyed structures.

The electrical corporations are aware of several potential data sources which could be used to evaluate conflagrations or develop a conflagration index. Examples that were discussed were sources such as CAL FIRE damage inspection (DINS) findings, CAL FIRE defensible space compliance records, insurance company records, real estate company records, and detailed structure and parcel information from cities and local jurisdictions. However, these data are not all publicly available, often lack completeness (e.g., real estate records generally only consider newer homes), and are not consistent in data format. The RMWG noted that conclusions drawn from damage inspection (DINS) data should be made with care, as there are many reasons why certain structural properties may correlate with damage (or lack thereof). For example, did one set of structures demonstrate greater resilience to wildfire or did fire fighters simply prioritize one neighborhood over another? As a result, most of the data sources were not being used at the time due to one or more of these obstacles. There was also some discussion on the use of proxies (such as date of construction) to estimate structural properties that relate to conflagration.

The RMWG agreed that if conflagration data were available in a complete form, they could be incorporated into consequence models by correlating the number of exposed structures to risk and assigning greater risk to structures that are more vulnerable. There was some discussion on an indirect index for building loss similar to discussions in future meetings on suppression, egress and ingress. Technosylva was developing a model that includes building loss as a risk which is being considered by multiple electrical corporations using their software. The building loss index uses building properties such as location, terrain, and slope when available to determine a “building loss factor” for each structure. At the time of the RMWG, the conflagration aspect of Technosylva’s model was not implemented into operations. The electrical corporations advised against including conflagration in consequence models due to:

+ Lack of available data (both structural and suppression related).
+ Lack of maturity surrounding conflagration modeling (i.e., even if good data were available, the models are not there yet).

- Including conflagration in the models could impact mitigation prioritization, but the data and models are not sufficiently robust for this application.
- There was also discussion that it is not an efficient use of electrical corporation resources.

The key takeaways from this meeting were:

- Including conflagration risk in wildfire consequence models is infeasible at this time given the lack of available existing resources.
- Conflagration risk plays an important role in understanding the consequences of a wildfire. However, additional discussion is needed on how to consider conflagration risk in the future. While there was some discussion on developing a risk index based on the data, follow-up is needed on this topic.
- Additional follow-up is needed on data sources and quality for conflagration risk assessment.
- Electrical corporations requested that a single entity manage a state-wide repository of structural data should conflagration risks be considered in the future. The electrical corporations should simply be accessing this repository.

2.5 05/10/23 – APPROACHES TO FACTORING SUPPRESSION INTO FIRE MODELS

The ability to control wildfires is not uniform across service territories due to different terrains, proximity to suppression resources, vegetation types, weather conditions, and so on. Understanding and modeling fire suppression may have an impact on both wildfire planning models and on operational models such as PSPS shutoff models. However, current fire models do not factor in fire suppression firefighting or the effectiveness of fire suppression. This session focused on fire suppression modeling needs, current models and data, and future strategies. This session started with a technical presentation with guest speakers from CAL FIRE and then went into the individual prompts provided to the electrical corporations.

Guest speakers Jeff Fuentes, Stephen Volmer, Dave Sapsis, and Mark Rosenberg from CAL FIRE presented an overview of wildfire suppression. CAL FIRE is responsible for wildfire suppression activities over approximately 1/3 of the state of California (31 million acres). CAL FIRE's objective is to keep wildfires contained to 10 acres or less, which it achieves for 90-95% of fires in the State Responsibility Area (SRA).

The speakers noted four different types of tools and groups used in fire suppression and containment:

+ **Hand crews**: Usually consists of 13-20 people per crew. Line construction rate, and ultimate effectiveness, depends on the difficulty of the terrain, fuel type and load, and accessibility to water and other resources. These crews can typically suppress fires up to 4 ft high.
+ **Bulldozers**: Have faster line construction rates than hand crews but cannot work on steep grades (above 45%).
+ **Fire engines**: Engine crews are generally first responders to an ignition event. Effectiveness depends on how many crew members are in the engine and the availability of water. Engines are also limited to road access so cannot reach many wildfire areas.
+ **Aircraft**: Used to slow fire spread but not suppress it. Areas can be pretreated by aircraft which improves effectiveness of lines constructed by hand crews or bulldozers. Aircraft still require ground crews to extinguish spot fires that jump lines. New fires where ground access is limited are the highest priority for aircraft resources.

The speakers also provided an overview of key variables which drive the effectiveness of fire suppression strategies:

+ **Initial Response Time**: The time between ignition and initial suppression activities is critical in preventing fires from becoming large events. Suppression resources are strategically staged throughout California so that most fires can be reached within 20 minutes of reported ignition. Staging strategies and priorities are continually evolving.
+ **High Winds**: Santa Ana winds have a large impact on most large fires and drive winds from high pressure areas in the inland mountains west to the coast.
+ **Atmospheric Stability**: Atmospheric stability plays a large role in suppression effectiveness. Stable atmospheric conditions naturally reduce fire activity while unstable conditions lead to increased fire spread rates and spotting.
+ **Time of Day**: Fire spread rates are typically faster during the day, especially in the afternoon and early evening, due to fuel being pre-heated by daytime temperatures. This is amplified on South-facing and West-facing slopes due to their higher incident exposure angle to the sun during the day.

- **Inter-Relationship Between Terrain and Vegetation**: Northern aspect of terrain generally has more trees and heavier vegetation because it receives less direct sunlight while southern aspects have more shrubs and grasslands.
- **Fuel Management**: Managing fuel is an important mitigation tool that can help the effectiveness of suppression activities. Areas that have not burned for extended periods of time, or have never burned at all, create faster moving fires that are harder to contain and suppress.

While CAL FIRE and USFS have their own areas of responsibility, there is agreement between the parties to aid in suppressing fires in land responsible by the other parties. Large fires that include State Responsibility Area (SRA), Federal Responsibility Area (FRA), and Local Responsibility Area (LRA) are managed based on the ignition location of the fire where the agency responsible for the ignition location leads suppression activities for the entire fire regardless of where it spreads.

There are some case models that can inform growth through the inclusion of suppression resources. Nevertheless, understanding large fires behaviors remains difficult. There are so many stochastic factors involved in fires that our knowledge of how to fight them remains limited. Unfortunately, modeling has not significantly impacted the five percent of fires that go large. When fires “get up go and go,” they expand rapidly. Use of fire suppression models to project the size of fires remains limited over the near term. CAL FIRE believes there are opportunities to add suppression to the electrical corporation planning framework – especially the initial attack and extended fire suppression operations.

With initial response time being so critical, the ability to reach ignition events quickly is a high priority. Strategic staging can help when a limited number of events are ongoing, but when several events are ongoing, prioritizing remaining resources to intervene quickly on new ignitions is difficult. Several large fires in the past have started because of delayed response due to resources already fighting other nearby fires. True extinguishment of fires is also difficult to predict. Areas that have been extinguished can dry out in the following hours/days and present a re-ignition hazard. It is common that extinguished areas reemerge as active fronts.

Metrics for assessing the potential for an ignition event to become a large fire are useful but not certain. Influencing aspects such as terrain difficulty correlate to this potential, but since large fire events are already fringe, they do not necessarily correlate well with expected metrics. This is true for other consequences such as the number of structures destroyed. There needs to be an understanding that individual events that result in high consequence are often on the fringe of expectations and, therefore, generalized relationships that are usually true are often false for large fires.

The guiding prompts provided to the electrical corporations on this topic were:

- What specific wildfire related operational and planning models would potentially be improved if suppression was incorporated into the models?
- Would the improvement likely make enough of a difference to warrant the effort to incorporate suppression models? If we’re not sure, what model analysis, test, or experiment would allow us to determine this?
- What suppression models are currently available? How effective are they? What are they currently used for? What are their inputs and outputs?
- If suppression models were incorporated into wildfire-related operational or planning models, where would they fit? How would they be incorporated? Should electrical corporations proceed in this area of modeling suppression, and if so, how?

The electrical corporations agree that attempting to model suppression directly within operational or planning models would not result in significant improvement at this time due to lack of ability to accurately capture the complex decision-making processes and complex physical phenomena that drive the effectiveness of wildfire suppression. Additional complexities include:

+ Lack of data on suppression effectiveness
+ High consequence of underestimating fires which are not successfully suppressed (particularly in operations)
+ Uncertainty in how agencies conduct suppression activities and the related decision-making
+ Technical uncertainties in how to integrate available suppression data to quantitative risk

However, the electrical corporations also agreed that the use of surrogate variables has the potential to help, similar to the discussion of conflagration risk. Technosylva has two indices, the Terrain Difficulty Index (TDI) and Response Complexity Index (RCX), which are in development, and with which some of the electrical corporations are experimenting. There was also discussion of the real-time Fire Behavior Index (FBI) and the Initial Attack Assessment (IAA) model to account for suppression effects and predict when suppression activities could fail and result in a large fire event. These indices include the ruggedness of terrain, access to infrastructure, and pre-positioning of suppression assets. However, obtaining meaningful data from suppression models is also a challenge. Physical metrics such as acres burned, structures destroyed, or fatalities are not explicitly included in surrogate variables that are being explored. This can make using these variables in larger wildfire risk models more challenging.

