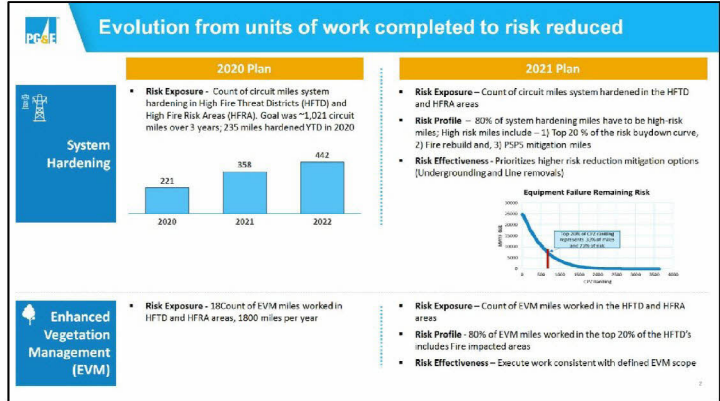


**Risk Models
&
2021 Workplans**

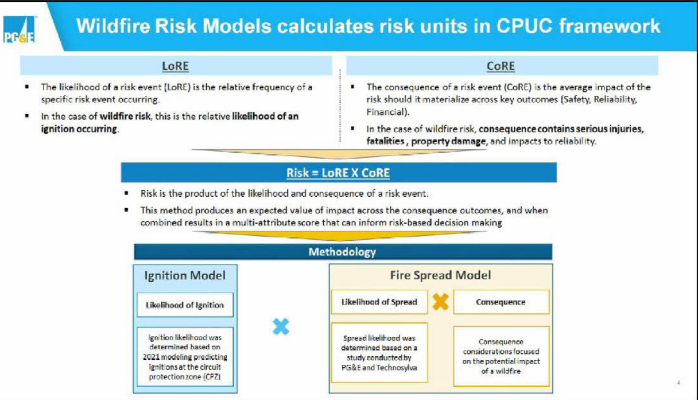
November 17, 2020

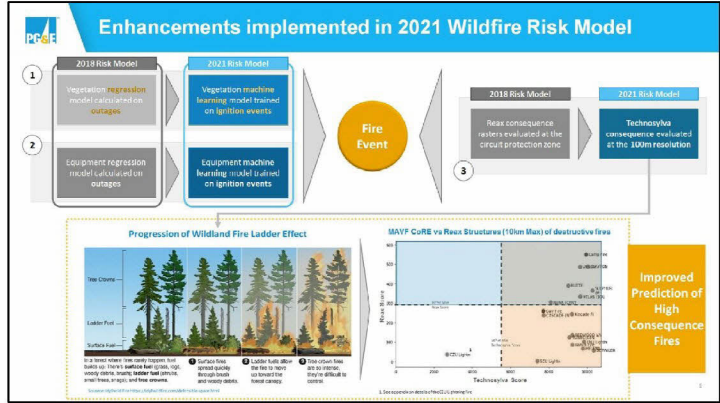


Together, Building
a Better California



Risk Model and Risk Quantification

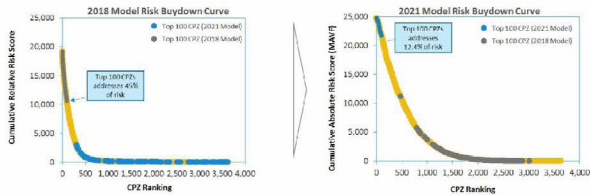






Risk models provide risk buydown curves to guide workplan

The risk buydown curve shows the amount of risk that can be addressed with every subsequent mile or CPZ that is mitigated. This view shows the relative magnitude of potential projects and can compare impacts of programs with varied effectiveness. The visualization helps to highlight the consolidation of risk by mile as you move down the prioritization list.

