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Witnesses:	B. Chiu D. Daigler P. Herrington M. Jocelyn L. Letizia D. Tessler T. Tran

SOUTHERN CALIFORNIA EDISON®

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(U 338-E)

Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program - Annotated

Before the

Public Utilities Commission of the State of California

Rosemead, California
September 10, 2018

SCE-01A: Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program - Annotated

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I.

INTRODUCTION AND EXECUTIVE SUMMARY

This testimony supports Southern California Edison Company's (SCE) request for authorization to record and recover the reasonable costs of the Grid Safety and Resiliency Program (GS&RP) incurred in 2018 and forecasted through 2020 that were not forecasted in the 2018 General Rate Case Application (A.) 16-09-001 (2018 GRC). The GS&RP is designed to implement measures addressing emerging state policy directed at reducing wildfire risk, the increasing magnitude of which was brought to light in a series of devastating fires in the latter half of 2017. These unprecedented events have continued into 2018, and well before the typical "fire season"—ushering in a "new normal" of year-round exposure to potentially catastrophic wildfires. This increasing risk must be addressed: wildfires not only threaten the state's residents and its economy, they also undermine its ambitious environmental policies for reducing greenhouse gas emissions.

Addressing wildfire risk requires enhanced approaches to the design, construction, operation, and maintenance of electric systems. Although wildfires happen for several reasons,[1] SCE fully agrees with Governor Brown that utilities have an important role in the statewide wildfire risk effort, and that even greater investments in wildfire-related safety enhancements to electric systems are needed.[2] President Picker also has noted that, for electric utilities, "the legislature has made it very clear that they expect us to do everything we can to prevent fires from [power lines owned by] regulated entities."[3] This direction is reflected in the recently approved Senate Bill (SB) 901, which provides that electric utilities must "construct, maintain,

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[1] Among these, electric utilities historically contribute to the causes of up to ten percent of all wildfires in California.

[2] *See* Letter from Gov. Brown to Sen. Dodd and Assemb. Holden (July 24, 2018).

[3] Audio: Statement of President Picker, California Public Utilities Commission Voting Meeting #3421, 28:34 – 28:46 (Aug. 9, 2018), *available at* http://www.adminmonitor.com/ca/cpuc/voting_meeting/20180809/.

and operate [their] electrical lines and equipment in a manner that will minimize the risk of catastrophic wildfire posed by those electrical lines and equipment."[4]

To that end, SCE's GS&RP contemplates broader, more advanced measures than those described in its 2018 GRC, which was filed before the devastating 2017 wildfires. The GS&RP is a comprehensive program, incorporating leading practices and mitigation measures selected based on their effectiveness and with appropriate consideration of resource allocation and alternatives. These measures will help enhance the safety of the electrical system and make it more resilient during wildfires, consistent with state policy. They will also benefit other key stakeholders by, for example, improving fire agencies' ability to detect and respond to emerging fires in coordination with utility emergency management personnel.

These additional measures involve costs above amounts currently authorized in rates, or requested in the 2018 GRC. SCE is therefore requesting through this Application that the California Public Utilities Commission (Commission or CPUC) review the GS&RP and authorize 2018-2020 program costs that are incremental to those requested in the 2018 GRC. SCE also requests Commission approval of the following ratemaking mechanisms[5] for incremental program costs recorded prior to 2021, when its next GRC will take effect:

1) **An interim GS&RP Memorandum Account (GS&RPMA),** to be effective as of this Application's filing date (September 10, 2018), to permit SCE to record incremental program costs during this proceeding; and
2) **A two-way GS&RP Balancing Account (GS&RPBA),** effective upon a final Commission decision, to recover incremental costs associated with implementing this program.

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[4] Senate Bill 901, 2017-2018 Reg. Sess. (Cal. 2018), *available at* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB901. To date, the bill is awaiting the Governor's signature.

[5] Chapter V provides an overview of the Commission's existing ratemaking mechanisms for recovering costs related to wildfires and other significant system-wide events (e.g., the Catastrophic Event Memorandum Account for system restoration costs and costs related to the drought, and the "Z-Factor" mechanism for unforeseen, exogenous events outside the GRC).

The GS&RP costs that SCE expects to incur beyond 2020 will be addressed in SCE's upcoming 2021 and 2024 GRCs, which will be filed in September, 2019 and 2022, respectively.

A. SCE Proposes Further Grid Hardening and Other Enhanced Measures to Address California's "New Normal" of Year-Round, Potentially Catastrophic Wildfire Risk

California's wildfire risk has increased in recent years due to climate change and other factors like the growing wildland-urban interface and significant build-up of fuel, including on federal and state forest lands.[6] The magnitude of the increased threat and the significance of its consequences did not become apparent until 2017, when California experienced five of the 20 most destructive fires in its history.[7] 2017 was the costliest and deadliest year of wildfires on record, which Governor Brown and other officials agree marked the beginning of an unprecedented "new normal" of a year-round wildfire season.[8] So far, this year is not disproving that conclusion. In August alone, there were 15 large wildfires burning across the state; two of which are among the top ten largest wildfires in California history.[9] As of August 29, 2018, these devastating fires have burned over 1,121,916 acres,[10] damaged or destroyed more than

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[6] *See e.g.,* Gov. Brown's Executive Order B-52-18, issued on May 10, 2018, ordering several projects to improve forest conditions and increase fire protection. The order notes the pace and scale of prescribed fire, fuel reduction, and thinning of overly dense forests "are far below levels needed to restore and maintain forest health."

[7] CalFire, Fact Sheet *Top 20 Most Destructive California Wildfires* (August 20, 2018), *available at* http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Destruction.pdf.

[8] Ruben Vives et al., *Southern California's Fire Devastation is the 'New Normal' Gov. Brown Says*, N.Y. TIMES (Dec. 2017), *available at* http://www.latimes.com/local/lanow/la-me-socal-fires-20171210-story.html; *see also* CA. Exec. Order No. B-52-18 (May, 2018), *available at* https://www.gov.ca.gov/wp-content/uploads/2018/05/5.10.18-Forest-EO.pdf.