The electrical corporations agree that the current state of practice in suppression modeling is not sufficiently robust to be used in operational risk models. However, the electrical corporations agree that suppression modeling through either explicit methods or surrogate variables could improve the consequence calculation in planning models if these could be sufficiently validated. There was specific discussion related to using these as a metric in considering updates to High Fire Threat Districts (HFTDs) and Severe Risk Areas (SRAs). Some of the electrical corporations noted using Technosylva's TDI model, but did not provide details on how it is being used. There was additional discussion that insurance companies have their own suppression models, but no specific model or details were provided.

Several electrical corporations highlighted the possibility of double-counting factors of wildfire risk if suppression is directly included. Those electrical corporations that are considering including suppression impacts in some form are being cautious to not accidentally double-count inputs and cause skewed results. Determining whether variables are truly being double counted is difficult because there is some degree of co-location of risk factors. There is concern that directly including suppression creates circular logic between the electrical corporations and policy makers where suppression policies are adjusted based on electrical corporation actions motivated by the electrical corporation risk models which are informed by suppression policy. Such relationships need to be understood before suppression can be included confidently in the models.

PG&E mentioned that, because their risk models use data from historical fire perimeters, the models implicitly account for suppression activities as suppressed fires are not represented as how large they would have otherwise been. In addition, while satellite data is great at picking up developed fires, there is room to improve when tracking ignitions that never develop into a fire.

The key takeaways from this meeting were:

- Most electrical corporations do not think that suppression should be included as a parameter. In particular, most electrical corporations do not recommend including suppression in operational models at this time.
- Suppression could be included in planning models, but there was not a consensus on how it should be considered.
- Some electrical corporations believe that a comparative study approach is the best way to determine whether adding suppression to their models is worthwhile. Such a study would need to be a collaborative approach led by suppression agencies (CAL FIRE or USFS), and supported by academia, insurers, and electrical corporations. However, electrical corporations expect such a study to support the view that the cost of adding suppression into the models does not merit the improvement that would be gained.

2.6 06/13/23 – APPROACHES TO FACTORING INGRESS AND EGRESS INTO FIRE MODELS

Considerations of limited or threatened ingress (of emergency personnel) and egress (of evacuating civilians) may have significant impacts on the safety consequences of a wildfire. These considerations may impact risk mitigation strategy or prioritization. This session explored available sources of relevant geolocated ingress and egress related data, ways to incorporate that data into wildfire operational and planning models, and future directions with respect to standardized selection and incorporation of ingress/egress data. This session started with a technical presentation from guest speakers from UCLA and then went into the individual prompts provided to the electrical corporations.

Guest speakers Marilia Ramos and Ali Mosley from Garrick Institute for the Risk Sciences at the University of California, Los Angeles (UCLA) presented on a software package they are developing in partnership with PG&E for modeling egress during wildfires. Ensuring communities can successfully egress from the path of a fire is another method of mitigating wildfire consequence. Identifying egress/ingress constrained communities can also inform ignition prevention measures. The core capability of the Wildfire Safe Egress (WISE) software is to predict the probability of a safe egress of a specific community to a specific fire threat using an ASET/RSET approach typical for fire evacuations.

The egress analysis split into three technical analysis aspects:

+ **Traffic/Transportation Infrastructure**: This model accounts for the traffic congestion resulting from the flow of evacuees over existing exit routes to calculate the time required for evacuation. The model uses the open-source Simulation of Urban Mobility (SUMO) software for traffic simulations leveraging public data from OpenStreetMap. Some key features of the model which were discussed are:
    - Model can allow people to take the shorted route to a shelter or safe zone or distributions of different routes to be used can be specified.
    - The model can account for staggered departure of people based on pre-evacuation times (awareness and decision making).
    - Includes traffic congestion over time to account for updated traffic behavior over duration of evacuation period
+ **Human Behavior**: It is difficult to predict actual traffic during egress given the large influence of human behavior in selecting a route based on perceived conditions and knowledge of routes and possible alternatives. Categories, penalty times, and their application are based on Human Reliability Analysis (HRA) which is a field that studies how and why people make errors in industrial settings. Data to support the model comes from many sources including public data such as World Pop and SVI data from the CDC. The WISE software has several features that can be used to evaluate the impact of human behavior on the evacuation times:
    - Modeled individuals receive a time penalty that increases their egress time based on socio-demographic characteristics. These penalties are split into awareness, decision-making, and mobility. People who have a low English level, have a low income, have a disability, or are over the age of 65 received varying amounts of penalties in each of the three (3) categories that total between 29 and 101 minutes of additional egress time.
    - People without access to a vehicle also receive a 1000-minute penalty to their modeled egress time.

  - WISE is capable of tailoring the sociodemographic characteristics of local communities and neighborhoods within a simulation. This allows for investigation of the impact of sociodemographic-based evacuation prioritization (i.e. trying to evacuate elderly populations first due to their expected increased egress time).

+ **Fire Dynamics:** WISE does not simulate fire behavior. It relies on outside platforms (such as Flame application or Technosylva) to predict progression of fire envelope and interprets results as necessary to develop ASET.

Each of these technical analysis aspects is challenging on their own, but egress analysis requires consideration of the interdependency of these aspects and the data that goes into them. The software provides additional integration features which can be used to evaluate these interdependencies:

+ **Egress Trigger**: WISE uses an egress trigger based on expected warning procedures and fire proximity. This accounts for uncertainty in effectiveness of evacuation warning and allows for people to not begin to act until fire proximity triggers are activated. The trigger effectiveness is stochastic and based on population sociodemographic inputs.
+ **Shelter Locations**: WISE uses pre-defined shelter locations and safe zone limits to direct people toward evacuation. They provide guidance on how to do this, but this is an input by the WISE user. This can be used to study the impact of fires blocking shelters or adding new shelters to a community.
+ **Egress Improvements**: WISE uses several different post-processing methodologies to study the impact of potential improvements to egress (such as new roads or better warning systems) to help prioritize community improvements.

The discussion after the presentation focused on real world use cases of the model and potential commercialization in the future. The participants noted the potential benefits of these more detailed models but agreed that additional data and development is needed before its use in electrical corporation wildfire risk planning.

The guiding prompts provided to the electrical corporations on this topic were:

+ What ingress and egress models and/or data are currently available? How have electrical corporations used or explored these models and/or data?
+ Where would ingress/egress considerations provide decision making value (better decisions) for operational and/or planning models? In other words, which specific existing models would improve the decision support capability by extending those models to make use of this data or these external models?
+ What are the pros and cons of adding this support to current models?
+ How often must this data be updated? For example, does it need to be updated based on longer term demographic shifts and resultant traffic changes? Does it need to be updated based on shorter duration shifts such as road or lane closures for construction or otherwise?
+ How should electrical corporations proceed forward in this area?

The electrical corporations generally consider developing models to consider ingress/egress in the planning phase allows for more inclusive risk models and better prioritization of mitigation activities. There was also general agreement that no significant benefit is gained by including ingress/egress modeling in the operational phase as the electrical corporations are not responsible for these evacuation decisions.

All of the participating electrical corporations currently consider egress within their planning decision making to varying degrees using several different approaches. Some electrical corporations performed detailed, community-specific egress modeling, but not widespread. More frequently, statistically based approaches are utilized in planning. Electrical corporations do not consider egress in operational decision making because their role in such decision making is minimal. The models that were currently being used or explored for use were Technosylva's WRRM/RAVE, UCLA's WISE, and electrical corporation custom models such as SDG&E's WiNGS model.

There is a general lack of detailed and accurate data that would be necessary to further develop egress within electrical corporations' planning models and decision making. The data that electrical corporations are currently using or are exploring for use include:

- CAL FIRE's Subdivision Review Program, Red Book Data, AB2911 Subdivision Review Program
- Census and AFM Data
- HFRA Data
- Wind Data (unspecified sources)
- Road Data (unspecified sources)

Electrical corporations did not discuss the consideration of ingress (either ingress of responders into communities or ingress of responders to fire fronts) in planning or operational decision making. The electrical corporations expressed additional concerns related to this topic:

- The electrical corporations generally agree that leveraging ingress/egress models/data for operational decision making is either outside the scope of responsibility for the electrical corporation (as this decision-making falls to emergency responders and coordinators) or would not add significant value.
- There was also discussion of potentially over-prioritizing areas for mitigation activities based on current ingress/egress data and models that have high degrees of uncertainty.
- The challenge of ensuring the same data (such as population mobility difficulties) are not considered multiple times within different aspects of the risk calculation was also discussed.

The discussion on data update frequencies focused on the purpose of updating the data, opposed to the needed frequency. The electrical corporations all agree that the purpose of updating the data is to capture population and demographic changes that can impact long-term mitigation planning. Trying to update data on short timescales to capture activities such as road closures does not provide nominal benefit. This is aligned with the comment by the electrical corporations that including egress/ingress in their operational models does not provide value since these decisions are outside of their scope. The electrical corporations recommended updating data ranges from yearly to up to ten years; however, they also noted that greenfield areas (such as new towns or subdivisions) would require more frequent updates.