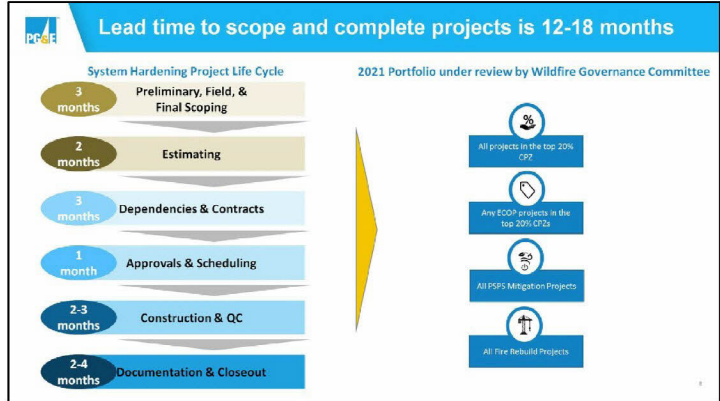


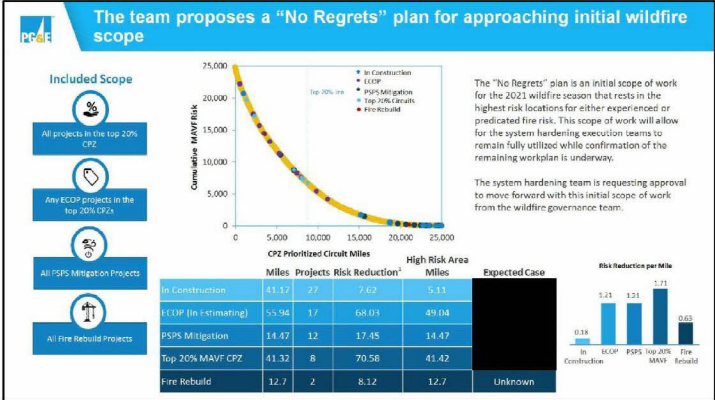
System Hardening Risk Buydown curves highlight the significant shift of where the top 100 CPZ's are between the two models