[9] The July 2018 Mendocino Complex Fire has been classified as the largest fire in state history, while the July 2018 Carr Fire has been classified as the seventh largest. CalFire, Fact Sheet *The Top 20 Largest California Wildfires* (August 29, 2018), *available at* http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf. (Note that this website is updated daily, and the numbers may have increased since August 29, 2018)

[10] National Interagency Fire Center (NIFC), *National Year-to-Date Report on Fires and Acres Burned by State and Agency* (August 29, 2018), *available at* https://gacc.nifc.gov/sacc/predictive/intelligence/NationalYTDbyStateandAgency.pdf. (Note that this website is updated daily, and the numbers may have increased since August 29, 2018)

2,500 structures,[11] and resulted in six fatalities.[12]

The 2017 and 2018 fires emphasize that California's wildfire risk has increased to the point where the safety of our communities necessitates additional measures designed to address a higher level of wildfire risk not contemplated by existing state standards or traditional utility fire mitigation practices. Wildfire mitigation measures have been part of SCE's operational practices for years, as high fire risk areas (HFRA) account for about 35 percent of SCE's service area.[13] However, SCE shares the state's conclusion that the unprecedented changes in this risk area require making further investments in utility infrastructure and enhancing operational practices. Accordingly, SCE has comprehensively reviewed its fire mitigation strategies and developed enhanced measures for areas where there is very high wildfire risk.

SCE intends to significantly expand its wildfire mitigation programs. SCE's efforts are focused on wildfire prevention (i.e., reducing potential ignitions) and supporting suppression (i.e., more rapid identification and assessment of wildfires), as well as enhancing system resiliency. Among other things, SCE is:

- Deploying insulated, or "covered," conductor in key portions of the HFRA where it was not previously needed to significantly reduce ignition sources caused by foreign objects such as palm fronds, debris, metallic balloons, etc., contacting overhead lines,

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[11] NIFC, *National Large Incident Year-to-Date Report* (August 29, 2018), *available at* https://gacc.nifc.gov/sacc/predictive/intelligence/NationalLargeIncidentYTDReport.pdf. (Note that this website is updated daily, and the numbers may have increased since August 29, 2018)

[12] Sarah Ravani and Lauren Hernandez, *California Wildfires: Firefighter's death the 6th of 2018; Yosemite Reopens*, S.F. CHRONICLE (August 14, 2018), *available at* https://www.sfchronicle.com/california-wildfires/article/Mendocino-Complex-fires-claim-first-life-5-000-13154845.php#photo-15986939.

[13] SCE had previously identified locations in its service area as high fire risk prior to the release of the most recent CPUC High Fire Threat District maps with Tier 2 and Tier 3 designation (*see* Decision 17-12-024). To date, combining with the CPUC Tier 2 and Tier 3 designations (plus a small buffer), SCE's existing high fire risk areas plus the Tier 2 and Tier 3 locations make up approximately 35 percent of the total SCE service area.

and using fire resistant composite poles when appropriate to further improve system resiliency;[14]

- Further enhancing its situational awareness capabilities to more quickly and fully assess potential wildfire conditions and develop additional response plans; and
- Bolstering its operational practices to include, among other things, using infrared cameras to inspect electrical equipment and implementing even more aggressive vegetation management activities.

Many of the actions being taken will be done in collaboration with, and will benefit, key stakeholders, including fire agencies. These actions will benefit system reliability, primarily in the long term, and help mitigate shorter term reliability impacts associated with wildfire mitigation measures such as de-energizing electric lines during extreme fire conditions.[15]

SCE developed this set of proposed wildfire mitigation activities based on a risk assessment that considered the cost and risk mitigation effectiveness of each option compared to other alternative measures. Given the need for immediate action, SCE is already implementing some GS&RP activities such as deploying covered conductor on its highest fire risk circuits, and installing additional weather stations and High Definition (HD) cameras in HFRA.[16] However, SCE anticipates it will take eight or more years to complete all program activities, at substantial cost. Table I-1 below provides an overview of SCE's program deployment timeline through 2025, highlighting the program activities in this Application's scope.

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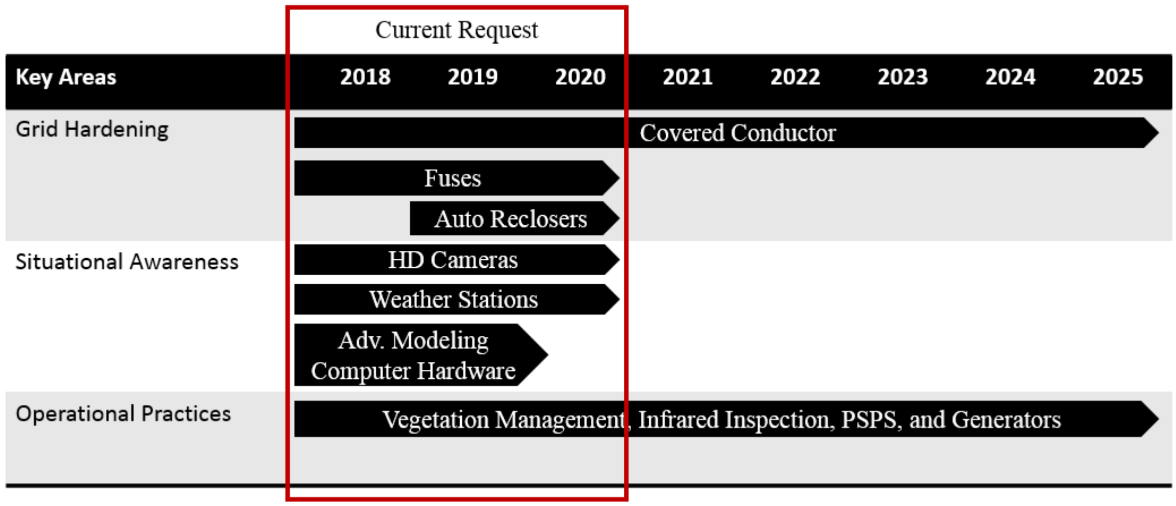
[14] As explained in Chapter IV, covered conductor is a more prudent mitigation solution compared to other alternatives, such as undergrounding lines.

[15] *See* Section B.5 for a discussion about SCE's Public Safety Power Shutoff protocol. SCE's grid hardening measures will also help reduce the future deployment of PSPS.

[16] SCE's HD cameras deployed at Santiago Peak help fire agencies respond to wildfires, and were able to capture what are believed to be the first images of the Holy Fire. *See* Kevin Sablan, *Holy fire time-lapse GIF captures smoke exploding into blaze*, O.C. Register (August 13, 2018), *available at* https://www.ocregister.com/2018/08/13/these-holy-fire-gifs-show-how-quickly-the-blaze-grew-and-how-winds-pushed-it-forward/.

