PACIFIC GAS AND ELECTRIC COMPANY
PG&E Ref. DRU12880-Case-Electric Undergrounding Expediting Program-Senate Bill (SB) 884
Data Request OEIS
Requester DR No. Energy Safety-DR-EUP-23-01 - Models and Metrics for Senate Bill ("SB") 884

Requester: Schonsheck, Stefan
Request Date: December 22, 2023
Response Date: January 08, 2024

Question No. 001:

Regarding Pacific Gas and Electric Company's ("PG&E") framework for measuring risk landscape

Please describe in a narrative format, PG&E's methodology for evaluating risk with respect to wildfires and reliability that are relevant to California Public Utilities Code § 8388.5 (d)(2) (4-5 sentences each). Specify what risks are formally quantified and what metrics and outputs are used in model-informed decision-making. Additionally, list any SB 884-related risks that PG&E addresses through non-numerical techniques means.

Lastly, please include:

a) An entity relation diagram of the system(s) used for quantifying wildfire risk.
b) An entity relation diagram of the system(s) used for (d)(2) reliability risks.: Requirements for Energy Safety Approval

Response to Question No. 001 Response No. 001:

We describe our methodology for evaluating risk with respect to wildfires and reliability in our Wildfire Mitigation Plan (WMP). Specifically, in Section 7.1 of PG&E's 2023-2025 WMP, Revision 3 (R3), pages 230 to 269, we describe our approach to risk evaluation. PG&E's 2023-2025 WMP, R3 can be found at the following link: www.pge.com/wildfiremitigationplan.

Our risk management approach is based on conducting a quantitative risk assessment to determine our overall utility risk from wildfire and Public Safety Power Shutoff (PSPS) events for our service territory. Our approach is built on an iterative process that starts by identifying risks, evaluating how those risks impact our systems and the community, responding to risks through mitigation and control programs, and monitoring how well our risk mitigation and management programs are working. Risk mitigation and management is an on-going effort through which we continuously evaluate risk and our response to that risk, and adjust our programs to address them. The intent of performing risk analysis is to understand the overall utility risk and the risk components across our service territory. We use this understanding of our risk to develop and prioritize the comprehensive wildfire mitigation strategy.

In Section 6 of the 2023-2025 WMP, R3, pages 139 to 228, we provide an overview of our approach to wildfire risk assessment and risk management. We describe our risk models, our risk analysis frameworks, risk calculations, quality assurance and quality control, and other aspects of our risk methodology and assessment processes.

In Appendix B of the 2023-2025 WMP, R3, pages 995 to 1001, we provide wildfire risk model and calculation schematics and narratives describing the model calculation procedures. Our wildfire risk model is called the Wildfire Distribution Risk Model (WDRM), version 3 (v3). We also have a wildfire transmission risk model, the Wildfire Transmission Risk Model (WTRM).

a) Diagram for wildfire risk – See Appendix B of the 2023-2025 WMP, R3 (pp. 995-1001).

b) Diagram for reliability risk – There is no equivalent reliability model to the WDRM. There are multiple reliability measures we use to evaluate reliability improvements. Our annual reliability performance is documented in our Electric Reliability Report. Our 2022 Electric Reliability report can be found here: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/infrastructure/electric-reliability-reports/2022-pge-annual-electric-reliability-report.pdf.

   We plan to use historical reliability data and Customer Minutes Interrupted (CMI) as the reliability measure in our 10-year undergrounding plan.

We have not finalized our approach for selecting and prioritizing projects for SB884. There may be cases in which non-numerical analysis is used in combination with WDRM and WBCA scores when selecting or prioritizing projects. This could include projects identified by Public Safety Specialists or fire rebuild projects.

Question No. 002:

Regarding PG&E's models used to evaluate wildfire risk and consequence

Please provide a list of models used to evaluate wildfire risks and consequences. This list should be at least as granular as the entity relation diagram from Q01.a. Then, for each model, detail the following in a narrative format (2-5 sentences each):

1) Model Usage – The model's scope, how often the model is invoked, and what subsections of the network are measured by this model. If multiple models are used to compute the same factors on different parts of the network, please describe them here.
2) Model Type – The model's taxonomy, particularly the quantitative nature of the calculations. Also, comprehensively describe the computational costs of querying the model.
3) Key Inputs – The data that is fed into a calibrated model, including a description of the original data collection when applicable. These may be in summary form (e.g., the electrical corporation may list "equipment properties" rather than listing out equipment age, maintenance history, etc.). Training data should not be mentioned here.
4) Model Solution – The method used to calibrate, train, simulate, optimize, or implement the model from a mathematical standpoint. If the model is based on a learning algorithm, briefly describe the optimization procedure, including the training data.
5) Model Outputs – The data produced by the model is fed into other models or used by PG&E to make risk-related decisions. Please comment on the type of output (ex: distribution, average