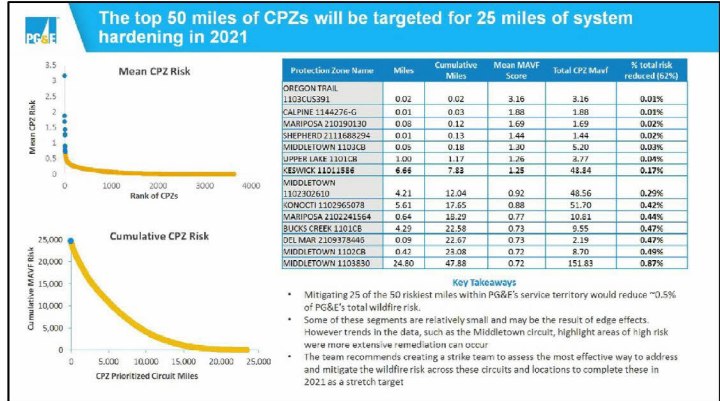
System Hardening



Together, Building
a Better California



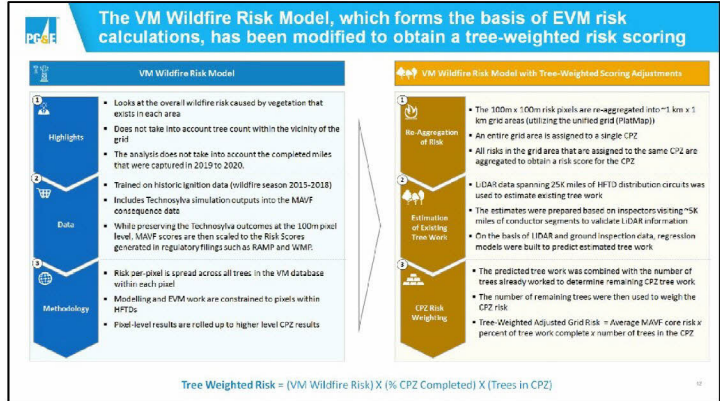


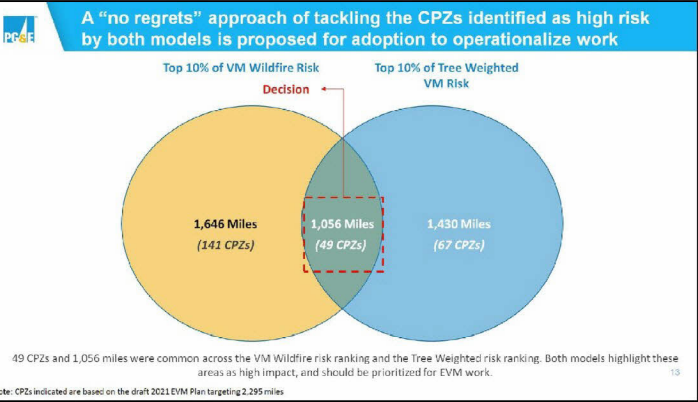


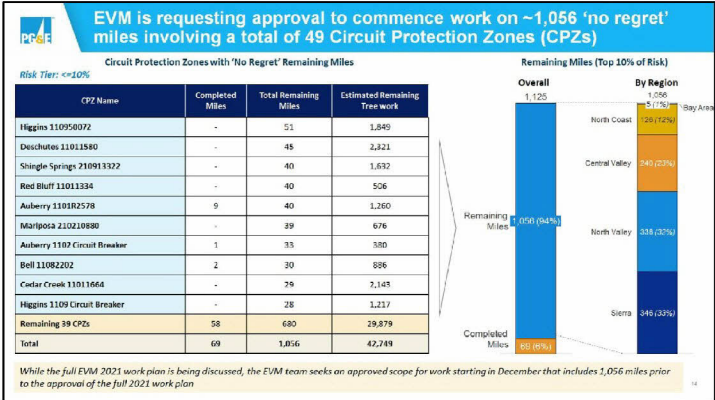
Enhanced Vegetation Management

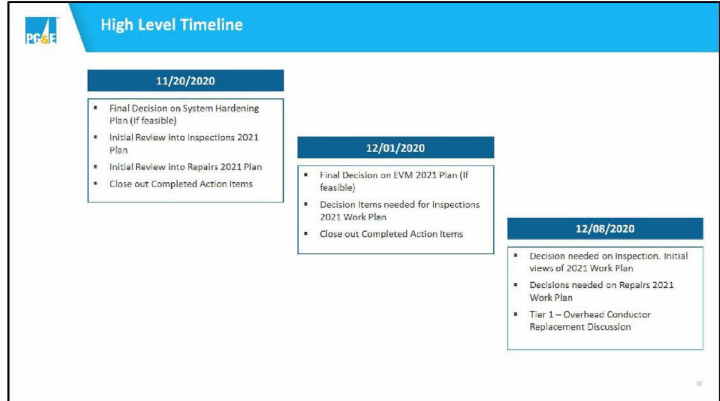


Together, Building
a Better California



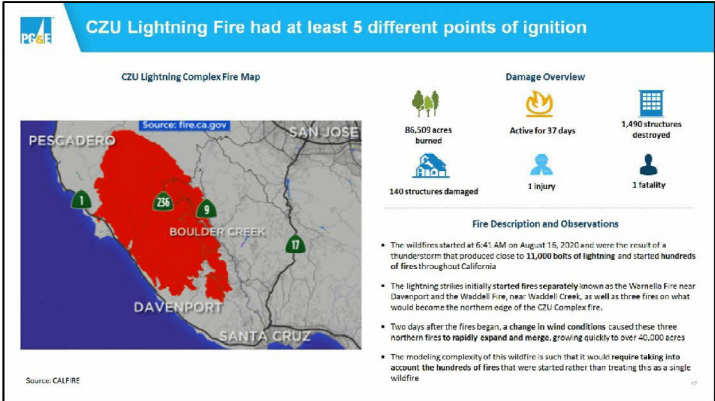


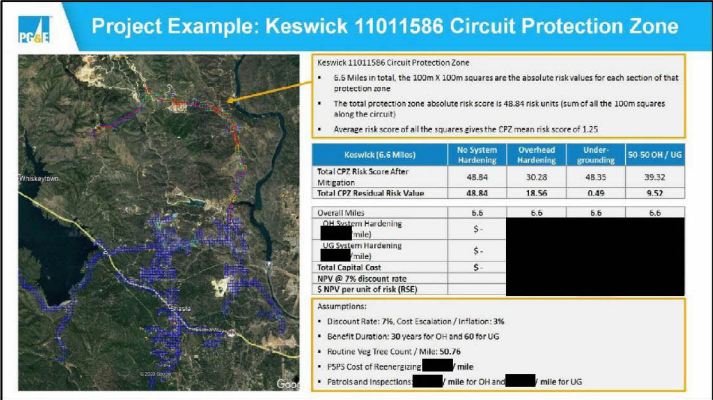


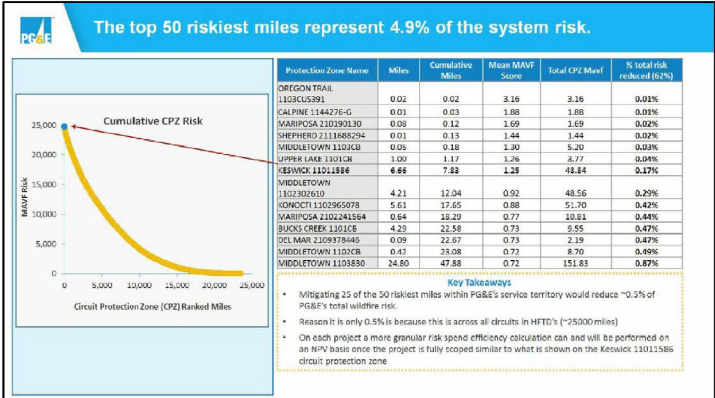



Appendix

16/000000







 **2021 Dx Model**

In the effort to prioritize circuits, 2021 Dx Model continues advancement of risk model capabilities compared to earlier models

	PRIORITIZATION DETAILS	RISK EQUATION
<p>Methodology</p> <ul style="list-style-type: none"> • Make Ignition predictions at a scale of 100m x 100m "pixels" along the Dx grid • Roll-up pixels to Circuit Protection Zones • For each pixel, assign risk score based upon the product of: 	<p>(1) Likelihood of ignition (2) Effect of a potential ignition</p> <hr/> <p>✓ Tier 3 ✓ Tier 2</p> <hr/> <p>✓ Likelihood: via Ignition prediction (Max Entropy) ✓ Effect: via : (1) Ignition spread (Technolyva) (2) Ignition consequence (Technolyva)</p>	<div style="border: 1px solid #ccc; padding: 10px; text-align: center;"> <p>Wildfire risk=</p> <p>LoRe X CoRe (Ignition Spread X Consequence)</p> </div> <p><small>Ignition