SVP / VP Reviewer: [redacted]	Date: 11/25/2020	☐	Action Requested
Law Reviewer: [redacted]	Date: 11/25/2020	☑	Information Only

Wildfire Risk Model Improvements

Full Board

December 10, 2020

Executive Sponsor(s): [redacted] (SVP and Chief Risk Officer)

Author(s) & Affiliation: [redacted] (Sr Director, Risk – Special Projects)

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Topic Summary

Item Overview

- Purpose of Presentation: To provide an overview of the Wildfire Risk Model Improvements
- Why: System Hardening and Enhanced Vegetation Management (EVM) are two key mitigation programs for wildfire risk reduction. The work performed as part of these programs targets ~25,000 electric distribution circuit miles in High Fire Threat Districts (HFTD). The Wildfire Risk Models are used to inform the highest risk miles and are also used to inform the 2021 – 2023 LTIP Public Safety metrics.
- Proposed Board / Committee Action: None

Key Takeaways

- The Wildfire Risk Models have been evolved to consider the CPUC approved risk framework of "Likelihood of a risk event" combined with "Consequence of the risk event"
- The models were initially developed in 2018 and further evolved through 2019 and 2020, using more advanced machine learning methods for predicting ignitions and shifting fire spread simulations, from REAX Engineering to Technosylva, for determining consequence
- The improvements made to the risk models resulted in a significant shift in the risk ranking of the circuit segments, or circuit protection zones, across the High Fire Threat Districts
- The enhanced risk models, Vegetation and Equipment, are used in conjunction with additional considerations including subject matter expertise from PG&E's Public Safety Specialists, with significant fire science and behavior experience, to inform the 2021 workplan for EVM, System Hardening and other wildfire risk reduction efforts

Wildfires have become more frequent and destructive in PG&E's service territory

Situation

Catastrophic wildland fires have become a major threat throughout PG&E's service territory and represent a significant risk to the safety of our customers and our communities we serve.

PG&E's electrical equipment has been the ignition source for a number of these fires and a multi-pronged approach has been developed to reduce the wildfire risk.

Complication

The frequency and severity of catastrophic fire events have increased dramatically over the last 10 years.

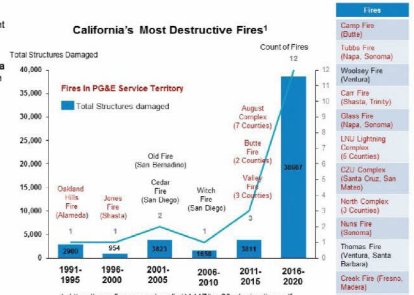
- PG&E's service territory has grown from ~15% HFTD to over 50% from 2012 through 2018, which includes nearly 31,000 miles[1] of PG&E's electric transmission and distribution system traversing HFTDs.

To meet these challenges, PG&E has developed a series of models to identify areas of highest consequence and potential for fire ignitions. These models continue to improve as the available information and understanding improves.

1. PG&E's total electric transmission and distribution system includes nearly 125,000 miles

Objective

- Outline the process for assessing risk
- Share the evolution of PG&E's risk modeling efforts to identify the highest potential wildfire risk areas within PG&E's service territory
- Identify the areas where risk modeling has been operationalized for risk reduction activities



Fires
- Camp Fire (Butte)
- Tubbs Fire (Napa, Sonoma)
- Woolsey Fire (Ventura)
- Carr Fire (Shasta, Trinity)
- Glass Fire (Napa, Sonoma)
- LNU Lightning Complex (5 Counties)
- CZU Complex (Santa Cruz, San Mateo)
- North Complex (3 Counties)
- Nuns Fire (Sonoma)
- Thomas Fire (Ventura, Santa Barbara)
- Creek Fire (Fresno, Madera)
- Atlas Fire (Napa, Solano)

The framework to assess wildfire risk includes the likelihood and consequence of a potential ignition event

LoRE

- The likelihood of a risk event (LoRE) is the relative frequency of a specific risk event occurring.
- In the case of **wildfire risk**, this is the relative **likelihood of an ignition occurring**.