The key takeaways from this meeting were:

- All electrical corporations are considering egress within decision making or planning models to some extent. However, expanding the scope of what is included in these models will require additional collaboration with a variety of other entities (local fire department, local law enforcement, CAL FIRE, CalTrans, and USFS).

- Additional investigation is needed into the importance of modeling ingress/egress in wildfire risk for planning.
- Electrical corporations agree that considering egress and ingress in operational models is not recommended at this time as the electrical corporations do not have control over these decisions.
- Egress data and surrogate metrics could be useful to identify more overlapping areas between high fire likelihood and limited egress availability. Additional discussion is needed on the data, indices, and how these would be used in the risk calculation.

2.7 07/11/23 – APPROACHES TO MODELING LONG DURATION, HIGH INTENSITY WILDFIRES

Current approaches to modeling the likely impact of wildfires use a combination of electrical corporation specific ignition models and eight-hour models of fire growth. These models fail to account for the risks associated with long duration (measured in days or weeks) and large (>10,000 acre) fires. This session discussed existing limitations and future directional guidance for modeling long duration (over 8 hour) wildfires. This session started with a technical presentation from a guest speaker and then went into the individual prompts provided to the electrical corporations.

Guest speaker Mark A. Finney presented information on large, long-burning wildfires, and examined their size and duration distributions. The speaker prefaced that for large wildfires the final size is driven primarily due to changes in weather conditions rather than suppression efforts. The distribution of acres burned and wildfire duration both follow a power law distribution which appears linear in a log-log plot. However, this same trend is not observed when modeling wildfires. The speaker noted two primary reasons for this difference:

- **Extrapolation**: Large fire models are extrapolations of models designed to assess small fires. While the model predictions provide interesting data, their application in long-duration fires is inappropriate.
- **Sparse Data**: The lack of observations poses a significant barrier to reaching appropriate confidence levels. The available data spans 30 years and large wildfires only account for 2% of all wildfires. Long duration wildfires account for 0.01% of all wildfires.

The solution to the sparse data problem is simulations; however, these are prone to the extrapolation problem. The simulation approach developed by the speaker used 10,000-50,000 "years" of artificial weather with fire growth simulations run repeatedly with different weather and ignition locations. Statistical models for fuels, moisture content, and suppression were incorporated into the modeling approach. The resulting distributions in acreage burned in the model were within a factor of 3-4 of historical estimates. The speaker noted that these findings indicated that the final distributions are a result of the joint distributions of spatial opportunities for fire growth (dependent on fuels and ignition location) and the temporal opportunities produced by conducive weather scenarios. The speaker emphasized the importance that the statistical properties of these characteristics be maintained for a realistic picture of the hazard posed by large fires.

The speaker also commented on the fundamental differences between small and large fires. He summarized the following differences that make large wildfires different to model compared with small and laboratory-scale fires:

- **Not a line fire**: (e.g. deep flaming and burning zones). Transitions from "flame scale" behaviors to "fire scale" behaviors. Large areas are burning at once, which can also have an impact on the scale of atmospheric interactions.
- **Coarse and Deep Fuel Materials**: Long burning (hours+) not fine fuel burned in flaming front.
- **Dynamical & Coupled**: Changes depend upon the state of the fire and interactions with the environment (fuel, weather, topography). Changes in fire behavior occur very rapidly, and that is something that our current models do not adequately simulate. Large fuel materials (not just fine fuels) become long-burning heat sources over large areas.

- **Transitions**: Rapid changes - step changes - spread vs. no spread caused by minor events (i.e. wind increases a small amount). Large fires often go through transitions that can, for example, turn a no-spread fire into a rapidly spreading fire due to an increase in the speed of the wind.

The speaker provided a series of concluding recommendations on improving management of large, long-duration fires:

- Prioritizing mitigation for large, long-duration fires
  - Landscape treatment - surrounding areas of concern, reduce fire growth rates, probability of burning
  - Local treatments - Reduce localized fire impacts
  - Target extreme conditions (climatology), long-burning fuels
- Impact on investment decisions
  - Landscape-scale perspective - consider where fires start, how they grow, critical weather conditions, treatment amount and patterns
- Pros: Certainty of having large fires (can estimate frequencies), influence kind and scale of mitigation
- Cons: Cannot reliably model many large-fire behaviors, extrapolations from current models.

The discussion between the RMWG and the speaker focused on the following key areas:

- **8-Hour Duration**: The RMWG asked whether the 8-hour fire in use in planning would be considered as a large or small fire. The speaker noted that size is not correlated with time. An 8-hour fire could mean a small fire that the fire service did not prioritize because it was low risk and there were too many other fires to deal with. It could also be a very large fire. A lot of fires, even if fire suppression agencies did not attack them would not grow very big no matter what.
- **Local Relevance & Insurance**: The RMWG asked to what extent this data is appropriate at the local scales and if it is used by insurance companies. The speaker noted that insurance companies are typically using local data rather than national since they do not insure everywhere in the country. Moody RMS noted that their insurance model builds off the groundwork presented by the speaker.
- **Large Woody Fires**: The RMWG asked the speaker about the role played by large fuels which was mentioned in the technical talk. The speaker noted that the high fuel loads in large woody fuels can lead to consistent burning for several hours, which contributes to the area versus line fire discussion earlier.

The discussion then transitioned to presentations by the electrical corporations. The guiding prompts provided to the electrical corporations on this topic were:

- From an overall impact perspective (cost, health and safety impacts, operational impacts, etc.), what is the overall impact on an annualized basis from long duration wildfires versus short duration wildfires?
- Within the IOUs, what existing work is underway, and strategies in place, to factor long duration wildfires into risk mitigation optimization?
- Beyond attempting to extend the existing fire growth models to cover long duration wildfires, what alternate (simplified) approaches might allow these risks to be incorporated into overall risk analysis? In what ways can spread of additional risk be analyzed outside of existing model constraints?

- For a model of long duration wildfires, what would be the likely inputs? In other words, what variables are predictive of whether a small fire will become a very large fire?
- Should electrical corporations use long-duration wildfire modeling, why or why not?
- If a long duration wildfire model must be developed, what stakeholders should develop that model? What stakeholders should provide input to the modeling process? What stakeholders should validate the model? Who should fund the model development?

The electrical corporation presentations presented some overlap with the speaker in terms of power distributions on wildfire burned area and the discussion of long-duration wildfires. All of the electrical corporations or the vendors developing the products in use calibrate simulations against historical fires to some degree, although not a lot of detail was provided on this calibration process. Several of the electrical corporations discussed plans to start using a 24-hour burning duration within Technosylva's product. SCE noted that they had experimented with extending beyond the 8-hour burning duration but decided against it for two reasons:

- The high uncertainty in large fire predictions. This is augmented by the variability depending on which decades are considered in the analysis period.
- SCE presented that the absolute risk may change, but the impact on the relative risk compared across the service territory is small when using 24-hour versus 8-hour simulations.

There were a few ideas presented on simplified approaches to incorporate long duration wildfires in the model. For example, PG&E discussed a 'dry wind condition' model which they are developing, similar to a red flag warning, which can be used to gauge when a wildfire might extend beyond 8 hours and can be used to predict fire outcomes. SCE discussed a probabilistic model 24-hour simulations based on the uncertainty in the model predictions, but did not believe the additional effort adds value. SCE also noted that developing full PDFs across the service territory for system wide analysis would require several trillion simulations.

The electrical corporations agree that the main inputs to long-duration wildfire models would be weather (temperature, humidity, wind speed), fuel moisture, fuel type, and terrain. These are the most significant predictors of large fires as they impact the rate of spread and intensity (difficulty to suppress). However, the electrical corporations generally did not see the benefit of extending to larger fire durations. PacifiCorp noted that whether or not a long-duration simulation is appropriate depends on what the electrical corporations are seeking to get from the model output. SCE provided a specific example case of the relative risks across their service territory developed based on 8-hour and 24-hour simulations. The magnitude of the expected consequence was 5x higher in the 24-hour simulations and as such would have a significant impact on cost-benefit ratios.

The key takeaways from this discussion were:

- Modeling long duration wildfires is important to align the probabilistic size of simulated fires with historical data; however, it is not always clear what duration is appropriate to model due to the high uncertainty in modeling long duration wildfires.
- If 24-h versus 8-h match drop simulations are applied equally across the full-service territory, the relative risk profiles identified by the electrical corporations do not change significantly. As a result, the electrical corporations do not see a significant benefit in extending the duration of the simulation. Large fire simulations could inform alternative investments compared to simulations that are more representative of smaller less destructive fires.

- The current objective of the electrical corporations is to optimize mitigation measures. However, as models are probabilistic, it's possible for any equipment to cause an ignition with high consequences (even if the probability is low). For this reason, the electrical corporations do not support mitigation selection purely on a cost-benefit basis. There is always residual risk as risk can never be fully eliminated. Future discussions on risk tolerance and the cost-benefit of on-going mitigations should be considered.
- The potential ramifications of this research topic seem to be worth studying and understanding because it could have an overall impact on what degree of risk is acceptable within the infrastructure framework and the cost-benefit of various mitigation strategies.
- It is unlikely that electrical corporations will make radical shifts on modeling long-duration wildfires in the near term based on the current research electrical corporations are conducting. In terms of how research spending will be prioritized, it will be relative to the perceived value of the results. The results in some cases may be of limited value relative to the difficulty involved.