value, score, probability) as well as the spatial resolution (ex: per circuit, per segment, per county) and temporal resolution (ex: per day, per season, per year).
6) Toy Problem – Please describe 3 examples of data input/output using synthetic data. One input should lead to a low-risk (or low-probability, low-consequence) output, one for a medium-risk case, and one for a high-risk case. In each case describe the magnitude of the inputs and outputs.
7) Shelf Life – Describe the length or period of time the model is expected to be valid. Describe if/how the model is expected to be updated, both regarding new calibration data and new project input data. Describe if/when the model is expected to be retired or replaced by another model.

Response to Question No. 002 Response No. 001:

The information requested in parts 1-5 and 7 of this question, as well as additional explanatory information, can be found in PG&E's 2023-2025 WMP, R3 as described in response to Question 1 above.

As discussed above, we describe our methodology for evaluating risk with respect to wildfires and reliability in our 2023-2025 WMP. Specifically, in Section 7.1 of PG&E's 2023-2025 WMP, R3, pages 230 to 269, we describe our approach to risk evaluation. In Section 6 of the 2023-2025 WMP, R3, pages 139 to 228, we provide an overview of our approach to wildfire risk assessment and risk management. We describe our risk models, our risk analysis frameworks, risk calculations, quality assurance and quality control, and other aspects of our risk methodology and assessment processes. In Appendix B of the 2023-2025 WMP, R3, pages 995 to 1001, we provide wildfire risk model and calculation schematics and narratives describing the model calculation procedures.

Per a discussion with Energy Safety, a response to portion 6 of this request will be provided by Friday, January 12, 2024.

Question No. 003:

Regarding PG&E's models used to (d)(2) reliability risks and consequences

Please provide a list of models used to evaluate (d)(2) reliability risks and consequences. This list should be at least as granular the entity level diagram from Q01.b. Then, for each model, describe the following:

1) Model Usage – The model's scope, how often the model is invoked, and what subsections of the network are measured by this model. If multiple models are used to compute the same factors on different parts of the network, please describe them here.
2) Model Type – The model's taxonomy, particularly the quantitative nature of the calculations. Also, comment on the computational costs of querying the model.
3) Key Inputs – The data that is fed into a calibrated model, including a description of the original data collection when appropriate. These may be in summary form (e.g., the electrical corporation may list "equipment properties" rather than listing out equipment age, maintenance history, etc.). Training data shall not be mentioned here.
4) Model Solution – The method used to calibrate, train, simulate, optimize, or implement the model from a mathematical standpoint. If the model is based on a learning algorithm, briefly describe the optimization procedure, including the training data.
5) Model Outputs – The data produced by the model is fed into other models or used by PG&E to make risk-related decisions. Please comment on the type of output (ex: distribution, average

value, score, probability) as well as the spatial resolution (ex: per circuit, per segment, per county) and temporal resolution (ex: per day, per season, per year).

6) Toy Problem – Please describe 3 examples of data input/output using synthetic data. One should input should lead to a low-risk (or low-probability, low-consequence) output. One for a medium-risk case and one for a high-risk case. In each case be sure to comment on the magnitude(s) of the inputs and outputs.
7) Shelf Life – What is the length or period of time the model expected to be valid? Describe if/how the model is expected to be updated, both regarding new calibration data and new project input data. Describe if/when the model is expected to be retired or replaced by another model.

Response to Question No. 003 Response No. 001:

We do not have an equivalent model that represents reliability risks and consequences as we have for the wildfire risk like the WDRM. To support this request, we will describe at a high level how we approach reliability risks and consequences for SB884.