CoRE

- The consequence of a risk event (CoRE) is the average impact of the risk should it materialize across key outcomes (Safety, Reliability, Financial).
- In the case of wildfire risk, **consequence contains serious injuries, fatalities, property damage**, and impacts to reliability.

Risk = LoRE X CoRE

- Risk is the product of the likelihood and consequence of a risk event.
- This method produces an expected value of impact across the consequence outcomes, and combined results in a multi-attribute score can inform risk-based decision making.

Methodology

Ignition Model

Likelihood of Ignition

Ignition likelihood was determined based on 2021 modeling predicting ignitions at the circuit protection zone (CPZ)

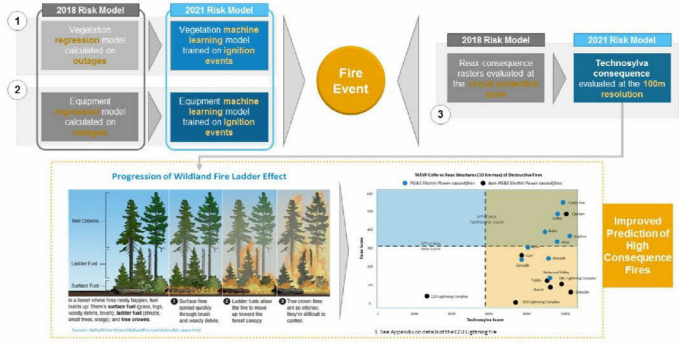
Fire Spread Model

Likelihood of Spread | **Consequence**

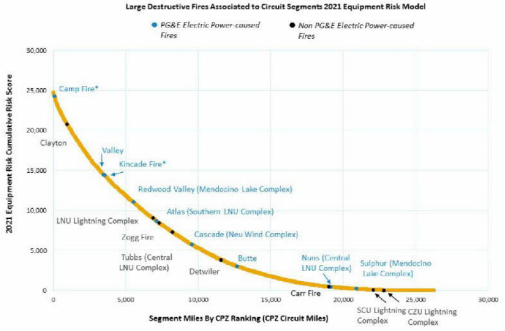
Spread likelihood was determined based on a study conducted by PG&E and Technosylva

Consequence considerations focused on the potential impact of a wildfire

Enhancements implemented in 2021 Wildfire Risk Models



Large destructive fires superimposed on the equipment risk profile curve



Key Takeaways

The majority of the large fires were captured in the top 50% of the circuit segment miles for the 2021 risk model.

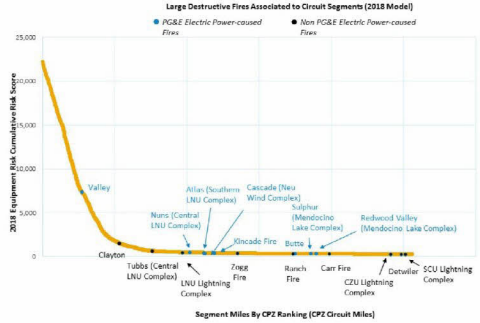
The risk profile curves include additional considerations such as:

- Probability of ignition
- Uses Mean Risk Score vs the Max Risk Score on the comparison between REAX and Technosylva

This adjusts the prioritization, and shifts the ignitions further down the risk curve.

*The Camp and Kincade Fires were associated to the nearest distribution segment to assign risk

Where do the High Consequence Fires show up on the Risk Buydown Curve



Key Takeaways

The 2018 model was less effective at identifying locations with large fires.

This prioritization also differs from a pure Reax scoring, as it includes Egress, and probability of ignition calculation.

The Camp fire was not able to be mapped due to changes in the designations between 2018 and 2020.

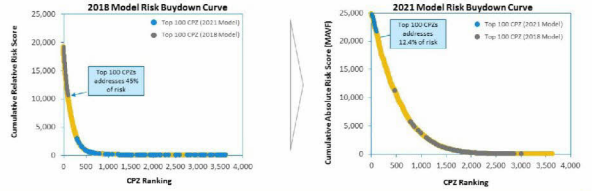
Slide 8

SS1 Can we include a footnote that provides additional details?