2.8 08/08/23 – PSPS PLANNING MODELS

The objective of this meeting was to understand how the participating electrical corporations are modeling the potential consequences of shutdowns and to identify areas of improvement. The workshop focused on discussing balancing the tradeoffs between safety and wildfire risk versus reliability and consequences associated with power shutoffs. The guiding prompts provided to the electrical corporations on this topic were:

+ How do existing PSPS planning models account for the consequences of PSPS events?
  - How are those consequences monetized, or if not currently monetized, how should they be monetized?
+ How do PSPS planning models account for probability of PSPS events?
  - What is the level of granularity?
  - What are the inputs and outputs of this component of the modelling?
  - Are the probabilities described as averages, distributions, or something else?
  - Are the probabilities dependent on or influenced by the PSPS operational models? In other words, if the operational model changes will the planning model change automatically? Manually? Not at all?
+ How do PSPS planning models account for the duration of PSPS events?
  - What is the level of detail?
  - What are the inputs and outputs of this component of the modelling?
  - Are the durations expressed as averages, distributions, or something else?

The discussion focused on the following areas:

+ Extent to which electrical corporations were using quantitative models and/or “rules of thumb” to guide shutdown decisions.
+ Explore whether electrical corporations were using deterministic single value estimates (i.e., expected value or worst-case value) versus full probability distributions to inform the decision-making process.
+ Discuss whether there is a common multi-attribute function or cost-benefit tradeoff between PSPS costs and wildfire risks and occurrences.

Four electrical corporations responded to the first question on consequences of PSPS events including SDG&E, SCE, PG&E, and Liberty. Part of the discussion focused on the metrics used in calculating the multi-attribute value (MAV) functions for safety, reliability, and financial impacts. The approaches were generally similar among the electrical corporations, but there were a few differences observed in the presentations.

The safety criterion in use by the electrical corporations is generally based on the expected negative impacts to customers per hour of de-energization. Some of the electrical corporations (SDG&E) limited this to fatalities, some included serious injuries (SCE), others (Liberty, PG&E) did not specify. The studies on which these numbers were based varied across electrical corporations (SCE, SDG&E), and it was unclear if there was a specific reason for this difference. A few of the electrical corporations (PG&E, SCE) noted that the consequences of an outage are not the same for all customers as there are populations which are more vulnerable within their service territory. Some of the electrical corporations (PG&E, SCE) account for this through different weightings or a linear multiplier applied to the safety score in the MAVF. It was unclear from the presentations whether the same approach was used across electrical corporations in this scaling.

The reliability criterion in use by the electrical corporations is based on the number of customer hours impacted by a de-energization event. Some of the electrical corporations (SCE, Liberty) assume 24 hours of de-energization per event, others assume 32 hours (SDG&E), and others (PG&E) did not specify. One of the electrical corporations (Liberty) noted that their 24-hour timeline is based on a 12-hour duration of extreme winds observed in their territory plus an assumed 12 hours to re-energize the system after each event. The other electrical corporations did not specify the basis of the duration. One electrical corporation (PG&E) noted that the de-energization duration was linked to their enterprise risk model (with assumed variability in duration). However, this electrical corporation did not describe the factors which affect the variability or the distribution of PSPS durations estimated by the model.

The financial criterion which was presented by the electrical corporations was similar at $250/hour; however, not all electrical corporations reported their financial criteria. One electrical corporation (SCE) noted the price per event was based on a Value of Lost Load (VoLL) which is an accepted industry methodology to estimate a customer's willingness to accept compensation for service interruption. VoLL is dependent on many factors, including the type of customer, the duration of the outage, the time of year, and the number of interruptions a customer has experienced. Although this number is assumed in planning, the electrical corporations noted that the actual financial impact is typically lower than this value.

None of the electrical corporations are currently monetizing PSPS consequences; however, each electrical corporation is following Order Instituting Rulemaking (OIR) Phase II Decision (November 2022) to evaluate future changes to this process.

One of the electrical corporations (PG&E) presented an overview of a detailed historical sensitivity analysis which they had conducted to account for the impact of climatology of weather and fuels on the modeled PSPS consequences. The focus was primarily on synoptic weather patterns. During this discussion it was noted that the electrical corporation was using a hindcast/back cast methodology in the context of PSPS planning. There was additional discussion on the tradeoffs between hindcast/back cast methodology in PSPS planning but using future weather predictions in wildfire planning. The concern was mentioned that the hazard posed to the public by PSPS and wildfire should be using the same projected future for planning purposes. Continued discussion on the topic was tabled for a future workshop. It was also suggested to pose the question in that workshop "How are risk models trading off the increase in risk due to PSPS versus the reduction in wildfire risk?"

The discussion then transitioned to a conversation on how the electrical corporations account for the probability of PSPS events in planning models. The IOUs all use a historic lookback period for the PSPS planning model; however, the duration of this period and how it is used varies across the electrical corporations. SDG&E uses historical PSPS events as inputs to predict future PSPS likelihood and discretizes the model at a circuit-segment granularity. PG&E uses a 12-year period based on previous PSPS events as well as outputs from the enterprise model risk score as inputs to the PSPS. The model uses a 2 km spatial resolution and is evaluated hourly. SCE's PSPS model is calibrated to a 10-year period, FPI risk scores, and current PSPS operational thresholds. The output of the model is the number of circuit hours which are above the PSPS thresholds. The model is evaluated at a 2 km spatial resolution and is based on a machine learning model. Liberty takes a different approach using forecasted wind speeds, Fosberg Fire Weather index, and dryness as model inputs along with historical fire weather data. The model outputs the number of PSPS events per year per 'zone'. Liberty has 5 'zones' in the service territory. None of the electrical corporations indicated that a change in the operational model would result in an automatic change in the planning model.

The rest of the discussion focused on the assumed duration of PSPS events after triggering. SDG&E assumes a 32-hour PSPS duration per triggering event. They expressed reluctance to "forward plan" instead of relying on historical benchmarks. PG&E models the duration of a PSPS event using the historical lookback model. They then add 11 hours of outage time to account for restoration, leading to better estimates of customer impacts. SCE's models the frequency and duration of PSPS events concurrently. This means that frequency is modeled over time and the duration is simply extracted as a result. Liberty assumes a 24-hour duration for PSPS events.

The key takeaways from this discussion were:

+ Stakeholders recommended for a future workshop to discuss the use of a hindcast vs. forecast for PSPS planning, and whether the same approach should be used in PSPS planning as in wildfire planning. One of the questions in that workshop would be "How are risk models trading off the increase in risk due to PSPS versus the reduction in wildfire risk?"
+ There is no consensus in the methods used to characterize the consequences for customers from a de-energization event. Standardization of these practices is part of on-going discussions in the RDF.
+ There is no consensus in the assumed duration of each PSPS used by the electrical corporations. Future discussions on this topic to better understand the factors that drive this variability may improve consistency across the industry.

2.9 09/14/23 – AVOIDING BIAS IN WILDFIRE PROBABILITY MODELING

Wildfire modeling may include built-in bias based on cases affected by mitigation measures. For example, if a circuit experiencing 75 MPH wind is shut down, then wildfire ignition models might conclude that high wind conditions are very low risk from an ignition perspective. This workshop explored ways to remove bias from wildfire planning models, with a goal of having a standard approach that may be adopted by the electrical corporations. This session included a speaker presentation from Level 4 who provided a high-level overview of the different types of bias which can occur in modeling. The electrical corporations then presented responses to prompts.

The guest speaker, Matthew Raphaelson, spoke at a high level about limiting bias in models. Like all modeling, wildfire modeling has built-in biases. For example, aggressive use of PSPS will reduce electrical corporation-ignited wildfires and constitute a source of bias when trying to estimate underlying ignition processes. The impact of biases in models is a subset of cognitive biases, systematic thought processes where information is simplified through filters of experience and preferences and assumed to be true. Knowing biases is not the same as overcoming them (i.e. GI Joe Fallacy) so several defensive strategies against bias were presented. The speaker noted that while there are over 150 identified cognitive biases, only the following bias types were covered in this presentation:

- Behavioral, Decision, or Belief Bias
  - Types:
    - **Framing**: people respond differently to alternative presentations of the same information based on a positive or negative connotation (ex. 20% fat vs 80% fat free).
    - **Priming**: exposure to information or stimulus can influence judgement (ex. Presenting crime rates then asking how safe one feels).
    - **Anchoring**: influencing how a person will think or respond by presenting often irrelevant data or numbers before posing a question (ex. Groups presented with “8x7x6x5x4x3x2x1” and 5 seconds to estimate will estimate higher than a group presented with “1x2x3x4x5x6x7x8”).
    - **Confirmation**: the tendency of people to favor information that confirms their beliefs (ex. Reading positive reviews before purchasing a product).
  - Defensive Strategies
    - **Reframing**: Reframing an issue involves challenging and then changing how information/situations/events are viewed.
    - **Red Team/Green Team**: Creating a Red Team and a Green Team to debate a topic is a proven way to remove the effects of framing, anchoring, and confirmation bias.
    - **Devil’s Advocate**: A Devil's Advocate designates one member of a group to test opposing arguments and is an informal way to identify biases in a group setting.
    - **Multiple Options**: Generating and debating Multiple Options is one of the most powerful antidotes in our medicine chest for curing bias.
- Model Bias
  - Types:

    - **Selection**: when randomized samples using probabilistic models are in fact not random (ex. Young white men were preferentially recruited for coronary artery disease studies, leading to little attention on gender differences in heart failure).
    - **Survival**: only the data that survives a “weeding out” process (ex. PSPS planning may create a dead zone in the data where there are no ignitions during high wind events).
    - **Automation**: uncritical acceptance of decision system recommendations, or quantitative model results (ex. Flaunting buzzwords like “AI” to make generated data seem more trustworthy).
    - **Flaw of Averages**: a set of systematic errors introduced when using single numbers to represent probabilistic outcomes.
    - **Flaw of Extremes**: a set of systematic errors from improperly summing tails of distributions, such as adding up maximum consequences.
  - Defensive Strategies
    - **Synthetic Data:** Synthetic data can reduce bias by adding additional opportunities for randomization and filling in gaps, especially for hard-to-get data or the sparse tails of probability distributions.
    - **Arithmetic of Uncertainty**: Correctly applying the arithmetic of uncertainty can prevent the flaw of averages and the flaw of extremes. Probability distributions can be summed, creating a new probability distribution. The correct average, median, and tail average or percentile can then be calculated from the new, more robust probability distribution.
- Social Bias
  - Types:
    - **Attribution**: a tendency to view the world or the beliefs/actions/motives of other groups as intentionally worse or hostile.
  - Defensive Strategy
    - **Assuming Positive Intent:** Assuming positive intent may reduce the energy and time wasted with attribution bias, which often causes unnecessary conflict over facts, analysis, and conclusions.

There was a request to provide more detail on summing up risk scores, which was postponed until after the workshop.

The discussion then transitioned to presentations by the electrical corporations. The guiding prompts provided to the electrical corporations on this topic were:

- How do electrical corporations identify which model biases are major contributors to model error?
- What specific models may be subject to bias? What sort of bias does this include?
- How are you balancing differing risk factors (ignition, consequence, and PSPS) and inherent biases included within and between those risks?
- What approaches are currently used to avoid bias? Are those approaches adequate?
- If improvement in this area is warranted, how should the models be modified to avoid bias?

The electrical corporations are using similar approaches to identify biases in their models. Most use ROC curves to quantify model performance and rely on SME oversight during model development and tuning. A manual process is used to identify discrepancies between predictions and observations to try and identify model bias. SCE noted that they calibrated sub-model components independently to avoid bias and improper combination of probabilities of separate phenomena. Technosylva looks for asymmetry in error distributions (difference between predictions and expectations).

Most of the electrical corporations account for bias in fire spread modeling, in part, by accounting for previously unconsidered input factors. SCE and PG&E both mentioned that it is difficult to validate models of catastrophic fires because they are very uncommon (few data points). When reducing the pool to electrical corporation-ignited catastrophic fires, the sample size is even lower.

The electrical corporations interpreted the third question regarding the balance of differing risk factors (ignition, consequence, PSPS) and inherent biases differently and the responses did not directly answer the question. The presentations on the topic discussed how regions are classified by the level of associated risk (SCE), the frequency of retraining risk models (SDG&E), and the differences in model structure between likelihood and consequence models (PG&E).

The electrical corporations are using similar strategies to avoid bias, focusing on feature selection, residual analysis, validation, calibration, and SME input.

The key takeaways from this discussion were:

+ Improved standards or guidelines on what validation activities and uncertainty assessments are necessary.
+ The electrical corporations requested that CPUC and ESPD define the specific types of wildfires and risk tolerance for which to calibrate their models.

2.10 10/11/23 – STANDARDIZED WILDFIRE RISK TYPE CLASSIFICATIONS AND IN SITU WILDFIRE RISK ASSESSMENT

Most discussions of wildfire risk in an electrical corporation setting deal with electrical corporations as sources of wildfires (transmitted risk). However, electrical corporations are also receivers of wildfire risk. Wildfires can damage the equipment (assets) of an electrical corporation, threatening reliability because the equipment could take considerable time to replace. This workshop explored ways to standardize wildfire risk type classifications, as well as recommendations for modeling received wildfire risk.

This session included a speaker presentation from Chris Lautenberger on the Pyregence tool developed on behalf of the California Energy Commission Electric Program Investment Charge (EPIC) program. The Pyregence tool is a suite of open-source wildfire risk models (in situ models) to assess wildfire threats to the electric power systems in California. The speaker gave a live demonstration of the software and showed several features including satellite views, fire histories across the US, and live camera feeds. The software includes a series of historical fuel layers sourced from LANDFIRE, including fuel type and fuel load level. Weather layers are sourced from NWS and NOAA operational models. This information can be useful when there is a lot of fire activity and to get an idea of potential smoke impacts, precipitation layers, wind gusts, vapor pressure deficits, and drying potential.

The Pyregence tool runs several types of models for weather and active fire tracking/forecasting. Tracking is in real time.

The RMWG attendees asked several questions to the speaker on the tool. The first round of questions was on the weather model forecast period. Forecast periods range from 60 hours to 16 days depending on resolution, but all forecasts are updated every 6 hours. The electrical corporations then asked whether the tool is able to model suppression. The tool models suppression by considering the proximity to roads, fuel types, and topography as well as the rate of fire spread along the perimeter; then models preferentially extinguish areas of the fire perimeter that are spreading at a low rate.

The discussion then transitioned to presentations by the electrical corporations. The guiding prompts provided to the electrical corporations on this topic were:

- What wildfire risk type classifications do you use when evaluating wildfire risk? What could be some potential standard classifications in this area?
- How are you working with the CEC regarding its EPIC program work? How has that impacted your evaluations and definitions of wildfire risk?
- To what extent, and in what ways, do IOUs have existing operational and/or planning models to manage received wildfire risk?
- To what extent, and in what ways, would improvements in those models, or new models, provide improved operational and/or planning decisions?

Each of the electrical corporations have a different approach to classifying simulated wildfires. Smaller electrical corporations may not do binning or classification of modeled fires at all. Liberty noted that fires in the smaller service areas may not constitute a large enough data set to classify.

PG&E discussed how the MAVF approach measures consequences on a continuum. Historic fires have measurable natural outcomes (acres burned, structures destroyed, fatalities) that serve as inputs to the MAV and produce a measure of consequence (price to the company, based on company-assigned values). In previous workshops, many electrical corporations have spoken on using a uniform damage cost for all structures, to address the bias toward protecting more expensive developed areas.

SCE presented their categorization scheme for small, significant, and destructive fires:

+ **Significant Fires**: simulated fires that, at 8 hours after ignition, burned more than 10,000 acres or had at least one fatality or at least 50 structures impacted
+ **Destructive Fires**: simulated fires that, at 8 hours after ignition, burned between 300 acres and 10,000 acres with zero fatalities and/or had fewer than 50 structures impacted
+ **Small Fires**: simulated fires that, at 8 hours after ignition, burned less than 300 acres with zero fatalities and no structures impacted

SDG&E discussed the NWCG's fire size class code standard which is used to track and manage fire suppression efforts across various agencies:

+ Designations A through L based on acres of fire spread.
+ These scales are already used for CPUC reportable definitions of ignitions, which makes the data from 2014 more useful for model training.

Technosylva presented on several indices within their software FireRisk and FireSight/WRRM (Wildfire Risk Reduction Model) models:

+ Modeling produces indexes such as Initial Attack Assessment Index, Fire Behavior Index, and Terrain Difficulty Index.
+ Continuous daily models assign index values to electrical corporation service territories based on environmental conditions in order to highlight high-risk areas.
+ Risk Planning models assign index values to areas under representative or worst-case conditions for the service territories to highlight high-risk areas and to see potential effects for mitigation activities.

On the topic of standardization, the electrical corporations requested a working definition of a "catastrophic" wildfire from ESPD may be useful. They indicated that the definition should include discrete risks, including social vulnerability, economic impacts, risk tolerance, risk scaling, etc.

The discussion then transitioned to the second topic in collaboration with the CEC and EPIC program. This collaboration ranges from direct collaboration (coordinated modeling efforts with CEC), to using CEC-developed tools or information (Pyrecast or publications), to no collaboration.

PG&E directly collaborates through involvement with the EPIC project and their modeling expert serving on the technical Advisory Board for the Pyregence team. They were involved in the first project centered on weather station locations and optimization. In contrast, SDG&E and SCE are not directly collaborating with the EPIC program. However, they are open to collaboration and are monitoring their progress.

Liberty has used the active fire forecast tool to obtain fire spread and smoke forecasts when fires are burning in or near service territories. They have also used the tool to identify potential incoming fire weather concerns and may use the weather station siting tool in the future.