1) Model Usage - Reliability Risk is represented in terms of Normal Operation Reliability + Enhanced Powerline Safety Settings (EPSS) Reliability + PSPS Reliability.
    - Normal Operation Reliability is based on historical outage performance (e.g., 2017-2022) delineated to the same granularity as the wildfire risk model. The reliability risk would be measured in Customer Minutes Interrupted (CMI), which is a measure of Customers Experiencing Sustained Outage (CESO) multiplied by Customer Average Interruption Duration Index (CAIDI).
    - EPSS Reliability is represented as a backcast against historical outage performance based on criteria in which EPSS would be activated. For example, based on the current EPSS criteria for 2023, which outage in 2017 would be impacted by EPSS and have a different reliability impact. The difference in reliability impact on a historical outage incident is based on EPSS's impact to CESO and CAIDI based on current operation. The resultant is a Customer Minutes Interrupted Multiplier when EPSS would have been in place during a historical time period. An alternative would be to present EPSS historical outage metrics only, which is a less precise measurement of the EPSS risk locationally.
    - PSPS Reliability is presented as a backcast against historical weather events based on current PSPS criteria. For example, based on the current PSPS criteria for 2023, a historical weather event in 2015 would have resulted in a PSPS event resulting in a certain set of customers de-energized. An alternative would be to present PSPS historical outage metrics only, which is a less precise measurement of the PSPS risk locationally.
2) Model Type – All reliability risk is based on historical outage or backcast analysis.
3) Key Inputs – Reliability risk is based on historical outage records, historical weather events, EPSS enablement criteria based on wind speed, humidity, and dead fuel moisture, and PSPS enablement criteria based on fire potential index and ignition producing winds.
4) Model Solution – As stated above, we do not have a WDRM-equivalent model for reliability. The reliability data is based on historical records or historical backcast on potential risk events.
5) Model Outputs – Average annual CMI is presented at the circuit protection zone level. The CMI is monetized based off the $/CMI as developed by the ICE Calculator from Lawrence Berkeley National Lab, consistent with the framework established through the Risk OIR, previously called S-MAP.
6) Toy Problem – Per a discussion with Energy Safety, a response to portion 6 of this request will be provided by Friday, January 12, 2024.
7) Shelf Life – The shelf life of the model is expected to be valid until the next iteration of data or protocol is established. Minor updates are expected to be bundled together with major updates

for consistency in the model results, which is expected to be updated approximately every three (3) years, consistent with the wildfire mitigation plan updates and model updates.

<u>Question No. 004:</u>

Regarding PG&E's evaluations of the efficacy of undergrounding

Please describe in a narrative format how PG&E values the efficacy of undergrounding a circuit in terms of wildfire and (d)(2) reliability risk models. Address which risk models described in Q03 and Q04 may be impacted by undergrounding projects. Specify which inputs and outputs to the risk models which may change after a circuit (or segment) is undergrounded and indicate the direction and scale of the expected change(s). Be sure to specifically detail how undergrounding a circuit affects ignition risk.

<u>Response to Question No. 004 Response No. 001:</u>

To value the efficacy of undergrounding a circuit, our grid engineers reviewed more than 2,000 outage combinations that occurred in our HFTD during wildfire season. Each outage combination represents the basic cause, supplemental cause, equipment involved, and equipment condition and is evaluated to determine if undergrounding the circuit would adequately address the outage combination. Based on the likelihood that undergrounding would prevent each outage combination and the frequency of each individual outage combination, a weighted average effectiveness of undergrounding is generated. Note that we performed this analysis on outage combinations instead of ignition events due to the larger sample size of outage event combinations which provide a more comprehensive estimation of effectiveness. These effectiveness values are applied specifically against each circuit protection zone's probability of ignition relative to each WDRM model subset, as referenced in Question 2, to arrive at a Circuit Protection Zone (CPZ)-specific effectiveness.

The above-described ignition reduction effectiveness analysis (reviewing over 2,000 outage combinations) determined, as some examples, that undergrounding a circuit results in approximately the following mitigation of risk from various potential ignition drivers:

- 98.4% reduction in Vegetation (Branch failures)
- 98.1% reduction in Vegetation (Trunk failures)
- 99.2% reduction in Vegetation (other)
- 99.3% reduction in Animal contract (Bird)
- 99.7% reduction in Animal contact (Squirrel)
- 91.0% reduction in Animal contact (other)
- 99.1% reduction in Third Party (Balloon)
- 98.1% reduction in Third Party (Vehicle)
- 69.4% reduction in Third Party (other)
- 92.5% reduction in Primary Conductor failure
- 91.3% reduction in Secondary Conductor failure
- 96.5% reduction in Equipment failure (Support Structure)
- 94.0% reduction in Equipment failure (Transformer)
- 96.2% reduction in Equipment failure (Voltage Control)
- 88.5% reduction in Equipment failure (other)

PG&E updates these values periodically.

Given these varying effectiveness results for different outage drivers, the undergrounding effectiveness for each CPZ can be modeled uniquely based on the historical combination of outage combinations on that CPZ and the specific effectiveness of undergrounding to mitigate each individual outage combination.

In a very similar manner to what is described above for ignitions, effectiveness values for the undergrounding impact on reliability were generated based on a review outage combinations. However, the reliability analysis did not limit the analysis to only those outage events that occurred during wildfire season, which means that winter storm related outage drivers were incorporated into the reliability effectiveness analysis but not the wildfire ignition effectiveness analysis. The determined undergrounding reliability effectiveness was applied to the historical reliability performance of circuit segments, as referenced in Question 3.