Table I-1
Grid Safety and Resiliency Program Deployment Timing



SCE's Application is focused solely on obtaining Commission approval of GS&RP program activities and associated incremental forecast costs not included in the 2018 GRC. This will allow SCE to recover costs associated with mitigation measures it believes can be deployed in the near future, including deployment of covered conductor on approximately 600 circuit miles of the approximately 10,000 total circuit miles in SCE's HFRA.[17] Table I-2 summarizes program activities, forecast incremental costs, and the associated revenue requirement in SCE's request.[18]

[17] SCE expects to continue advancing its understanding of enhanced fire risk mitigation measures, and refining its risk mitigation efforts as part of the GS&RP.

[18] SCE's estimates are based on the best information available at this time. As with any new program, SCE expects to refine work processes and tools that may impact spending levels. Additionally, factors outside of SCE's control, such as limited material supplies or large events (e.g., storms) could divert internal resources or limit the availability of contractor resources and impact SCE's ability to execute the proposed plan. SCE anticipates gaining additional information that will help refine and inform elements of SCE's GS&RP that will extend into future GRCs.

Table I-2
Forecast of Incremental Costs and Revenue Requirements of GS&RP in the Near Term (2018-2020)[19]

Grid Safety & Resiliency Program					
Line	**Description**	**2018**	**2019**	**2020**	**Total**
1	Capital (2018 Constant $000)	54,371	112,137	240,781	$407,290
2	O&M (2018 Constant $000)	8,095	53,235	113,712	$175,042
3	Revenue Requirement (Nominal $000)	10,490	67,349	151,233	$229,072

B. <u>SCE Seeks Appropriate Ratemaking Mechanisms That Will Facilitate Incremental GS&RP Activities During This Proceeding and Allow Forecast Program Costs to be Included in Rates Upon a Final Decision</u>

Once the Commission has issued a final decision in this proceeding, SCE proposes to include in rates a forecast of the GS&RP revenue requirement in distribution rates beginning in 2019 and to continue to include a forecast in distribution rates in 2020.[20] In addition, SCE proposes to establish: (1) the initial GS&RPMA, effective as of this Application's filing date; and (2) the GS&RPBA, effective upon a final Commission decision. Both accounts will record actual GS&RP incremental Operations & Maintenance (O&M) expenses and capital-related revenue requirements (e.g., depreciation, return on rate base, property taxes, and income taxes) to provide for the recovery of all recorded GS&RP-related revenue requirements. Amounts recorded in the GS&RPMA would be transferred to the GS&RPBA upon a final Commission decision.[21] GS&RP activities and costs forecasted for 2021 and beyond will be included in future GRC proceedings.

SCE respectfully requests the Commission authorize the GS&RPMA as of the date of this filing, to permit SCE to record incremental expenditures associated with immediate implementation of critical program activities, including deploying covered conductor in circuits

[19] Refer to Work Paper Vol. 2 (Revenue Requirement)

[20] Recovery of the GS&RP revenue requirement will be included in SCE's 2021 GRC revenue requirement request.

[21] Once the GS&RPBA is established, SCE will cease recording entries in the GS&RPMA, and the balance recorded in the GS&RPMA will transfer to the GS&RPBA.

in HFRA. Because the Commission will perform a full reasonableness review of the scope of the GS&RP activities and forecast costs in this proceeding, SCE also requests the Commission establish a "reasonableness threshold" be set at 115% of the total GS&RP capital and O&M forecast of $582 million (2018 $) over the 2018 – 2020 time period, or $670 million (2018 $). SCE proposes that the total recorded spend up to $670 million (2018 $) be deemed reasonable and any amount of total spend recorded in excess of these amounts will be subject to a traditional reasonableness review in a future application.[22]

To further support a "reasonableness threshold," SCE proposes that a subsequent reasonableness review of the GS&RP will not be required if the following two conditions are met: (1) SCE's GS&RP spending is less than or equal to the reasonableness threshold; and (2) SCE manages the cost per circuit mile for the covered conductor program to up to 115% of the estimated amount of $428k/mile in 2018 supported in Chapter IV, Section B. If the cost for the covered conductor program exceeds 115% of the estimated amount, or $493k/mile, escalated appropriately, then SCE will file an application to support why the costs to install covered conductor were greater than that threshold. As described further in Chapter V.E, SCE selected the 115% threshold because it is supported by generally accepted cost engineering practices.

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[22] The Commission would review GS&RP program costs under the threshold in SCE's annual Energy Resource Recovery Account (ERRA) Review proceedings to ensure account entries are stated correctly and associated with GS&RP activities as defined and approved by the Commission in this proceeding.

II.

SCE IS COMMITTED TO SAFELY OPERATING ITS ELECTRIC SYSTEM UNDER THE "NEW NORMAL" OF INCREASING WILDFIRE RISK IN CALIFORNIA

In this Chapter, SCE summarizes the GS&RP and places it in context. That is, SCE first reviews California's historical wildfire risk and explains how the state's approach to managing this risk changed following the devastating 2017 wildfires and amid the continuing catastrophic fires ongoing in 2018.[23] SCE then summarizes its existing efforts to mitigate, either directly or indirectly, wildfire risk in its service area, including coordinating with state agencies and other key stakeholders. Many of SCE's existing programs were included in SCE's 2018 GRC, which was filed in 2016 and before the events giving rise to this Application. After providing this contextual information, SCE explains how its GS&RP will further address wildfire risk by hardening the electric grid and enhancing the utility's situational awareness capabilities and operational practices in order to address the increased threat of wildfire.

A. California's Wildfire Risk Landscape Has Changed Dramatically

Historically, California has experienced wildfires that are driven by the region's warm climate, shrub-dominated landscape, rugged terrain, and extensive wildland-urban interface.[24] Between autumn and early spring, warm, arid Santa Ana winds increase the likelihood of wildfires and can cause ignited fires to expand rapidly.[25] Extreme heat events and reduced precipitation further enable wildfires by reducing fuel moisture and increasing flammability. Similarly, drought stress increases the prevalence of desiccated fuels, and is associated with

[23] Gov. Brown's Exec. Order No. B-52-18 (May 10, 2018), *available at* https://www.gov.ca.gov/wp-content/uploads/2018/05/5.10.18-Forest-EO.pdf. The Governor described the 2017 wildfires as "the largest, deadliest, most destructive and costliest in state history" and ordered a number of actions to be taken across a variety of sectors to address the state's fire risk.