Some electrical corporations and stakeholders mentioned some specific concerns with the usage and calibration methods of the Pyregence tools. Some examples included:

- The models have not been calibrated to localized climates
- The customized fuel packages that cover different service territories (in development since 2011) may not be sufficiently granular in space and time to support operational decision-making. They may also not refresh frequently enough for electrical corporation needs.
- The current resolution (3 km spatial, day of predictions) is less resolved than what the electrical corporations are using now (2 km spatial, 4-5 days of predictions).
- The information and interface are not optimized to provide data in a format that meets the needs of electrical corporation compliance and reporting obligations.
- The models have not been validated by CAL FIRE for operational use.

There was additional discussion in this topic on integration of climate variables (from CAL Adapt data) into long term fire modeling that aims to simulate wildfires out to 2030.

The discussion then transitioned to the third question on what extent electrical corporations consider the risk to their equipment from wildfires. Most electrical corporations do not include received wildfire risk as part of their planning models (Liberty, PG&E, SDG&E). One of the electrical corporations discussed mitigating received wildfire risk through process and procedures as opposed to modeling. They discussed implementing hardened infrastructure and targeting areas even outside of areas that were modeled. Technosylva tools (FireSight RAIL and RAVE analyses) could be used for planning purposes to highlight historical areas of potential concern based on reanalysis of weather inputs at high resolution, and to examine the assets or values at risk.

On the operations side, Liberty mentioned using the Pyrecast tool to monitor actively burning fires. PG&E and BVES mentioned using the Technosylva tools in a similar way, with risk tracked daily through wildfire forecasts. SCE and SDG&E instead rely on on-site coordination with response agencies during operations rather than relying on models. One electrical corporation relies on portals for information-sharing between public safety partners ("Public Safety" portal, Outage portal, PSPS Weather Awareness portal, Weather portal, and Fire Detection portal). Other information sources include CAL FIRE Incident Information, NASA Fire Information Resource Management System (FIRMS), and National Interagency Fire Center.

Additional discussion points included how modeled or forecasted received risk could impact mitigation decisions, and how to measure resilience to received wildfire risk. To date, resilience against received risk has been a by-product of electrical corporation mitigation efforts, rather than the objective. SCE noted that mitigations are designed to stop ignition risks related to electrical corporation assets, which should make assets more resilient. However, mitigations like steel or fire-wrapped poles do not directly address electrical corporation ignition risk and have not been considered to date. There is no metric similar to a risk spend efficiency or cost benefit ratio for resiliency or adaptation investments. Considering climate effects or calculating the effects of electrical corporation mitigations on other parties (e.g., calculating the benefit of undergrounding cables to suppression/egress) is also difficult.

The electrical corporations and vendors responded to the last set of questions with discussions on how models could be improved, rather than what decision-making could be affected by the improvements. The general recommendations for model improvements which were discussed were:

- ESPD should determine how and if received wildfire risk should be incorporated into planning models. It would be best modeled in a new process or in collaboration with first responders, academia, and/or other interested parties.
- Improved data sharing and situational awareness capabilities with crowd-sourced tools like Watchduty.org with live satellite photos and fire station updates.
- Improved spatial and temporal granularity of wildfire data is needed.
- Include climate-linked variables in modeling (temperature, population, urban development)
- Expand the calibration dataset to evaluate current vs. historical conditions and new fuel types
- Apply machine learning to fire weather models and fire potential index refinement
- Tackling existing limitations associated with structure-to-structure spread, suppression, plume-dominated fire behavior, and wind modeling.

There was also a concern mentioned that adding received risk into modeling objectives would dilute the response to ignition risk. In other words, a new modeling objective may reduce confidence in the existing model outputs.

There was additional discussion on the following topics not included in the original prompts:

- **Crowd Source Communication**: The discussion on crowd sourcing explored whether it would be one-way communication (but there were no experts on call) and examples of crowdsourcing tools with real time updating capabilities (ex. thermal imaging, radio channel access).
- **Vulnerable Communities**: When asked if the electrical corporations are currently integrating vulnerable communities into consequence values, there were a few responses from the larger electrical corporations and Technosylva that there are built-in considerations for vulnerable communities (due to age, wealth, location, etc.) for egress and safety indexing.
- **Use of Climate Data**: One main concern was using data that was not and cannot be validated. It was suggested that instead of plugging in climate models that project out to 2100 and downscaling it down to 1 km resolution by the hour (exaggeration), models could look at the ways climate change could dry out fuels where Diablo/Santa Ana wind events tend to happen, and what the consequences would be. Handling climate projections is still in the early stages.

The key takeaways from this workshop were:

- There is a need for a more standardized classification of wildfire consequences. The electrical corporations requested a working definition of a “catastrophic” wildfire from ESPD may be useful. They indicated that the definition should include discrete risks, including social vulnerability, economic impacts, risk tolerance, risk scaling, etc.
- The EPIC program provides valuable research and there are some tools which are beneficial, in particular the weather station siting tool. However, additional development is needed before extensive use by the electrical corporations:
  - The data and tools need to be validated for local conditions before they can support operational usage.
  - The resolution needs to match or exceed what the electrical corporations are using now.

- The information, interface, and API need to be optimized to provide data in a format to streamline its use by the electrical corporations.

+ Electrical corporations are not currently modeling received wildfire risk to their equipment. Improved resilience of their infrastructure is a natural byproduct of implementing mitigations. However, mitigations targeted at making equipment more resilient to external wildfire have not been the focus. It was requested that ESPD prescribe how received risk should be considered if it is to be added.

+ Long-term risk is projected for events in future decades using near-term data tools that have climate-adjusted inputs based on climate projections (for temperature, precipitation, wind, etc.). However, these models cannot be validated and may not be realistic, especially for wind models.

2.11 11/08/23 – MODEL MAINTENANCE AND DATA COLLECTION

Both operational and planning models require on-going maintenance (calibrations, extensions, and so on). Those maintenance requirements require data collection to both validate and update the models. Models rely on accurate data, including upkeep and updates, to provide useful and reliable outcomes, particularly when using machine learning within models. This workshop explored approaches to standardizing and enhancing model maintenance, including related data collection and calibration.

This session included a presentation by guest speaker David Saah, a professor at the University of San Francisco. The presenter began by demonstrating the significance of wildfire hazard as a global problem. Recently, climate-driven trends which increase the severity of wildfire were discussed and included longer and hotter summers, increased prevalence and severity of droughts and increased tree mortality and the resulting increase in dry surface fuel loads.

The speaker then pivoted to talk about the existing lag between basic research and implementation in planning and operations; a problem which is exacerbated by the complex, multidisciplinary nature of wildfire. Rather than sequentially passing knowledge from basic research to applied research to end-user solutions to the market adoption, the speaker suggested that ongoing collaboration must occur among all parties using an open and accessible “open science” framework similar to that developed by NASA and NSF.

The speaker categorized wildfire models into three types based on time horizon and application: operational (~1-2 weeks), planning (1-3 years), and long-term (20-100 years). For each of these types of models, results could be generated more quickly, validated more thoroughly, and shared more broadly if data and models were open source and publicly accessible. The speaker mentioned several input data, modeling, and output data products offered by Pyregence, a consortium of which the speaker is the PI. This consortium collaborates with a variety of partners, including universities, electrical corporations, and government agencies.

During the following discussion amongst the RMWG, a concern was raised about how data can be aggregated given that various parties have internal and conflicting constraints on data formatting. The speaker explained that in cases where multiple databases are used to store the same type of high-level information, documentation of each database and development of a translation tool between databases can be used to preserve separation while allowing for translation and aggregation. Another concern was raised about how data can be made open source without violating confidentiality. The speaker acknowledged this problem but suggested that aggregation prior to upload can be used in some cases to protect sensitive data.

The discussion then transitioned to presentations by the electrical corporations. The guiding prompts provided to the electrical corporations on this topic were:

- What models currently undergo or would benefit from on-going or periodic maintenance?
  - For each model, include a list of the maintenance sub-components, defined as the model elements that would be separately maintained.
  - For each model sub-component, how do you determine the indicating current and optimal maintenance/update intervals, or for non-interval-based maintenance, the maintenance trigger event(s)?
  - How does validation and/or verification determine maintenance needs?
  - For each model sub-component, what are the current and potential sources of maintenance/calibration data?

- How are optimal sources of data determined? At what point is data perceived as sufficient and accurate, and how is data upkeep managed to maintain and enhance such quality?

+ For each model sub-component, what data is being shared across electrical corporations? What data cannot be reliably/usefully shared and used?

The majority of the electrical corporations limited their response to the first set of questions to a listing of their models and the maintenance intervals, with the rationale that much of the discussion on data sources, verification, validation, and calibration has been provided in prior meetings of the RMWG. SDG&E provided a more detailed response to the question than the others. A consistent comment by SDG&E on model maintenance was that most models are re-calibrated annually at a minimum but are also evaluated on an ad-hoc basis throughout the year. Updates are employed when maintenance is determined to be needed based on these assessments. PG&E noted that part of their model maintenance is maintaining the infrastructure to make sure that they produce a forecast every single day, 365 days a year so there are no gaps in operations.