Overall, the expected change is a substantial reduction in the probability of a wildfire ignition and improvement in reliability performance, and its scale is more significant than aboveground hardening.

Question No. 005:

Regarding PG&E's methods used to predict the cost of undergrounding projects

Please describe in a narrative format how PG&E predicts costs for undergrounding projects. Describe what basic units are used as inputs to the cost model and the resolution of the predictions. Additionally, describe the scope, frequency, and resolution of these evaluations. Lastly, comment on how these do or do not align with the frequency and resolution of risk model evaluations.

Response to Question No. 005 Response No. 001:

Once an undergrounding project has been initiated, our teams forecast the full estimated cost to complete that project. This is performed initially at a high level by an engineering team while they are scoping the project, including the expected route, or path, of the new underground lines including the anticipated needed boxes, equipment, and other considerations. Then this initial project cost estimate is built out into a full project cost estimate by a designer (or "estimator") while they perform the technical design of all the project details such that this forecast estimates the cost to perform all designed job tasks. The project forecasted cost is then maintained by the project manager as the project unfolds, including if unexpected conditions change the design or cost estimate, all the way through completion and closeout.

Before undergrounding projects have been initiated and project-specific details have been incorporated into a cost forecast as discussed above, we assign a feasibility factor (a "score" between 1 and 3) to each CPZ that accounts for the presence of hard rock, gradient (e.g. steep inclines), and water crossings. A higher feasibility factor represents an increased level of difficulty anticipated during the construction phase of the project to relocate overhead lines underground. Using this systematic estimate for project cost based on feasibility factors, a baseline undergrounding unit cost is multiplied by the feasibility factor and the length of a CPZ to arrive at an adjusted, high-level forecast cost for undergrounding that CPZ.

We continue to evaluate how we forecast costs for undergrounding projects and anticipate continuing to evolve the approach described in this response as our undergrounding program continues to mature.

Lastly, the cost forecasting described in this response is not connected to the "frequency and resolution of risk model evaluations."

<u>Question No. 006:</u>

Regarding PG&E's evaluations of the efficacy of aboveground hardening

Please describe in a narrative format how PG&E values the efficacy of aboveground hardening of a circuit in terms of wildfire and (d)(2) reliability risk models. Address which risk models described in Q03 and Q04 may be impacted by aboveground hardening projects as well as the different types of aboveground hardening that are considered. Specify which inputs and outputs to the risk models which may change after a circuit (or segment) is undergrounded and indicate the direction and scale of the expected change(s). Be sure to specifically detail how undergrounding a circuit affects ignition risk.

<u>Response to Question No. 006 Response No. 001:</u>

To value the efficacy of aboveground hardening, our grid engineers reviewed more than 2,000 outage combinations that occurred in our HFTD during wildfire season – the same process that was completed for undergrounding as described in Question No. 004 Response No. 001.

Each outage combination represents the basic cause, supplemental cause, equipment involved, and equipment condition and is evaluated on if aboveground hardening the circuit would adequately address the outage combination. Based on the likelihood of that outage combination and each individual outage combination effectiveness, a weighted average effectiveness of aboveground hardening is generated. Specifically, we consider outage combinations instead of ignitions directly due to the larger sample size of event combinations in order to provide a more comprehensive estimation of effectiveness. These effectiveness values are applied specifically against each circuit protection zone's probability of ignition relative to each WDRM model subset referenced in Question 2, to arrive at a CPZ specific effectiveness. These effectiveness values are applied specifically against each circuit protection zone's probability of ignition relative to each WDRM model subset, the model referenced in Question 2, to arrive at a CPZ specific effectiveness. Similarly, effectiveness values are generated for reliability and applied to the historical reliability performance, referenced in Question 3.

Similar to the underground effectiveness results referenced in Question 4 above, aboveground hardening a circuit results in the following approximate risk mitigation from various potential ignition drivers:

- 76.5% reduction in Vegetation (Branch)
- 61.2% reduction in Vegetation (Trunk)
- 78.0% reduction in Vegetation (other)
- 76.7% reduction in Animal (Bird)
- 77.2% reduction in Animal (Squirrel)
- 69.5% reduction in Animal (other)
- 85.7% reduction in Third Party (Balloon)
- 63.0% reduction in Third Party (Vehicle)
- 50.3% reduction in Third Party (other)
- 67.6% reduction in Primary Conductor
- 62.2% reduction in Secondary Conductor
- 75.7% reduction in Equipment (Support Structure)

- 68.0% reduction in Equipment (Transformer)
- 43.9% reduction in Equipment (Voltage Control)
- 60.2% reduction in Equipment (other)

PG&E updates these values periodically.