[24] Yufang Jin et al., *Identification of Two Distinct Fire Regimes in Southern California: Implications for Economic Impact and Future Change*, 10 ENVTL. RES. LETTERS 094005, 1 (September 8, 2015), *available at* http://iopscience.iop.org/article/10.1088/1748-9326/10/9/094005.

[25] Tom Rolinski et al., *The Santa Ana Wildfire Threat Index: Methodology and Operational Implementation*, 31 AM. METEOROLOGICAL SOC'Y 1881, 1883. (Dec. 2016), *available at* https://journals.ametsoc.org/doi/pdf/10.1175/WAF-D-15-0141.1.

heightened wildfire size and severity. Drought events and bark beetle infestation also increase tree mortality, which augments fuel load and fuel-driven fires.[26] SCE has been removing dead, dying, and diseased trees that can fall into its lines, but large amounts of such trees remain beyond its lines that can fuel fires once there is an ignition event.[27] On the non-climate side, growth of the wildland-urban interface (i.e., the area where houses and wildland vegetation meet or intermingle) can lead to more wildfire ignitions, heightened risks to public safety, and greater costs associated with fires.[28]

Coinciding with these historical risk factors, wildfire activity has increased in recent decades.[29] Since 1979, while the number of fires in California decreased, the acreage burned per year increased. Similarly, the average acres burned per fire has increased over the same time period.[30]

While the size and impact of California's wildfires has grown, recently our state experienced a dramatic increase in year-round, devastating wildfires unlike anything seen previously. This happened in 2017, which was a historic year for wildfires in the state. Southern California experienced "unremitting" Santa Ana winds accompanied by extremely low humidity

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[26] Scott Stephens et al., *Drought, Tree Mortality, and Wildfire in Forests Adapted to Frequent Fire*, 68 BIOSCIENCE 77, 78 (Feb. 2018), *available at* https://www.fs.fed.us/psw/publications/fettig/psw_2018_fettig002_stephens.pdf.

[27] These costs are recovered through a combination of base rates and CEMA filings.

[28] Alexandra D. Syphard et al., *Human Influence on California Fire Regimes*, 17 ECOLOGICAL APPLICATIONS 1388, 1398 (July 1, 2007), *available at* https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/06-1128.1.

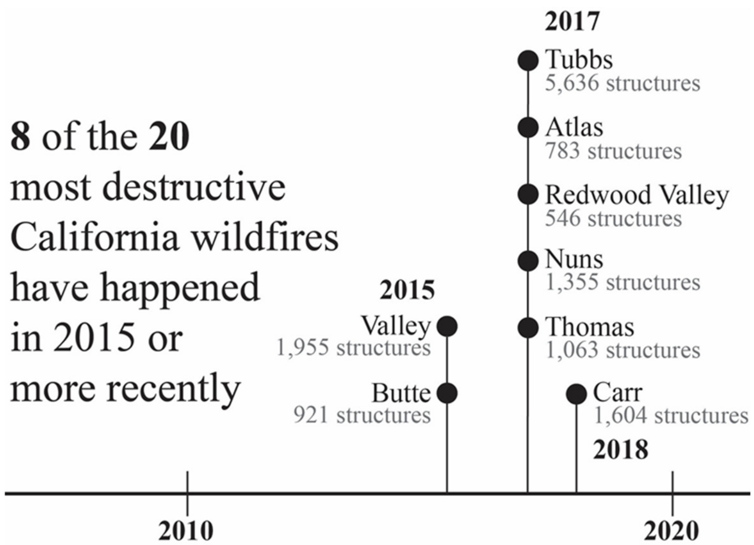
[29] *See* National Oceanic and Atmospheric Administration, *Assessing Fire Hazard Risk In Southern California(2018)*, *available a*t https://coast.noaa.gov/digitalcoast/stories/californiafire.html; *see also,* John Abatzoglou &A. Park Williams, *Impact of Anthropogenic Climate Change on Wildfire Across Western US Forests,* PNAS, (October 18, 2016),*available at* http://www.pnas.org/content/113/42/11770.

[30] Calfire Redbooks, 2016 Wildfire Activity Statistics, *available at* http://www.fire.ca.gov/downloads/redbooks/2016_Redbook/2016_Redbook_FINAL.PDF.

(as low as one percent) with low single-digit readings even at the beaches. This resulted in "near apocalyptic" fires.[31]

As illustrated in Figure II-1, eight of the state's 20 most destructive fires have happened in 2015 or more recently. Although there were no major destructive fires in 2016, six of the state's 20 most destructive fires have occurred within the last year. This includes one of the state's largest fires, the Thomas Fire, which occurred as late in the year as December 2017—an unprecedented event for a fire of this magnitude.

Figure II-1
Timeline of Most Destructive California Wildfires 2015-2018[32]



According to CalFire, California agencies responded to over 7,000 fires in 2017.[33] After the 2017 wildfires, CalFire confirmed that California "now often experiences a year-round fire

[31] Rong-Gong Lin II, *L.A.'s increasingly hot and dry autumns result in "these near-apocalyptic fires,"* L.A. Times (December 21, 2017), *available at* http://www.latimes.com/local/lanow/la-me-ln-weather-thomas-fire-20171221-story.html.

[32] CalFire statistics as of 8/20/2018. Does not include Mendocino Complex fire, which is currently the largest in California's history (acres burned) but not within the top 20 most destructive (structures destroyed). Structures include homes, outbuildings (barns, garages, sheds, etc.) and commercial properties destroyed.

[33] CalFire, *2016 Wildfire Activity Statistics*, CalFire Redbook 1 (2016), *available at* http://calfire.ca.gov/downloads/redbooks/2016_Redbook/2016_Redbook_Summary.pdf; CalFire,

season, with an increase in both the number and intensity of large, damaging fires over the last decade."[34] California's traditional notion of a fire "season" is no longer true.[35] News agencies have reported that "the weather conditions that fueled Southern California's December firestorms offer a window into a future that could include more destructive fires."[36] It is also worth noting that in December 2017 the state experienced some of the strongest winds on record (up to 80 mph)[37] that present increasing risks for utility lines considering the large volume of vegetation outside utility rights of way that could be blown from long distances into these lines.