The general maintenance frequencies used by the electrical corporations are:

+ **Asset Data**: Updated quarterly (PG&E, PacifiCorp), monthly (SCE), not mentioned by others. Not all attributes updated at this same frequency. Data refresh intervals of 1-3 years.
+ **Buildings / Communities**: Triennially as data is available (Microsoft Buildings)
+ **Egress**: Triennially to capture new housing developments.
+ **Ignition Likelihood**: Updated annually, or in some cases, as asset data is updated. Calibrated to past occurrence rates.
+ **Index Components**: Typically, annual updates (Building Loss Factors, Initial Attack Assessment, Terrain Difficulty Index) but some such as fire potential index updated more frequently aligning with fuel model updates.
+ **Fuel Model Maps**: Minimum annually, but some electrical corporations multiple times per year. Typically driven by vendor updates.
+ **Fuel Moisture Maps**: PacifiCorp mentioned real-time updates based on RAWS data as well as bi-weekly field measurements. Not mentioned by other electrical corporations.
+ **Population**: Triennially, as data is available (Homeland Security)
+ **PSPS**: Annual review of post event reports, de-energization criteria, and number of customers on a circuit. On-going work assessing consequences through PSPS joint working group.
+ **Tree Data**: Tree data updated at the 1-3 year interval (PG&E).
+ **Verification / Validation**: Typically, annually or biennially, but may be more frequent as model improvements are made (e.g., updated fuels). Machine learning models are updated at a similar frequency depending on updates to training data, model inputs, and model subcomponents. Consequence models are calibrated by comparing simulated data to external information (e.g., Fire Guard, VIIRs, etc.). Fire validations are typically conducted by the vendor and then reviewed by SMEs at the electrical corporation.
+ **Weather**: Annual updates. Weather model drives several sub-models such as fire potential index as well as outage and ignition probability models. Often augmented with weather station data and machine learning algorithms to correct systematic biases.

- **Wildfire Spread**: Annual updates and as needed. Typically driven by vendor updates.

Data quality and usefulness is typically assessed through statistical methods augmented by SME judgement. PG&E and SCE both discussed their data governance procedures in the meeting. PG&E has an overarching enterprise data governance program that runs a lot of data through a data synthesis platform called Palantir Foundry. SCE maintains internal data governance procedures to maintain and update information records (e.g., FIPA, WiSDM, SAP, GESW/Map 3D). SCE continually updates its data given that its risk models are used across the enterprise for both wildfire and non-wildfire use cases.

The discussion then transitioned to the second question which explored data collection and what can be shared across electrical corporations. The electrical corporations were generally open to sharing the following types of information:

- Weather data
- Fuel and Canopy characteristics data
- Technosylva sub-models
- Strategy for POI, Consequence calculation, Adaptation
- PSPS consequence proxy calculations

The electrical corporations were not open to sharing the following types of information:

- Asset information
- Customer information
- Local data
- PSPS likelihood (weather and wind data, post-event reports, current de-energization criteria, number of customers)
- PSPS consequence (number of customers on a circuit, asset outage history)

The key takeaways from this meeting were:

- Typically, models are updated annually or as needed as new data are collected or parameters change. Models directly supporting operations may change more frequently if discrepancies are observed between model predictions and reality.
- Electrical corporations track the sub-components of models and check the verification/validation of models when sub-components change. It was unclear based on the discussion how automated this process is / what degree of unit and integration tests are used in the process.
- Re-evaluated annually or as needed based on model performance. Models are compared with historical and current data. If discrepancies are observed, model maintenance may be performed.
- The electrical corporations discussed their data governance processes at a high level. Data assessment typically includes statistical analysis augmented with SME judgement. However, specific examples of this process were not provided.

- The electrical corporations were willing to share weather, fuels, and fire spread related data. They were also willing to share the calculation processes for probability of ignition and consequence proxies. However, they were not willing to share data on assets, customers, and local historic records (de-energization, outage history, etc.). They were also not willing to share specific de-energization criteria.

2.12 12/13/23 – REVIEW OF WILDFIRE-RELATED OPERATIONAL MODEL

Electrical corporations use models to inform various aspects of operations, such as PSPS, protective device settings, resource deployment, and responding to potential risk events. This workshop focused on operational models currently used by electrical corporations (as opposed to planning models). Discussion included ways to validate that the models are optimized in terms of safety and ways to standardize or improve the models across the electrical corporations. The guiding prompts provided to the electrical corporations on this topic were:

- Describe the key differences between planning and operational models, specifically variables such as fuels and weather data.
- What wildfire operational models are currently in use, and for what purpose? In other words, what specific decisions do they support? Do they differentiate between transmitted and received wildfire risk, and if so, how?
- How are operational models being used to inform situational awareness for prioritization of operational work, such as responding to potential risk events? Provide the pros and cons for using an operational model in such a way.
- What data are being used as inputs to inform operational models of real-time wildfire risk?
- To what extent, and in what ways, would improvements in those models, or new models, provide improved operational decisions?

The electrical corporations noted that the main difference between planning and operations is time. This includes both the time horizon of the projected event (hours or days vs weeks to years) and the frequency of input updates. The electrical corporations use planning models to prioritize mitigations and operations models to guide immediate operational decisions. A few of the key similarities and differences noted by the electrical corporations were:

- **Data Update Frequency**: The electrical corporations update many operational model inputs on an hourly basis or daily basis (temperature, wind, fuel moistures, etc.) which is much more frequent than for planning models which are typically updated annually.
- **Fuel Maps**: One difference that was noted is that the fuel maps used are different between the two, with a best estimate of the current fuel map used in operations and a projected 2030 fuel map used in planning.
- **Fuel Moisture**: Long term planning uses annual updates for seasonal moisture. These may be adapted to local moistures within the simulated weather history, but the focus is on seasonal levels with the worst fire days. Operations use more representative fuel moisture content based on near-term forecasts.
- **Weather Conditions**: Long term planning uses historical climatology/weather with the worst weather days of the last 30 years to interpret how bad the fires could be in the future in a worst case. The approach is different in operations where predictions can be more precise to specific forecasts. These systems leverage weather stations and are often bias corrected with machine learning models.

The discussion then transitioned to discuss the specific operational models that are in use, and how they are used. All electrical corporations use some form of a fire potential index (FPI), and wildfire spread forecasts in assessing the maximum potential size of a wildfire given an ignition in the service territory. In addition, all electrical corporations utilize forecasted wind speeds as a data point in the PSPS decision-making process. Other operational models are used by some electrical corporations but not others. For example, PG&E noted the use of an outage probability weather model and an ignition probability weather model, whereas SCE does not use an outage probability model during operations. Most of the electrical corporations do not explicitly model or estimate received wildfire risk; however, they do monitor active fires in the region and coordinate with emergency response teams as necessary. PacifiCorp noted that they model received risk to inform operational actions such as isolating circuits and protection of electrical corporation assets such as pole wrapping. There was also some discussion on the use of different fragility curves for assets during operations, although this topic was not fully explored.

The model results are generally used in similar ways across the electrical corporations. These include restrictions on hot work, enabling more sensitive settings on protective devices, restricted testing and/or maintenance on reclosers and switching/load transfers, as well as monitoring the potential for a PSPS. The electrical corporations do not use the operational models to weigh the relative response to various circuits. Rather, they use the models to understand how many staff need to be on hand to respond to faults.

The primary benefits of these activities are reducing the risk of starting a wildfire and reducing the breadth of de-energization that is required to mitigate that risk. Some of the difficulties that were noted in this discussion were:

+ There is a large increase in coordination and labor to generate and process results. For example, rather than enabling protective device settings on a grid-wide basis, applying that same protection on a subset of lines involves a lot of communication with those in the field. PacifiCorp summarized this concern well by saying that "… given two different models, I don't necessarily want the more accurate one, per se. I want the one that's going to be more actionable and get me where I need to be when I need to be there to take the actions necessary to mitigate the wildfire risk."
+ There was also discussion of the trade-offs in model uncertainty and spatial granularity of the model and data.
+ The time constraints of supporting real-time operations can make it difficult to digest the various sources of data and model predictions. In addition, due to the relatively short time horizon of operation models (hours to days), there isn't enough lead time to meaningfully impact operations such as vegetation management. Rather, they take a proactive approach to such operations and prioritize based on planning models instead.

The data used by electrical corporations to inform operational models is similar. The inputs used in operational models such as FPI include wind speed, humidity / dew point, fuel moisture, and topography. Data on the number, type, and location of assets are also used and compared with forecasted weather conditions. The values at risk, such as population, buildings, roads, etc. are also used in the consequence assessments.

The final discussion of this meeting was what ways future improvements to models or new models would improve operational decisions. One topic that was discussed was transitioning to a data-driven FPI model using machine learning. The benefits of this approach are allowing the model to use more complex outputs from the weather models as part of the consideration, such as local measures of friction velocity or turbulent kinetic energy. The disadvantage of these approaches is a model that cannot be easily explained, and model transparency is critical to decision makers in operations. The other area that was mentioned was reducing error in weather forecasts. Improvements in the physical models, spatial resolution, and integration of additional weather stations will help. In addition, further integration of the machine learning approaches for bias correction can improve the realism of the predictions. Part of this discussion also mentioned the difficulties in machine learning models extrapolating to higher wind speeds than have been seen in a region.