<u>Question No. 007:</u>

Regarding PG&E's methods used to predict the cost of aboveground hardening

Please describe in a narrative format how PG&E predicts costs for aboveground hardening projects. Describe what basic units are used as inputs to the cost model and the resolution of the predictions. Additionally, describe the scope, frequency, and resolution of these evaluations. Lastly, comment on how these do or do not align with the frequency and resolution of risk model evaluations.

<u>Response to Question No. 007 Response No. 001:</u>

The process for estimating or predicting the costs for overhead hardening projects is very similar to the process for estimating the cost for undergrounding projects as discussed in the response to Question 5 above. Overhead hardening project costs are similarly forecast on a per mile basis. The basic components that make up covered conductor are described in PG&E's 2023 General Rate Case (See A. 21-06-021, Exhibit PG&E-4, Chapter 4.3, Section C.1.3).

As stated in the response to Question 5, there is no relationship between the resolution of forecast and recorded costs for covered conductor and risk model evaluations.

<u>Question No. 008:</u>

Regarding PG&E's methods used to evaluate efficacy and costs for "other alternative mitigation strategy[s]" relevant to SB 884

Please comment on any "alternative mitigation strategies" (California Public Utilities Code § 8388.5(c)(4)) including covered conductor, vegetation management, EPS and combinations of the above, which PG&E may consider in their 884 plan. When possible, please detail the modeled efficacy and cost predictions as in Q04. and Q05.

<u>Response to Question No. 008 Response No. 001:</u>

We have not finalized which alternative mitigation strategies we will include in our SB 884 Undergrounding Plan. At a minimum we will include:

- Undergrounding;
- Overhead Covered Conductor;
- Line Removal via deployment of a Remote Grid (which is roughly 100% effective at removing the existing ignition risk associated with the existing overhead powerline); and
- Current Baseline System (no asset upgrades) including deployment of EPSS.

PG&E will also discuss Rapid Earth Fault Current Limiter (REFCL) in our Undergrounding Plan. At this time, REFCL has not been shown to be a scalable solution that can be used as a mitigation alternative systemwide. For additional information regarding PG&E's work with REFCL, please see Section 8.1.8.1.3.1 of the 2023-2025 WMP.[1]

[1] 2023-2025 WMP (R3), pg. 573.

PACIFIC GAS AND ELECTRIC COMPANY
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Data Request OEIS
Requester DR No. Energy Safety-DR-EUP-23-01 - Models and Metrics for Senate Bill ("SB") 884
Supplemental Response

Requester: Schonsheck, Stefan
Request Date: December 22, 2023
Response Date: January 12, 2024

Question No. 002:

Regarding PG&E's models used to evaluate wildfire risk and consequence

Please provide a list of models used to evaluate wildfire risks and consequences. This list should be at least as granular as the entity relation diagram from Q01.a. Then, for each model, detail the following in a narrative format (2-5 sentences each):

1. Model Usage – The model's scope, how often the model is invoked, and what subsections of the network are measured by this model. If multiple models are used to compute the same factors on different parts of the network, please describe them here.
2. Model Type – The model's taxonomy, particularly the quantitative nature of the calculations. Also, comprehensively describe the computational costs of querying the model.
3. Key Inputs – The data that is fed into a calibrated model, including a description of the original data collection when applicable. These may be in summary form (e.g., the electrical corporation may list "equipment properties" rather than listing out equipment age, maintenance history, etc.). Training data should not be mentioned here.
4. Model Solution – The method used to calibrate, train, simulate, optimize, or implement the model from a mathematical standpoint. If the model is based on a learning algorithm, briefly describe the optimization procedure, including the training data.
5. Model Outputs – The data produced by the model is fed into other models or used by PG&E to make risk-related decisions. Please comment on the type of output (ex: distribution, average value, score, probability) as well as the spatial resolution (ex: per circuit, per segment, per county) and temporal resolution (ex: per day, per season, per year).
6. Toy Problem – Please describe 3 examples of data input/output using synthetic data. One input should lead to a low-risk (or low-probability, low-consequence) output, one for a medium-risk case, and one for a high-risk case. In each case describe the magnitude of the inputs and outputs.
7. Shelf Life – Describe the length or period of time the model is expected to be valid. Describe if/how the model is expected to be updated, both regarding new calibration data and new project input data. Describe if/when the model is expected to be retired or replaced by another model.

<u>Response to Question No. 002 Response No. 002:</u>

PG&E hereby supplements our response to Question No. 002 part 6, submitted to Energy Safety on January 8, 2024.