Unfortunately, 2018 is shaping up to be another devastating year, with low precipitation, returning drought conditions, and record-setting heat occurring as early as July 2018.[38] This year, the state has seen the largest fire in its history with respect to acreage burned, the Mendocino Complex Fire.[39] As of August 29, 2018, California's wildfires have burned over

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Incident Information Number of Fires and Acres in 2017, *available at* http://cdfdata.fire.ca.gov/incidents/incidents_stats?year=2017.

[34] News Release, CalFire, Board of Forestry and Fire Protection and CALFIRE *Working to Increase Pace and Scale of Wildfire Prevention Activities* (Dec. 2017), *available at* http://www.fire.ca.gov/communications/downloads/newsreleases/2017/2017_BOF_CALFIRE_VTPPEIR_newsrelease.pdf.

[35] Marissa Clifford, *In California, It's Always Fire Season Now*, LA CURBED (June, 2018), *available at* https://la.curbed.com/2018/6/5/17428734/wildfires-calfornia-risk-prediction.

[36] Rong-Gong Lin II, *L.A.'s increasingly hot and dry autumns result in "these near-apocalyptic fires,"* L.A. Times (December, 21, 2017), *available at* http://www.latimes.com/local/lanow/la-me-ln-weather-thomas-fire-20171221-story.html.

[37] In December 2017, the state for the first time experienced "purple" (i.e., extreme) winds capable of reaching 80 mph. Associated Press, *California wind hits unprecedented high—and so does fire danger* L.A. Times (December, 7, 2017), *available at* http://www.latimes.com/local/lanow/la-me-ln-purple-wind-map-20171207-story.html.

[38] National Interagency Fire Center, *Southern and Central California Monthly/Seasonal Outlook* (Aug. 2018), *available at* https://gacc.nifc.gov/oscc/predictive/outlooks/myfiles/assessment.pdf. (Note that this website is updated daily, and the numbers may have increased since August 2018)

[39] Eric Levenson, *A look at California's largest wildfires by the numbers,* CNN (August 7, 2018), *available at* https://www.cnn.com/2018/08/07/us/california-fire-numbers/index.html.

1,121,916 acres,[40] damaged or destroyed more than 2,500 structures,[41] and resulted in six fatalities.[42]

Experts had predicted that decades from now climate change would increase the risk of these uncharacteristically large and severe wildfires, including a potential increase in the total area burned.[43] However, it appears that these projected impacts are happening now, and regrettably much farther ahead of some forecasts. Shortly after the Mendocino Complex Fire, Governor Brown explained that "[t]he more serious predictions of warming and fires to occur later in the century, 2040 or 2050, they're now occurring in real time."[44] California's recently released Fourth Climate Change Assessment—while acknowledging that projecting future wildfires is complicated—nonetheless notes the potential for greater fire risk in the future and particularly "mass fires" burning large areas simultaneously.[45]

This sudden increase in the size and destruction of wildland urban interface fires, along with the extremity of contributing weather conditions, marks a significant change in the state's firefighting posture, and an increased need for comprehensive, year-round mitigation and

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[40] National Interagency Fire Center ("NIFC"), *National Year-to-Date Report on Fires and Acres Burned by State and Agency* (August 29, 2018), *available at* https://gacc.nifc.gov/sacc/predictive/intelligence/NationalYTDbyStateandAgency.pdf (Note that this website is updated daily, and the numbers may have increased since August 29, 2018)

[41] NIFC, *National Large Incident Year-to-Date Report* (August 29, 2018), *available at* https://gacc.nifc.gov/sacc/predictive/intelligence/NationalLargeIncidentYTDReport.pdf (Note that this website is updated daily, and the numbers may have increased since August 29, 2018)

[42] Sarah Ravani and Lauren Hernandez, *California Wildfires: Firefighter's death the 6th of 2018; Yosemite Reopens*, S.F. CHRONICLE (August 14, 2018), *available at* https://www.sfchronicle.com/california-wildfires/article/Mendocino-Complex-fires-claim-first-life-5-000-13154845.php#photo-15986939

[43] Tania Schoennagel et al., *Adapt to More Wildfire in Western North American Forests as Climate Changes*, (May, 2017), *available at* http://www.pnas.org/content/pnas/114/18/4582.full.pdf.

[44] Jaclyn Cosgrove et al., *California fires rage, and Gov. Jerry Brown offers grim view of fiery future,* L.A. Times (Aug. 2018), *available at* http://www.latimes.com/local/lanow/la-me-ln-california-fires-20180801-story.html.

[45] Bedsworth, Louise, Dan Cayan, Guido Franco, Leah Fisher, Sonya Ziaja. (2018). Statewide Summary Report. *California's Fourth Climate Change Assessment.* Publication number: SUMCCCA4-2018-013, *available at* http://www.climateassessment.ca.gov/state/docs/20180827-StatewideSummary.pdf.

preparedness efforts. Our state's recent fires are proving that historical mitigation and preparedness efforts are not enough for the current hazards and risks associated with wildfires in California—it is therefore essential for all stakeholders to change the way we approach fire mitigation efforts. SCE agrees with the Governor's recent proclamation that in order to address this threat "[w]e're going to have to adapt. We're going to have to change our technology."[46]

B. SCE's Existing Efforts to Mitigate Wildfire Risk in Its Service Area

Fire mitigation has been an integral part of SCE's operational practices for years, and it has several programs in place that either directly manage this risk or help contribute toward reducing it. Several of these programs were implemented, or substantially enhanced, following the 2007 wildfires in SCE's service area. For operations, SCE uses a map that is informed by and recently updated to incorporate the Commission's new fire threat maps to identify HFRA.[47] As shown below in Figure II-2 and Table II-3, approximately 35 percent of SCE's service area is considered by the utility to be high fire risk. This includes the areas identified as Tier 2 and Tier 3 on the Commission's fire threat map adopted January 2018, plus areas that SCE previously designated as high fire risk areas (referred to in the table below as "SCE HFRA not in CPUC Tiers").

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[46] Jaclyn Cosgrove et al., *California fires rage, and Gov. Jerry Brown offers grim view of fiery future,* L.A. Times (Aug. 2018), *available at* http://www.latimes.com/local/lanow/la-me-ln-california-fires-20180801-story.html.

