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)

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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 the two key mitigation programs in use for wildfire risk buydown. The work done through these programs has to target the right miles from the ~25,000 circuit miles in High Fire Threat Districts. The Wildfire Risk Models are the method used to target the right miles for risk buydown.
- Proposed Board / Committee Action: None

Key Takeaways

- The Wildfire Risk Models are built around 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 revamped in 2020, using more advanced machine learning methods for predicting ignitions and shifting from REAX Engineering simulations to Technosylva simulations for determining consequence
- The improvements made to the risk models resulted in a major shift in the risk ranking of the circuit protection zones across with the High Fire Threat Districts for both System Hardening and Enhanced Vegetation Management
- The new risk models (Vegetation and Equipment) are used in conjunction with field information to determine the 2021 workplan for EVM and System Hardening

Wildfires have become more frequent and destructive, highlighting the importance of understanding wildfire risk

Situation

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

PG&E recognizes our electrical equipment has been the ignition point for a number of these fires and is working to understand the causes of catastrophic fires to target wildfire risk reduction work for maximum risk buydown.

Complication

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

- PG&E's service territory has grown from 15% HFDT to over 50% from 2012 through 2020.
- The historical methods for managing fire risk need to evolve to mitigate risks to communities in the wildland urban interface amid changing climatological conditions.

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

Objective

- Outline the process for assessing risk
- Communicate the evolution of PG&E's risk modeling efforts
- 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 (6 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)

From 2012 – 2020 HFTD went from 15% to 50%

The framework to assess wildfire risk examines 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**.

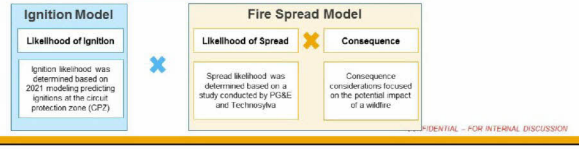
CoRE

- 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.

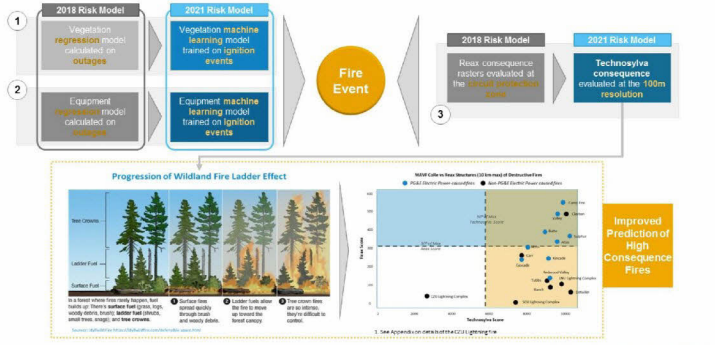
Risk = LoRE X CoRE

- 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 when combined results in a multi-attribute score that can inform risk-based decision making

Methodology

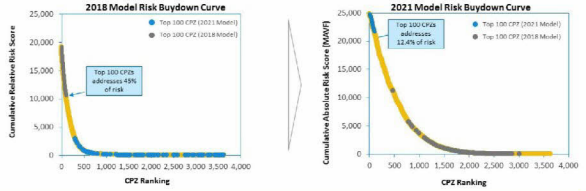


Enhancements implemented in 2021 Wildfire Risk Models



Risk models provide risk buydown curves to guide workplan

The risk buydown 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 Buydown 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

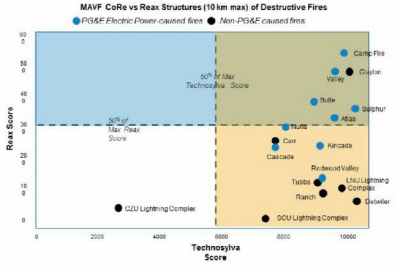
System Hardening Workplan

- 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 8 of more times during the 11 PSPS events taken in 2019 and 2020
- Final identified list of System Hardening projects to be worked in 2021 are being checked by Public Safety Specialists for final confirmation

Appendix

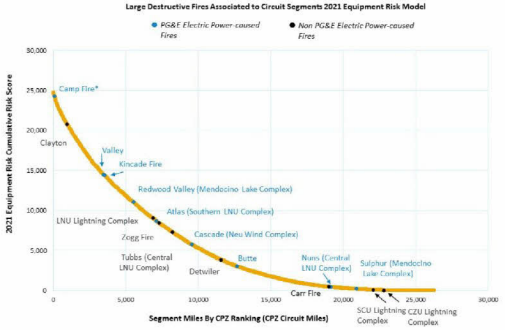
Technosylva more accurately predicts high consequence fires as having high risk

Technosylva based wildfire consequence data better identifies historical destructive fire locations