"Toy problem" is not a term or process that is regularly used by PG&E. Therefore, in attachment *"DRU12880_Q02.D002_Atch01_Toy Problem.xlsx"* we provide sample "toy problems" relating to our evaluation of (1) wildfire risk and consequence using our Wildfire Distribution Risk Model (WDRM) v3 and (2) reliability risk and consequence for circuit segments of different risk profiles. For wildfire risk, the attachment uses example probability and consequence outputs from the WDRM to show the risk at each circuit segment. For reliability risk, the attachment uses example probability and average Customers Experiencing Sustained Outages (CESO) and Customer Average Interruption Duration Index (CAIDI) metric outputs to show risk at each circuit segment – shown as Customer Minutes Interrupted (CMI). The attachment shows how PG&E can apply the effectiveness of a mitigation—in this case, undergrounding and overhead hardening—to calculate a post-mitigation risk score at each circuit segment based on the contributions of the different risk sub-drivers (e.g., equipment and vegetation). It also shows how we convert the outputs from the WDRM and our reliability metrics to a monetized value that can be combined for different cost/benefit analyses. Please note that the example numbers and percentages included in these "toy problems" are illustrative and do not relate to specific circuit segments in PG&E's service territory.

Below, PG&E provides additional, high-level context regarding our framework for evaluating wildfire/ignition risk using the WDRM that may be helpful when reviewing the sample "toy problems" provided in this supplemental response. PG&E provides additional details about the outage data metrics that we use to evaluate reliability risk and consequence, including CESO, CAIDI, and CMI in our response to Question No. 003, Response No. 001 of this data request.

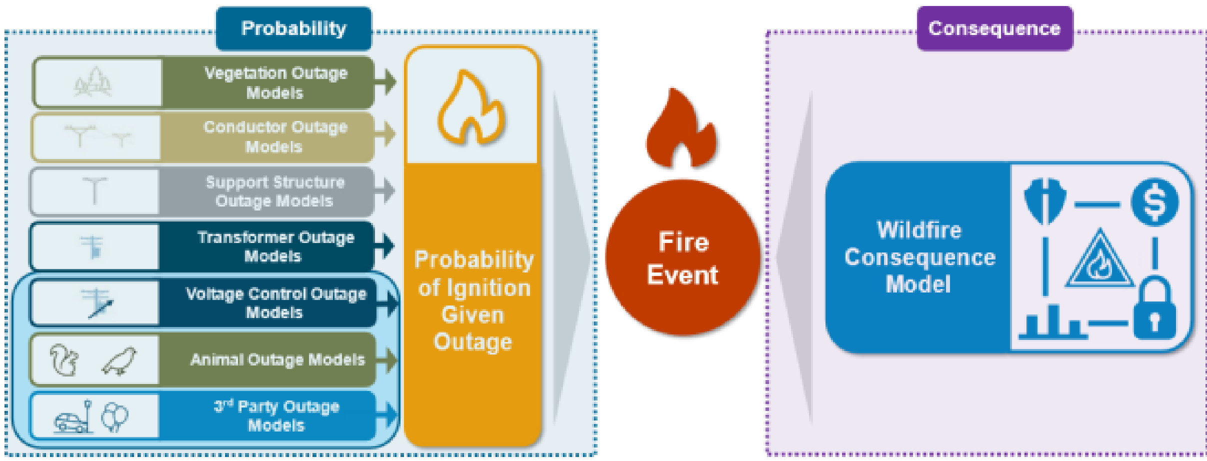
Wildfire/Ignition Risk Framework Background

PG&E describes our wildfire risk/ignition risk framework in our 2023-2025 Wildfire Mitigation Plan (WMP), R4, Section 6.2.1, pp. 154-161.The data that is input into the WDRM to evaluate wildfire risk at the circuit segment level consists of probability data and consequence data. We discuss each of these inputs in more detail below.

WDRM Inputs

The WDRM incorporates the probability of ignition and wildfire consequences as shown in the figure from page 161 of PG&E's 2023-2025 WMP below.

FIGURE PG&E-6.2.1-2:
PROBABILITY AND CONSEQUENCE



Risk = Probability(Outage) x Probability(Ignition Given Outage) x Wildfire Consequence

<u>Probability of Ignition Inputs</u>

The WDRM v3 draws on approximately 114,000 events in the target event dataset. The three datasets are:

1. Outages and Forced Outages

- Source: PG&E's Integrated Logging Information System; and
- Outages are defined as times when electricity ceases to be delivered to customers. Detecting outages is done electronically and is automatically recorded.

2. Hazards and Damages

- Source: Post-PSPS Inspection Data; and
- These are issues classified as potential hazards or equipment damage identified during the inspection of de-energized equipment before power can be restored after a PSPS event.