[47] Since the October 2007 wildfires in Southern California, the Commission, in collaboration with utilities and other agencies, has continued to update fire threat maps to identify HFRA throughout the state.

Figure II-2
SCE High Fire Risk Areas

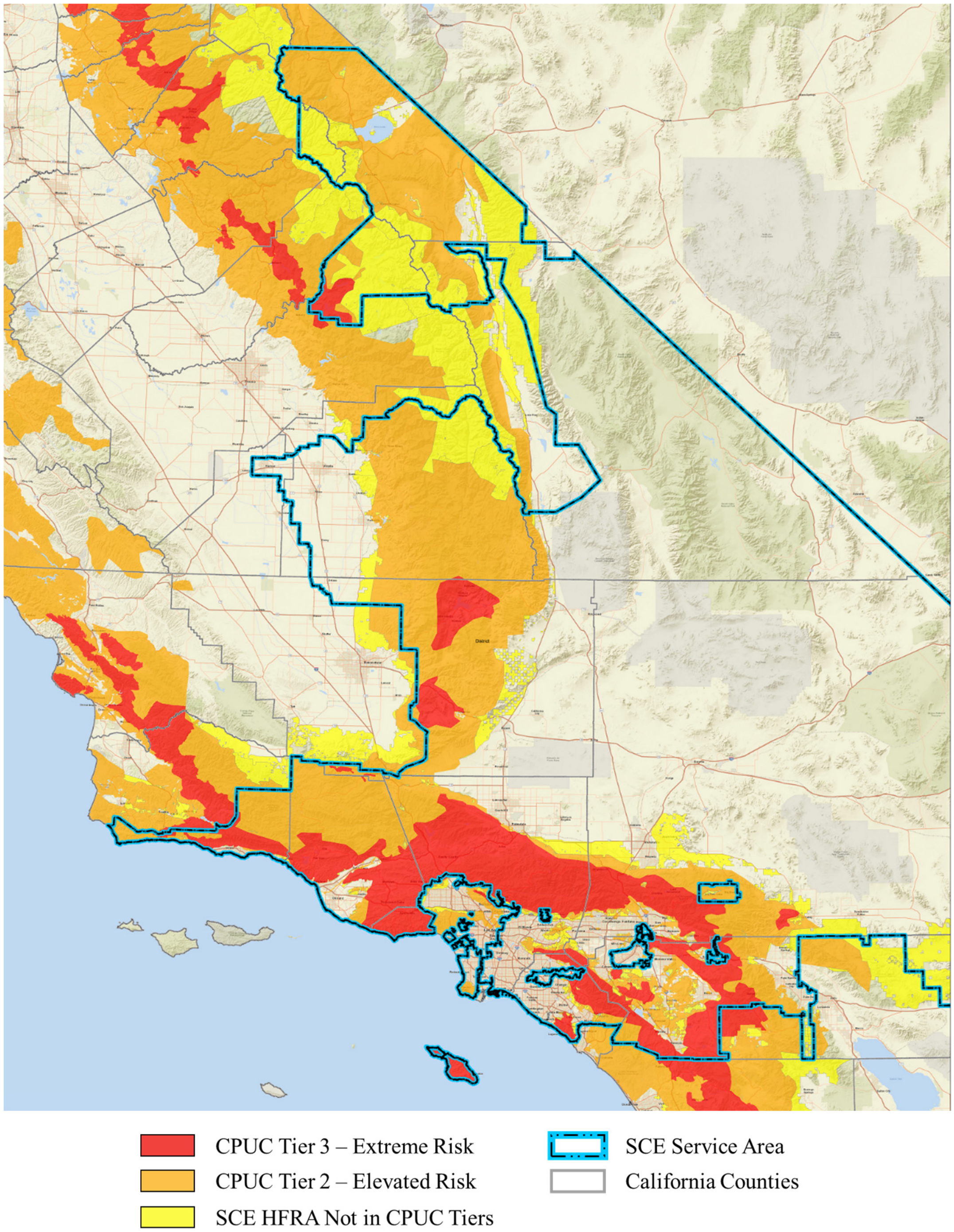

Table II-3
Breakdown of Areas Comprising SCE's High Fire Risk Areas

	Area (Sq. Miles)	Percent of Service Area
CPUC Tier 3 – Extreme Risk	4,708	9 percent
CPUC Tier 2 – Elevated Risk	9,573	18 percent
SCE HFRA Not in CPUC Tiers	4,212	8 percent
TOTAL	**18,493**	**35 percent**

SCE's longstanding wildfire mitigation efforts are generally categorized into five areas:

- Planning
- Engineering and System Design
- Grid Improvements
- Vegetation Management and other Inspection and Maintenance Programs
- Standard Operating Practices, Emergency Planning and Response, and Stakeholder Outreach

These existing efforts are summarized below and are included in the 2018 GRC. These efforts will be enhanced by incremental GS&RP activities that are the subject of this Application and described in Chapter IV.

1. Existing Planning Activities

SCE has several plans in place to prepare for, and mitigate the impact of, potential wildfires and other emergency events like storms in its service area. Among these, SCE's Fire Prevention Plan is the key planning document for wildfires. This plan consolidates practices and policies that SCE personnel follow to minimize the likelihood that utility lines and equipment could increase fire hazards (i.e., fire ignitions associated with electrical equipment or lines) in its service area, with special attention for designated HFRA. SCE reviews the plan at least annually, with the most recent update in October 2017. The plan includes operating restrictions on electrical lines during dry and windy weather conditions, such as Red Flag Warnings, preventive measures, system design and construction practices, and actions SCE's crews and support staff must follow during high wind events and other serious events such as snow, heat, wind, and rain storms.

2. Existing Engineering and System Design Activities

SCE has traditionally designed its system to provide safe and reliable power to customers, and these efforts provide wildfire mitigation benefits. Automation equipment such as circuit breakers, remote-controlled automatic reclosers (RARs), and radio communications systems along SCE's distribution lines are used to quickly detect faults, isolate circuits, and restore electric service to customers. SCE has installed automated RARs and circuit breakers on its distribution lines in HFRA to prevent reclosing should faults occur during high wind events, which lessens the potential for fires from distribution line faults. SCE also follows several principles when designing its system, including using wider easements and rights of way and clearing buffers around substations to reduce the possibility of ignition due to debris contacting substation equipment.