[redacted] 11/29/2020

Risk models provide risk profile curves to guide workplan

The risk profile curve shows ***the amount of risk that can be addressed*** with every subsequent mile within a Circuit Section (or referenced as Circuit Protection Zone, CPZ) that is mitigated. This view illustrates the relative magnitude of risk associated with the top 100 CPZs and the visualization highlights the consolidation of risk by CPZ as you move down the prioritization list.



Equipment (Conductor) Risk Profile curves highlight the significant shift of where the top 100 CPZ's are between the two models primarily as a result of the shift in the consequence model

Additional data and local field Information informs the workplan

EVM Workplan

- Vegetation Risk Model Segment Ranking determines the initial workplan
- LiDAR data on strike potential trees spanning the 25,000 miles of High Fire Threat Districts adjusts the plan
- Final identified list of EVM miles to be worked in 2021 are being checked by Public Safety Specialists for final confirmation

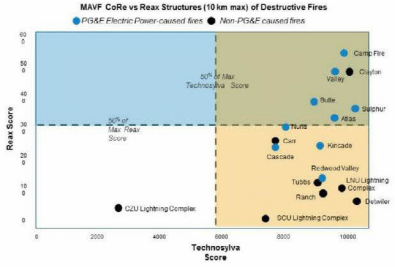
System Hardening Workplan

- Equipment Risk Model Segment Ranking determines the initial workplan
- Project by project review ensures appropriate mitigation method is selected
- Address circuits where customers have been impacted multiple times by 2019 and 2020 PSPS Events
- Final identified list of System Hardening projects to be worked in 2021 are being checked by Public Safety Specialists for final confirmation

Appendix

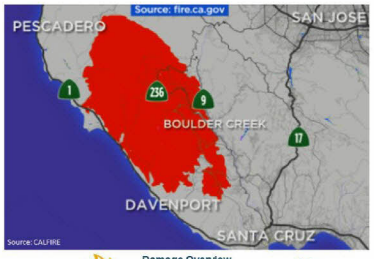
Technosylva more accurately predicts high consequence fires as having high risk

Technosylva based wildfire consequence data better identifies historical destructive fire locations



Fire Name	Cause	Circuit Segment Name
Butte	Electrical Power	Electra 110 CB
Valley	Electrical Power	Middleto
Clayton	Arson	Highlan
Detwiler	Shooting	Bear Va
Cascade (Neu Wind Complex)	Electrical Power	Bangor
Tubbs (Central LNU Complex)	Private Electrical System	Calistog
Redwood Valley (Mendocino Lake Complex)	Electrical Power	Calpella
Nuns (Central LNU Complex)	Electrical Power	Dunbar
Atlas (Southern LNU Complex)	Electrical Power	Pueblo
Sulphur (Mendocino Lake Complex)	Electrical Power	Redbud
Carr	Vehicle	French Gulch
Ranch Fire (Mendocino Complex)	Human	Potter Valley PH
Camp Fire	Electrical Power	Cresta 1
Kincade Fire	Electrical Power	Calpine
SCU Lightning Complex	Lightning / Under Investigation	Westley
LNU Lightning Complex	Lightning	Silverad
CZU Lightning Complex	Lightning	Point Moretti

CZU Lightning Complex Fire



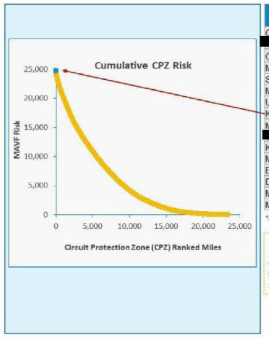
Damage Overview

- 86,509 acres burned
- Active for 37 days
- 1 fatality
- 1 Injury
- 1,490 structures destroyed
- 140 structures damaged

Fire Description and Observations

- The wildfires started at 6:41 AM on August 16, 2020 and was the result of a thunderstorm that produced close to **11,000 bolts of lightning** and **started hundreds of fires** throughout California
- The lightning strikes initially **started fires separately** known as the Warnella Fire near Davenport and the Waddell Fire, near Waddell Creek, as well as three fires on what would become the northern edge of the CZU Complex fire.
- Two days after the fires began, **a change in wind conditions** caused these three northern fires **to rapidly expand and merge**, growing quickly to over 40,000 acres
- This was not one fire but a **merging of small fires into one massive fire**. Our current **consequence models focus on potential fires growing from one ignition point** as compared to simulating the fire behavior of multiple ignition points combining into one fire.
- The modeling complexity of this wildfire is such that it would **require taking into account the hundreds of fires** that were started rather than treating this as a single wildfire
- Also, the focus of our **consequence model evaluates the potential ignition points from our overhead electric** distribution circuits in HFTDs and several of the ignition points for this fire occurred where none of our **assets existed**.