3. Ignitions

- Source: PG&E's Historical Ignitions Data, 2015-2021 (approximately 2,500 CPUC-reportable ignitions and approximately 1,900 non-reportable ignitions); and
- CPUC-reportable ignitions data is limited to fire events that meet the following criteria:
  - A self-propagating fire of material other than electrical and/or communication facilities
  - The resulting fire traveled greater than one linear meter from the ignition point; and
  - The utility has knowledge that the fire occurred.

Collectively, the three types of events are described as failures. Failures are defined as incidents where damage to the grid has occurred, or damage to the environment has occurred due to grid equipment operation, even if no outage occurs. The failure data includes events that occurred within the boundaries of PG&E's overhead distribution lines from 2015-2021 during fire season (June through November). Attributes of the target set of events that are used to define 17 non-overlapping subsets in the WDRM v3 are summarized in the following table from PG&E's 2023-2025 WMP.

TABLE PG&E-6.2.1-1:
WDRM v3 SUBSET CHARACTERISTICS

Line No.	Subset	Voltage Category	Equipment Type	Cause	Sub-cause	Modeling Category	Model Type[(a)]
1	Vegetation_other	Any	Any	Vegetation	Other	Object Contact	MaxEnt
2	Primary_conductor	Primary	Conductor	Any	NA	Equipment	MaxEnt
3	Vegetation_branch	Any	Any	Vegetation	Branch	Object Contact	MaxEnt
4	Vegetation_trunk	Any	Any	Vegetation	Trunk	Object Contact	MaxEnt
5	Animal:_bird	Any	Any	Animal	Bird	Object Contact	MaxEnt
6	Secondary_ Conductor	Secondary	Conductor	Any	NA	Equipment	MaxEnt
7	Other_equipment_ Type	Any	Other	Any	NA	Equipment	MaxEnt
8	Third_party_balloon	Any	Any	Third party	Balloon	Object Contact	MaxEnt
9	Third_party_other	Any	Any	Third party	Other	Object Contact	MaxEnt
10	Third_party_vehicle	Any	Any	Third party	Vehicle	Object Contact	MaxEnt
11	Animal_squirrel	Any	Any	Animal	Squirrel	Object Contact	MaxEnt
12	Voltage_control equipment_type	Any	Voltage Control	Any	NA	Equipment	MaxEnt
13	Animal_other	Any	Any	Animal	Other	Object Contact	MaxEnt
14	Support_structure equipment_cause	Any	Support Structure	Equipment	Structural	Support Structure/ Transformer	Asset Attribute
15	Support_structure equipment_electrical	Any	Support Structure	Equipment	Electrical	Support Structure/ Transformer	Asset Attribute
16	Transformer equipment_leaking	Any	Transformer	Equipment	Leaking	Support Structure/ Transformer	Asset Attribute
17	Transformer equipment_cause	Any	Transformer	Equipment	Failure	Support Structure/ Transformer	Asset Attribute

(a) For subsets with outages driven by environmental determinants, such as vegetation caused outages, the WDRM v3 employs a MaxEnt model structure, with primarily spatially varying covariates resulting in grid pixel level estimates of P(outage).

For modeling categories that relate to equipment failures due to internal attributes, such as transformers and support structures, the WDRM v3 employs Asset Attribute models fit via Random Forest to one row of data per asset year.

A third model type, Logistic Regression, is used to estimate the probability of ignitions associated with outages, given outage characteristics.

Consequence Inputs

The Wildfire Consequence Model (WFC) uses four sources of data to determine Fire Hazard Intensity or fire severity:

- Outputs from 2021 updated simulations from Technosylva;
- Satellite detected fires from VIIRS (infrared satellite);
- CAL FIRE data on fire outcomes correlated to VIIRS fires (used to assign Multi-Attribute Value Functions [MAVF], Consequence of Risk Event [CoRE] values); and
- Daily estimates of the 1-5 scaled R-score provided by the Fire Potential Index (FPI) produced for Public Safety Power Shutoff (PSPS) models for every 2 x 2-kilometer square in PG&E's service territory. See pages 767-773 of Section 8.3.6 of our 2023-2025 WMP R4, for a more detailed description of the FPI model.

The output from the WDRM is the ultimately the probability of failure and wildfire consequence at each circuit segment.