3. Existing Grid Improvement Activities

Over the years, SCE has implemented many infrastructure investment programs. These programs help mitigate wildfire risk and include replacement programs designed to mitigate in-service failures for transmission and distribution assets (e.g., wooden poles, overhead conductors, relays, etc.). SCE reviews its multiyear plan for these infrastructure investment programs during the annual operating plan process and, as necessary, reprioritizes and adjusts program investments accordingly.

4. Existing Vegetation Management and Other Inspection and Maintenance Program Activities

SCE has several vegetation management programs to maintain the approximately 900,000 trees in its inventory. These programs focus on identifying, and either pruning or removing, trees in HFRA (and non-HFRA) based on proximity to transmission and distribution lines, their health and expected growth (or decline), and environmental conditions such as drought. SCE uses inspections and tracking processes to meet Commission and all applicable regulations. It also has programs to perform additional detailed inspections and address trees near circuits with the highest number of interruptions in HFRA and in canyons where high winds and narrow roads increase fire risk. In addition, SCE staff meet and accompany local, county, or state fire agency personnel to perform supplemental patrols of overhead lines to strengthen fire readiness in HFRA.[48]

SCE has other inspection and maintenance programs that, among other objectives, help minimize sources of fire ignition and other wildfire risks, such as the Overhead Detailed Inspection Program (ODIP)[49] and the Intrusive Pole Inspection Program (IPIP).[50] SCE also conducts annual grid patrols and performs routine and detailed inspections and maintenance of its transmission lines.

5. Existing Standard Operating Practices, Emergency Planning and Response, and Stakeholder Outreach Activities

SCE has several policies and standard operating procedures for wildfire mitigation in HFRA, and for managing its system during a fire event. These include specific procedures for operating distribution lines traversing HFRA,[51] and for standing up the Incident Command System (ICS) during critical events (SCE's ICS is modeled after Federal Emergency

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[48] Since 2001, SCE has been annually organizing Operation Santa Ana, which is a partnership with state and county fire authorities to perform joint patrols of overhead pole and powerline inspections to ensure appropriate tree-to-powerline clearances and brush removal around poles to strengthen fire readiness in HFRA.

[49] The ODIP involves visually evaluating SCE's overhead electrical distribution facilities to identify and document obvious discrepancies and validate accuracy of asset information and facility inventory mapping references for appropriate corrective action. Inspectors also identify and perform certain maintenance tasks during the course of a detailed inspection.

[50] The ODIP involves evaluating SCE's wood pole system using both visual and internal examinations to identify and document damage or decay on poles requiring remediation. Inspectors also apply a preservative to passing poles to reduce the likelihood of future decay.

[51] SCE utilizes an operating policy called Standard Operating Bulletin 322 to standardize the operation of distribution voltage lines traversing fire hazard areas. This policy imposes operating restrictions on designated overhead distribution lines to reduce the risk of wildfires during a Red Flag Warning. This policy requires all circuit breakers and reclosers in fire hazard areas be made non-automatic until the Red Flag Warning expires. If protective relays on these circuit breakers operate to interrupt the flow of electricity, the line is not re-energized until it is patrolled and deemed safe.

Management Agency (FEMA) protocols). The ICS structure facilitates SCE's own response and coordinated multi-agency responses during fire events. SCE also conducts exercises and drills with local emergency responders, fire agencies, regulatory agencies, and neighboring utilities annually to test its ICS framework and enhance coordination efforts during emergency events such as fires.

SCE has also recently instituted a formalized Public Safety Power Shutoff (PSPS) protocol where it may de-energize power in HFRA to reduce the risk of fire ignition during the most extreme and potentially dangerous fire conditions. A PSPS event is the preventive measure of last resort in a robust line of defenses against fire risk deployed by SCE. This practice is aimed at keeping the public, SCE customers, and SCE employees safe. SCE currently considers many factors before deciding to de-energize, such as input from in-house meteorologists about current and forecasted fire weather conditions, and fuel characteristics and moisture levels for vegetation surrounding utility infrastructure.

SCE also participates in the California Utility Emergency Association, which serves as a point of contact for critical infrastructure utilities, the California Office of Emergency Services, and other governmental agencies before, during, and after an event to facilitate communications and provide emergency response support. And it maintains a Fire Management Team that serves as SCE's primary interface with fire incident responders.[52]

A critical component of SCE's wildfire mitigation and recovery efforts is effectively communicating with customers, community groups, and other stakeholders about how to prepare for, prevent, and mitigate wildfires in its service area. It also uses communication plans during a fire event to inform stakeholders and provide them with necessary information. Core outreach initiatives related to wildfires also include collaboration and training for local firefighting agencies.

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[52] These Fire Managers have experience as fire fighters and/or linemen. They have strong relationships with the communities and the fire incident commanders in SCE's service area, and a detailed understanding of SCE's electric infrastructure. They keep lines of communication open to involved agencies, provide training and training materials, and serve as onsite coordinators during fire events.

C. SCE's GS&RP: Further Hardening the Electric System and Enhancing Utility Situational Awareness and Operational Capabilities

1. Creation of Program Management Office Focused on Addressing Increasing Wildfire Risk

SCE agrees with the Governor, the legislature, and other state officials that additional investments to further enhance the safety and resiliency of the electric system are warranted following the 2017 wildfires. Because addressing this issue is a top priority, in early 2018 SCE created a program management office (PMO) aggregating SCE's fire mitigation efforts and focused on bolstering public safety and system resiliency.

SCE charged the PMO with the following, overarching objectives: (1) executing near-term actions to further mitigate increased wildfire risk; (2) developing enhancements to its operational plans for long-term wildfire, public safety, and related resiliency strategies; and (3) integrating SCE's wildfire mitigation strategies with existing programs, such as long-term capital planning, the Risk Assessment and Mitigation Phase (RAMP),[53] and the GRC. The first two objectives are most relevant to this Application—for these, the PMO reviewed fire mitigation strategies and researched potential enhancements focused on fire prevention (avoiding ignitions), aiding suppression activities by others (speeding confirmation and assessment of fires), and system resiliency (withstanding fires). The PMO also researched existing and emerging utility fire mitigation strategies related to risk management and asset management for applicability to SCE's wildfire mitigation efforts.