likelihood: The likelihood of ignition in 100m x 100m pixels</small></p> <p><small>Ignition spread: The likelihood of ignition spread in 100m x 100m pixels</small></p> <p><small>Consequence: The Consequence score is the effect on structures and natural resources in 100m x 100m pixels</small></p>

2021 Dx Model (EVM Model)
LoRE Ignition likelihood calculation

IGNITION LIKELIHOOD

Wildfire Risk = LoRE • CoRE (Ignition Spread • Consequence)

Scoring methodology

Ignition likelihood (LoRE) was determined based on a probability analysis predicting ignitions in 100m pixels. The model was trained on ignitions limited to fire season events and CPUC reportable ignitions from 2015 to 2018.

1 Variables importance ranking

Variable	Permutation Importance
soil_hgt_ft	0.12
soil_hgt_ft_sq	24.8
water_distance_ft	21.8
prop_hgt_ft_sq	9
tree	4.3
prop_hgt_ft	3.1
prop_hgt_sq	2.8
prop_hgt_ft_sq	2.4
prop_hgt_ft	2.3
prop_hgt_sq	1.9
prop_hgt_ft	1.8
prop_hgt_sq	1
prop_hgt_ft	0.8
prop_hgt_sq	0.8
prop_hgt_ft	0.6
prop_hgt_sq	0.4

2 Model Type

Maximum Entropy: The principle of maximum entropy states that the probability distribution which best represents the current state of knowledge is the one with the largest entropy, in the context of precisely stated prior data

Model Results

Top 10 feeders with the highest predicted count of vegetation caused ignitions:

Feeder name	Predicted count
GARBERVILLE 1103	0.000336
FRUITLAND 1142	0.000333
FRUITLAND 1141	0.000274
GARBERVILLE 1102	0.000265
BEN LOMOND 0401	0.000245
BEN LOMOND 1101	0.00024
GARBERVILLE 1101	0.000216
HOOFA 1101	0.000218
FELTON 0401	0.000215
PARADISE 1108	0.000204

Model Statistics and Performance

- Predicted annual HFTD ignitions (average): 100
- Observed total HFTD ignitions (2015-2018): 401
- Model Performance
- ROC-AUC - 0.737 (in-sample)
- ROC-AUC - 0.716 (out-of-sample)

2021 Dx Model (Conductor Model) LoRE Ignition likelihood calculation

IGNITION LIKELIHOOD

Wildfire Risk = **LoRE** • CoRE (Ignition Spread • Consequence)

Scoring methodology

Ignition likelihood (LoRE) is calculated using classification model that identifies the likelihood of at least one ignition per year at a given 100m by 100m pixel location. More specifically, the Conductor Failure models the conditional probability that a reportable ignition will occur within a given pixel location:

1 Variables importance ranking

Variable	Permutation Importance
Non burnable area	30.8
Daily precipitation, mean	25.8
Conductor material: ACSH	9.7
Estimated conductor age	8.9
Maximum height	4.3
Reliability Program: vprk	4.3
Vapor pressure deficit, mean	4.0
Conductor size: 2	3.0
Conductor size: 4	1.6
100-hour leaf, mean	1.1
Max temperature, mean	1.0
Wind speed, mean	0.9
Local topography	0.2
Conductor size: 6	0.1
Conductor material: AI	0.0
Conductor material: CS	0.0

Model Results

Top 10 feeders with the highest probability of ignition led by asset failure:

Feeder name	Mean Ignition Probability
CRESTA 1101	.001
PARADISE 1105	0.00098
BIG BASIN 1101	0.00091
APPLE HILL 1104	0.00086
CAMP PINE 1104	0.00079
PARADISE 1109	0.00072
CURTIS 1105	0.00070
PARADISE 1104	0.00067
CEDAR CREEK 1101	0.00065
PARADISE 1106	0.00064

Model Statistics and Performance

- Predicted annual HFTD ignitions (average): 60
- Observed total HFTD ignitions (2019-2018): 242
- ROC-AUC: 0.76 (in-sample)
- ROC-AUC: 0.74 (out-of-sample)

2021 Dx Model – Technosylva Modeling and CoRE Calculation

IGNITION SPREAD

Wildfire Risk = LoRE * CoRE (Ignition Spread * Consequence)

Ignition Spread Calculation: Concept

- Ignition points were selected within a 200m buffer around PG&E's assets, creating a grid of 100m squares. (~254,000)
- For each point on the grid pick a date from the worst weather dates (452)
- Simulate a fire and let it burn for 8 hours using underlying fuel and weather conditions.
- Simulation results were aggregated including acres burned, flame length, rate of spread, buildings destroyed, and fire volume.
- Pixel's were then averaged across CPZs to create consequence scores for CPZs

Destructive fire probability

A destructive fire probability is calculated at each of the 2154 HFTD locations by taking a ratio of number of simulations that met the following criteria

1) Acres burnt* >= 300 Or 1) FBI >= 3
2) Building destroyed* >= 50 Or 2) FBI >= 2
3) Fire behavior index (FBI) >= 2

* Acres burnt and building destroyed are at the end of the 8 hr simulation.

CONSEQUENCES

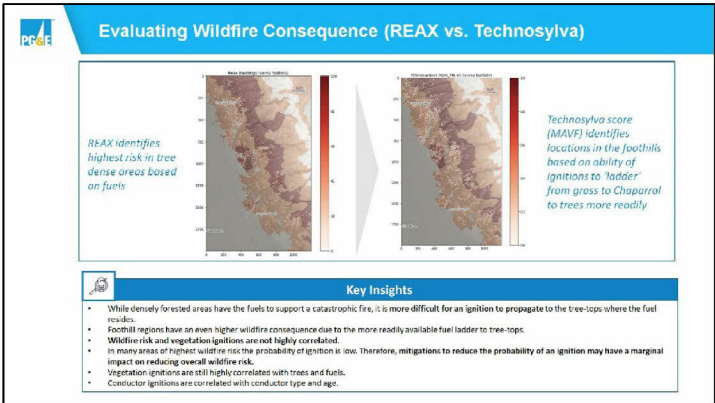
Wildfire Risk = LoRE * CoRE (Ignition Spread * Consequence)