<u>Question No. 003:</u>

Regarding PG&E's models used to (d)(2) reliability risks and consequences

Please provide a list of models used to evaluate (d)(2) reliability risks and consequences. This list should be at least as granular the entity level diagram from Q01.b. Then, for each model, describe the following:

1. Model Usage – The model's scope, how often the model is invoked, and what subsections of the network are measured by this model. If multiple models are used to compute the same factors on different parts of the network, please describe them here.
2. Model Type – The model's taxonomy, particularly the quantitative nature of the calculations. Also, comment on the computational costs of querying the model.
3. Key Inputs – The data that is fed into a calibrated model, including a description of the original data collection when appropriate. These may be in summary form (e.g., the electrical corporation may list "equipment properties" rather than listing out equipment age, maintenance history, etc.). Training data shall not be mentioned here.
4. Model Solution – The method used to calibrate, train, simulate, optimize, or implement the model from a mathematical standpoint. If the model is based on a learning algorithm, briefly describe the optimization procedure, including the training data.
5. Model Outputs – The data produced by the model is fed into other models or used by PG&E to make risk-related decisions. Please comment on the type of output (ex: distribution, average value, score, probability) as well as the spatial resolution (ex: per circuit, per segment, per county) and temporal resolution (ex: per day, per season, per year). 6. Toy Problem – Please describe 3 examples of data input/output using synthetic data. One should input should lead to a low-risk (or low-probability, low-consequence) output. One for a medium-risk case and one for a high-risk case. In each case be sure to comment on the magnitude(s) of the inputs and outputs.
6. Shelf Life – What is the length or period of time the model expected to be valid? Describe if/how the model is expected to be updated, both regarding new calibration data and new project input data. Describe if/when the model is expected to be retired or replaced by another model.

<u>Response to Question No. 003 Response No. 002:</u>

PG&E hereby supplements our response to Question No. 003 part 6, submitted to Energy Safety on January 8, 2024.

Please see our supplemental response to Question No. 002, part 6, above for "toy problem" information regarding reliability risk and consequence calculations responsive to this request.

Please note that the example numbers and percentages included in these "toy problems" are illustrative and do not relate to specific circuit segments in PG&E's service territory.

Acronyms:

PoI = Probability of Ignition

PoO = Probability of Outage

<u>Question 2 part 6</u>	**<u>Toy Problem</u>**		
Wildfire Monetized Risk Factor	10,000		
Effectiveness	**Equipment**	**Vegetation**	**Other**
Underground	95%	96%	85%
Aboveground Hardening	78%	70%	60%

Circuit Segment	Risk Example	PoI - Equipment	PoI - Vegetation	PoI - Other	Annual Frequency	Consequence	Risk Score	Monetized RS	UG Effectiveness	OH Effectiveness	UG Mitigated RS	OH Mitigated RS	UG Monetized Mitigated RS	OH Monetized Mitigated RS
1111	Low Probability/Low Consequence/Low Risk	0.5	0.3	0.3	1.1	20	22	$ 220,000	93%	71%	1.64	6.4	$ 16,400	$ 64,000
2222	Medium Probability/Medium Consequence/Medium Risk	0.8	0.4	0.8	2	50	100	$ 1,000,000	91%	69%	8.8	30.8	$ 88,000	$ 308,000
3333	High Probability/High Consequence/High Risk	0.7	0.55	0.4	1.65	100	165	$ 1,650,000	93%	71%	11.7	47.9	$ 117,000	$ 479,000
4444	High Probability/Low Consequence/Low Risk	0.8	0.9	0.6	2.3	5	11.5	$ 115,000	93%	70%	0.83	3.43	$ 8,300	$ 34,300

<u>Question 3 part 6</u>	**<u>Toy Problem</u>**		
Reliability Monetized Risk Factor	3		
Effectiveness	**Equipment**	**Vegetation**	**Other**
Underground	85%	96%	85%
Aboveground Hardening	20%	40%	60%

Circuit Segment	Risk Example	PoO - Equipment	PoO - Vegetation	PoO - Other	Annual Frequency of Event	Average CESO	Average CAIDI	Consequence	Risk Score (CMI)	Monetized RS	UG Effectiveness	OH Effectiveness	UG Mitigated RS	OH Mitigated RS	UG Monetized Mitigated RS	OH Monetized Mitigated RS
1111	Low Probability/Low Consequence/Low Risk	5	3	3	11	10	120	1,200	13,200	$ 39,600	88%	36%	1,584	8,400	$ 4,752	$ 25,200
2222	Medium Probability/Medium Consequence	8	4	8	20	20	130	2,600	52,000	$ 156,000	87%	40%	6,656	31,200	$ 19,968	$ 93,600
3333	High Probability/High Consequence/High Risk	10	15	9	34	50	170	8,500	289,000	$ 867,000	90%	39%	29,325	175,100	$ 87,975	$ 525,300
4444	High Probability/Low Consequence/Low Risk	8	9	6	23	1	130	130	2,990	$ 8,970	89%	38%	320	1,846	$ 959	$ 5,538