Fire Name	Cause	Circuit Segment Name
Butte	Electrical Power	Electra 1101CB
Valley	Electrical Power	Middletown 11014646
Clayton	Arson	Highlands 1103828
Detwiler	Shooting	Bear Valley 210110000
Cascade (Neu Wind Complex)	Electrical Power	Bangor 11011958
Tubbs (Central LNU Complex)	Private Electrical System	Calistoga 1101734
Redwood Valley (Mendocino Lake Complex)	Electrical Power	Calpella 1101542
Nuns (Central LNU Complex)	Electrical Power	Dunbar 110147964
Atlas (Southern LNU Complex)	Electrical Power	Pueblo 11041304
Sulphur (Mendocino Lake Complex)	Electrical Power	Redbud 1101CB
Carr	Vehicle	French Gulch 11021462
Ranch Fire (Mendocino Complex)	Human	Potter Valley PH 11051904
Camp Fire	Electrical Power	Cresta 1101546650
Kincade Fire	Electrical Power	Calpine 1144CB
SCU Lightning Complex	Lightning / Under Investigation	Westley 1103237522
LNU Lightning Complex	Lightning	Silverado 210234969
CZU Lightning Complex	Lightning	Point Moretti 110112122

Large destructive fires plotted on the 2021 equipment risk buydown curve



Key Takeaways

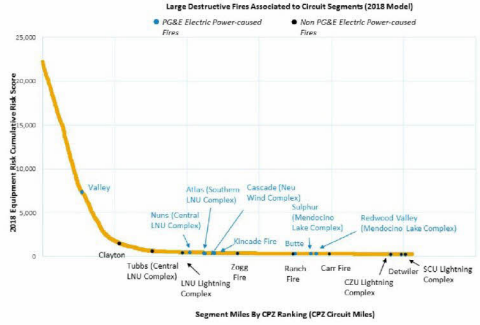
The majority of the large fires were captured in the top 50% of the segment miles for the 2021 risk model.

The risk buydown 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 Fire was associated to the nearest distribution segment to assign risk

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



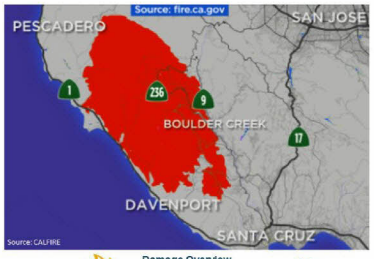
Key Takeaways

The 2018 model was less effective at identifying locations with large fires, with only 1 large fire begin identified before the inflection point.

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

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

CZU Lightning Complex Fire



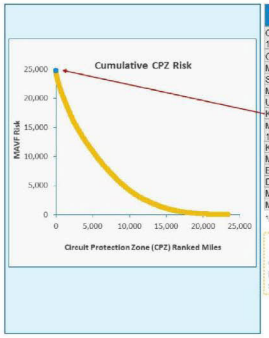
Damage Overview

- 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**.

The top 50 highest risk-miles represent 1.4% of the total risk



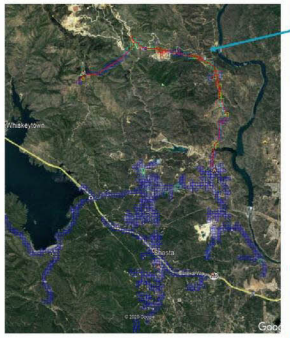
Protection Zone Name	Miles	Cumulative Miles	Mean MAVF Score	Total CPZ MAVF	% total risk reduced[1]
OREGON TRAIL 1103OUS391	0.02	0.02	3.16	3.16	**0.01%**
CALPINE 1144276.G	0.01	0.03	1.88	1.88	**0.01%**
MARIPOSA 210190130	0.08	0.12	1.69	1.69	**0.02%**
SHEPHERD 2111688294	0.01	0.13	1.44	1.44	**0.02%**
MIDDLETOWN 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 11011586	6.66	7.83	1.25	48.64	**0.17%**
MIDDLETOWN 1102302610	4.21	12.04	0.92	48.56	**0.29%**
KONOCTI 1102965078	5.61	17.65	0.88	51.70	**0.42%**
MARIPOSA 2102241564	0.64	18.29	0.77	10.81	**0.44%**
BUCKS CREEK 1101CB	4.29	22.58	0.73	9.55	**0.47%**
DEL MAR 2109378446	0.09	22.67	0.73	2.19	**0.47%**
MIDDLETOWN 1102CB	0.42	23.08	0.72	8.70	**0.49%**
MIDDLETOWN 1103830	24.80	47.88	0.72	151.83	**0.87%**

[1]Based on assuming an OH hardening risk mitigation (62% 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 own[redacted] the asset life) once the project is fully scoped similar to what is shown on the Keswick [redacted] circuit protection zone on the next slide

Project Example: Keswick [redacted] Circuit Protection Zone



Keswick [redacted] 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