System Hardening Example: The top 50 highest risk-miles represent 1.4% of the total risk



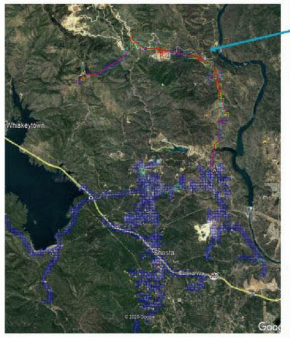
Protection Zone Name	Miles	Cumulative Miles	Mean MAVF Score	Total CPZ MAVF	% total risk reduced[1]
[redacted]	0.02	0.02	3.16	3.16	**0.01%**
CALPINE [redacted]	0.01	0.03	1.88	1.88	**0.01%**
MARIPOSA [redacted]	0.08	0.12	1.09	1.09	**0.02%**
SHEPHERD [redacted]	0.01	0.13	1.44	1.44	**0.02%**
MIDDLETOWN 1103CB	0.05	0.18	1.30	5.20	**0.03%**
UPPER LAKE 1101CB	1.00	1.17	1.26	3.77	**0.04%**
KESWICK [redacted]	6.66	7.83	1.25	48.64	**0.17%**
MIDDLETOWN [redacted]	4.21	12.04	0.92	48.56	**0.29%**
KONOCTI [redacted]	5.61	17.65	0.88	51.70	**0.42%**
MARIPOSA [redacted]	0.64	18.29	0.77	10.81	**0.44%**
BUCKS CR [redacted]	4.29	22.58	0.73	9.55	**0.47%**
DEL MAR [redacted]	0.09	22.67	0.73	2.19	**0.47%**
MIDDLETO [redacted]	0.42	23.08	0.72	8.70	**0.49%**
MIDDLETOWN [redacted]	24.80	47.88	0.72	151.83	**0.87%**

[1]Based on assuming an OH hardening risk mitigation (82% risk reduction effectiveness)

Key Takeaway

On each project a more granular risk spend efficiency evaluation will be performed on an NPV basis (total cost of ownership for the asset life) once the project is fully scoped similar to what is shown on the Keswick 11011586 circuit protection zone on the next slide

System Hardening Project Example: Keswick 11011586 Circuit Protection Zone



Keswick 11011586 Circuit Protection Zone

- 6.6 Miles in total, the 100m X 100m grid points are the absolute risk values for each section of this protection zone
- The total protection zone absolute risk score is 48.84 risk units (sum of all the 100m grid points along the circuit)
- Average risk score of all the grid points results in the CPZ mean risk score of 1.25

Keswick (6.6 Miles)	No System Hardening	Overhead Hardening	Under-grounding	50%-50% OH / UG
Total CPZ Risk Reduced After Mitigation	0	30.28	48.35	39.32
Total CPZ Residual Risk Value	**48.84**	**18.56**	**0.49**	**9.52**
Overall Miles Mitigated	0.0	6.6	6.6	6.6
OH System Hardening ([redacted] mile)				
UG System Hardening ([redacted] mile)				
Total Capital Cost				
Average O&M Cost (per year)				
NPV @ 7% discount rate				
$ NPV per unit of risk (RSE)				
Estimated Time to Complete		12 mos	24 mos	18 mos

Assumptions:

- Discount Rate: **7%**, Cost Escalation / Inflation: **3%**
- Benefit Duration: **30** years for OH and **60** for UG
- Routine Veg Tree Count / Mile: **80.76**
- PSPS Cost of Reenergizing [redacted] **mile**
- Patrols and Inspections [redacted] **/ mile** for OH and [redacted] **/ mile** for UG