Scoring methodology

Within PG&E, the Meteorology team is working with Technosylva to create fire spread simulation for every 100 x 100m pixel within HFTD regions. By leveraging the Technosylva fire spread modeling outputs and historical Red Flag Warning shapefiles, consequence model are developed to distinguish the consequence within the HFTD tranche at 100m x 100m grid level. The steps implemented included:

- 1) **Calculate RFW and Fire Size Probabilities**
Technosylva and (Red Flag Warning) RFW shape files from National Weather Service to be used to calculate the probability of the fire size given an ignition, and the probability of RFW at 100m pixel level
- 2) **Calculate pre-calibrated MAVF CoRE**
Combining the fire size probabilities and RFW probabilities calculated in Step 1 with MAVF CoRE values at tranche, the MAVF CoRE values at 100m tranche level are calculated.
- 3) **Calibrate MAVF CoRE w.r.t Ignition Driver**
Calibrate the CoRE by matching uncalibrated Risk per event to the weighted average CoRE from the wildfire bovine model. By applying uniform calibration factor across all pixels, this method preserves the relative consequence difference between 100m pixels

Redacted for Privilege



Risk Model Action Items					
Workstream	Action Item	Description	Responsible Party	Resolution	Date
Risk Model	Risk model contributors	Provide a detailed description of the top model contributors		Complete - suggested for inclusion in top 100 contributors	11/17/2020

Vegetation Model – Contributors Description		Conductor Model – Contributors Description	
Variable	Description	Variable	Description
Flow height-avg	Maximum flow height, in meters, for each 100m x 100m area along the distribution grid	High-temperature area	Used surface temperature similar to top temperatures, but vertices surface, that typically don't ignite unless a spark occurs
100-hour-fuel-avg	The dead fuel moisture data from GRDMET	Daily precipitation, mean	The average daily precipitation from the GRDMET dataset
Vapor pressure-deficit-avg	The average vapor pressure deficit from the GRDMET dataset	Conductor material: ACOR	Alignment conductor steel-voided
Windy summer day pct	Percentage of days that have high frequency of gusts	Edwin conductor age	Number of years since the installation year
WIND	High fire threat index	Max tree height	Maximum tree height, in meters, for each 100m x 100m area along the distribution grid
Precipitation-avg	The average daily precipitation from the GRDMET dataset	Reliability Program splice	Spans with more than three splice per phase
Impervious	Impervious ground cover (i.e. non-forested)	Vapor pressure deficit, mean	The average vapor pressure deficit from the GRDMET dataset
Specific humidity-avg	The average specific humidity from the GRDMET dataset	Conductor size: 2	Conductor size-2
Burn index-avg	An derived variable based off of the geographical and topographical aspects of a location	Conductor size: 4	Conductor size-4
Wind-max	The maximum wind velocity at a height of 10 meters from the Real-Time Mesoscale Analysis (RTMA) dataset at a resolution of 2.5-km	100-hour fuel, mean	The dead fuel moisture data from GRDMET
Temperature-avg	The average temperature from the GRDMET dataset	Max temperature, mean	The average maximum temperature from the GRDMET dataset
Windy summer-day pct	Percentage of days that have a high percentage of days with high average wind speed	Wind speed, mean	The average wind velocity at a height of 10 meters from the Real-Time Mesoscale Analysis (RTMA) dataset at a resolution of 2.5 km
Local-topography	The topographic position index (TPI) was extracted from a USGS digital elevation model (DEM) at 100-meter resolution	Local topography	The topographic position index (TPI) was extracted from a USGS digital elevation model (DEM) at 100-meter resolution
100-hour-fuel-avg	The dead fuel moisture data from GRDMET		
Energy-release-avg	Average release of energy from fuels		