The key takeaways from this meeting were:

- The condensed time scale in operations requires that decision-makers focus on the key areas that matter for making the decision.
- Weather forecasts tend to under-predict the wind speeds in high-risk scenarios. Using weather station data and machine learning approaches can help correct for these biases.
- Due to the high uncertainty in operational forecasts, these are considered as a data point in the operational decision-making process, but the final decision is up to the operators and is typically based on weather station data.
- All electrical corporations are using some form of a receptive bed model such as fire potential index to understand the potential size of fires which could be expected.
- Electrical corporations consider the number, type, and location of assets as part of the PSPS decision making process. However, there was some discrepancy between electrical corporations in how asset age and fragility curves are used in the modeling approach.
- Future development improving FPI and weather forecasts would improve the use of these tools in operational decision-making.

3.0 Conclusions and Recommendations

Some of the key conclusions and recommendations made by the RMWG participants during this phase of the RMWG are summarized below. Note that this list documents the general consensus of the RMWG at the time of these meetings and does not reflect a specific list of actions to be undertaken.

+ **Conflagration Risk**: Electrical corporations do not account for conflagration in risk models at this time due to a lack of adequate data availability and model maturity. However, conflagration risk is an important portion of understanding wildfire risk and associated mitigation selection. Electrical corporations requested that a single entity manage a state-wide repository of structural data should conflagration risks be considered in the future.
+ **Consequence Classification**: There is not a common classification scheme used by electrical corporations for characterizing the degree of consequence (e.g., small, destructive, catastrophic) from a wildfire or PSPS. Adopting a common classification scheme would improve the ability to share data and compare trends across the industry.
+ **Data Repository**: A common data repository should be established where various agencies can share data relating to wildfire risk. This will improve communication between agencies and reduce costs and burdens associated with repeat validation and acquisition which is currently done independently by each electrical corporation.
+ **Definitions**: Definitions should be agreed upon for absolute risk, relative risk, catastrophic fires, and acceptable risk tolerance threshold.
+ **Egress**: All electrical corporations are considering egress in planning models to some extent. However, additional discussion is needed on the data, indices, and how these can be used in the consequence calculation. At the time, electrical corporations do not account for egress in operational models due to their lack of control and responsibility for evacuation, but identifying egress/ingress constrained communities can inform prioritization for ignition mitigation in those areas.
+ **Future Fuels**: A statewide resource should be developed for future fuelscapes and scenarios rather than delegating this task to each electrical corporation to conduct independently. Should a statewide source be utilized, then the fuel layers and scenarios should be reviewed by Energy Safety and the electrical corporations as part of standardization.
+ **Model Maintenance**: All models are evaluated annually, and some are evaluated more frequently. The primary focus of model maintenance during operations is to ensure zero downtime (i.e., predictions are available every day).
+ **Planning Horizon**: For projecting fuelscapes within planning models, electrical corporations recommended limiting the forecast horizon to one decade due to high propagation of uncertainty with longer time-horizon forecasts.
+ **Suppression**: Electrical corporations do not account for suppression activities in operational risk models due to a lack of data, the high consequence associated with overestimating suppression effectiveness, and the lack of certainty on whether and how 3rd parties will conduct suppression activities. A proxy index could be used to account for the accessibility of various locations. However, additional discussions are needed to standardize this proxy across the industry, especially given the variability and impact due to suppression on wildfire spread.

- **Long Duration Fires**: This topic should be further studied given the impact on the magnitude of the risk which informs the acceptable risk thresholds and cost benefit analysis. Whether 8-hour simulations or 24-hour simulations were used, SCE noted there was not much effect on which areas would be modeled as higher risk. At this time, the electrical corporations focused on defining the relative risk between regions in their service territories and opted to use the less computationally demanding 8-hour simulations.
- **Operational Model Outputs**: Due to the need for immediate operational decision making, risk model outputs must be clear and concise in order to be reliably acted upon. Operational models cannot be overburdened with complex risk model outputs.
- **PSPS Criterion**: Weather forecasts tend to under-predict the wind speeds in high-risk scenarios. Due to the higher uncertainty in operational forecasts, forecasted wind speeds are a data point in the operational decision-making process, but the final decision is up to the operators and is typically based on weather station data.
- **PSPS Planning**: The approaches used by electrical corporations in PSPS planning varies across the industry. Currently, some electrical corporations utilize simulated risk across the territory along with a PSPS risk threshold, while other electrical corporations simply project future PSPS events based on historical frequency and duration. While a more standard approach may be desirable, it will be difficult to establish a single method for estimating PSPS frequency and duration due to variability in assets and service territory.
- **Received Risk**: The electrical corporations are not currently considering received risk (i.e., damage to their equipment resulting from a non-electrical corporation wildfire) as part of their planning or operational decisions. However, all electrical corporations track active fires in their service territory, and some use that information to target local equipment protection such as wrapping poles. If received risk is considered in the future, the electrical corporations request that Energy Safety establish clear requirements for how it should be incorporated into planning models.
- **Standard Wildfire Models**: There was some interest in more standardization in wildfire models; however, the RMWG raised concerns with this approach. The main concerns were related to a lack of calibration to localized climates and fuels as well as limited validation in operation use. In addition, the information and interface of existing tools have not been optimized to provide data in a format that meets the needs of electrical corporation compliance and reporting obligations.
- **Urban Development**: In order to more accurately understand and reflect population changes, electrical corporations should work to be informed of planned construction earlier in the process so that they may account for future development in long time-horizon models.
- **Verification and Validation**: All electrical corporations evaluate the verification and validation basis of models and sub-models annually. As new data is collected, it is compared with predictions. The validation basis of models and sub-models are re-evaluated more frequently when discrepancies in model performance are identified. The current requirements on model verification and validation are unclear. Establishing best practices, including clear requirements for model validation and uncertainty assessments, would improve verification and validation processes.

4.0 Next Steps

Phase I and II of the RMWG covered a wide range of technical topics related to electrical corporation wildfire and outage risk modeling. These meetings focused on information gathering and knowledge sharing, including from outside experts, as various approaches used by the electrical corporations varied significantly at the start of the RMWG. The approaches used by the electrical corporations have started to converge in some areas, while continuing to evolve differently in other areas. As the electrical corporation risk models mature and become more stable, it has become more practical to establish areas of consensus or difference in wildfire and outage modeling approaches. Phase III of the RMWG, which occurred in 2024, mostly focused on how to use the information and discussions from Phases I and II of the RMWG to inform guidelines, as well as restructure the RMWG to move away from information sharing into reaching tangible conclusions that could be used to inform risk modeling moving forward.

The focus going forward in Phase IV is to summarize approaches and potential best practices for electrical corporations for modeling the wildfire risk to the public from their equipment. This Approaches Document will summarize the discussions of the RMWG, and the modeling approaches presented by the electrical corporations in their WMPs. The document will serve as guidance for how to conduct the analyses and present the results for review by other stakeholders. Areas where consensus has been reached on best practice will be documented and recommended for use. Areas where there is no consensus on best practice will be discussed with recommendations made on the comparisons needed to justify an individual approach. Areas where future developments are needed to improve will be summarized with recommendations made to potentially responsible parties for driving these improvements. The objective is to document areas where there is and is not consensus in wildfire and outage risk modeling approaches with discussion around why one approach may be used over another, as well as discussion of areas that need continual improvement and possible paths forward.

This document will be developed through Phase IV (2025) and Phase V (2026) of the RMWG. All electrical corporations and stakeholders are invited to participate in redlining the Approaches Document as it is being developed. The intent is to have two primary topics in each meeting. The first topic is a technical discussion by electrical corporations or stakeholders clarifying key points on approaches. The second topic is a summary of the Approaches Document section drafted since the previous meeting. The final two meetings of the year are reserved for discussion on integration of best practice recommendations into the broader WMP technical guidelines and maturity model.

A tentative schedule of meetings for Phase IV is provided in Table 5.

Table 5. Phase IV (2025) Tentative Meeting Schedule

Date	Technical Topic	Approaches Document Section
1/22/2025		Initial Outline
2/26/2025	Event Framework, Stakeholder Review Process, Catastrophic Fires, Tail Risk	Revised Outline
3/26/2025	Natural units given fire perimeter, natural units to $, risk framework	Final Outline, Risk Framework
4/23/2025	Wildfire Smoke Impact on Consequence	-
5/27/2025	Fuels and Fire Behavior, Weather and Fire Weather	Natural units given fire perimeter, natural units to $, risk framework
6/25/2025	Non-utility mitigations, non-utility infrastructure, population and socio-economic factors	Fuels and Fire Behavior, Weather and Fire Weather
7/23/2025	Scenarios, External Event Frequency	Non-Utility Mitigations, Non-Utility Infrastructure, Population and Socio-Economic Factors
8/27/2025	Assets, Vegetation, Probability of Ignition	Scenarios, External Event Frequency
9/24/2025	Model Documentation and Reporting	Assets, Vegetation, Probability of Ignition
10/22/2025	PSPS and PEDS Impact	Model Documentation and Reporting
11/19/2025	Future Development, WMP Guidelines	PSPS and PEDS Impact
12/17/2025	Maturity Model,	Future Development