Based on this assessment, SCE proposes further enhancing the safe operation of its electric system and improving its resiliency by focusing on three primary areas: (1) further grid hardening; (2) enhanced situational awareness; and (3) enhanced operational practices. SCE's portfolio of mitigation measures addresses all aspects of fire risk, but primarily focuses on

[53] RAMP filing requirements are guided by decisions in the Risk-Informed Decision Making for General Rate Cases Rulemaking (D.14-12-025) and in the subsequent Safety Model Assessment Proceeding (D.16-08-018). SCE will file its RAMP report on November 30, 2018.

preventing potential fire ignitions associated with utility equipment. This is an appropriate focus: although utility equipment is only connected with up to ten percent of all of the state's historical fires, these fires can be large. For example, fires associated with electrical facilities have been as large as 25 to 46 percent of total acreage burned in the state resulting from all fires in prior years.[54] This is primarily due to greater wind speed, which means conditions more favorable to the spread of wildfire, conditions where suppression is less effective, and conditions in which firefighters are likely to be spread thin.[55]

The increase of wildfire risk creates an even stronger need to find means to reduce the cause of wildfires and enhance methods to detect and suppress them more quickly. This approach is consistent with the legislature's direction in SB 901, which, as noted earlier, provides that electric utilities must "construct, maintain, and operate [their] electrical lines and equipment in a manner that will minimize the risk of catastrophic wildfire posed by those electrical lines and equipment."[56]

2. Overview of Key GS&RP Wildfire Mitigation Activities

a) Enhanced Grid Hardening

SCE is proposing to harden its infrastructure to significantly reduce potential fire ignition sources. Figure II-3 below is a breakdown of fires associated with SCE's distribution system located in HFRA. As shown in Figure II-3, SCE's historical data show that over half of all fires associated with SCE's distribution infrastructure in HFRA were caused by foreign objects such as palm fronds, metallic balloons, debris, etc., contacting electric facilities.

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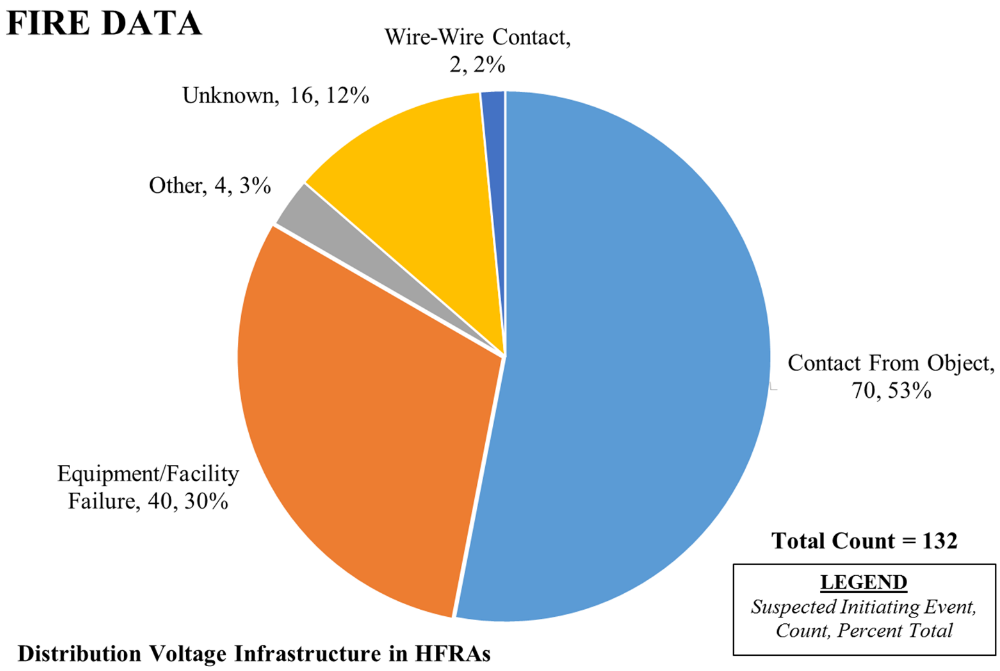
[54] *See* Chapter III.A.1, *infra.*

[55] Kousky, C., Greig, K., Lingle, B., & Kunreuther, H. *Wildfire Costs in California: The Role of Electric Utilities,* Issue Brief (Aug. 2018), *available at* https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/08/Wildfire-Cost-in-CA-Role-of-Utilities-1.pdf This study was partially supported by an unrestricted gift by Edison International.

[56] Senate Bill 901, 2017-2018 Reg. Sess. (Cal. 2018). SB 901 has been submitted to the Governor for signature.

Figure II-3
Breakdown of SCE's Historical <u>Fire</u> Causes
(Distribution Voltage Infrastructure in HFRA from 2015 – 2017)



To address this, SCE's grid hardening approach centers on replacing standard "bare" overhead conductor (i.e., exposed electric wires) with "covered" conductor, which is covered with special layers of insulation materials that protect electric lines against contacts from foreign objects and also against power lines coming into contact with each other during high winds. This is a more progressive approach compared to current utility practice,[57] and is supported by research that determined it to be effective under severe wildfire conditions as it prevents faults from occurring and avoids ignitions at the site of the fault and potential failure of upstream conductor. Research also determined it to provide the best customer value compared to other potential mitigation measures, like undergrounding. SCE will prioritize

[57] Today, most utilities across the U.S. are able to accept the consequence of foreign objects contacting overhead lines by relying on protective relays and circuit reclosers that can detect these anomalies and quickly isolate line faults even though there is arcing with sparks that could cause ignitions. This is a standard utility practice that has been in place for many decades and is entirely reasonable—but SCE has determined this approach should now be adjusted to incorporate the use of covered conductor in selected situations given the heightened fire risk under the "new normal" environment in California.

deploying these conductors according to risk, focusing on portions of circuits in HFRA with the greatest exposure to potential wildfire ignitions from line faults. Additionally, for covered conductor projects in HFRA, SCE will use fire resistant composite cross-arms and poles with a fire protective shield for pole replacements, when appropriate, to increase resiliency and reduce potential outage impacts resulting from a fire event.

SCE's grid hardening efforts will also focus on limiting potential faults from igniting wildfires. To accomplish this, SCE will add (and replace) certain devices on its system to mitigate fault-related ignition risks. SCE will install additional fuses that activate quickly to reduce the energy transmitted to faults and, accordingly, further reduce the risk of ignitions from faults. Additionally, the existing remote-controlled automatic reclosers (RARs) and selected substation Circuit Breakers (CBs) protecting circuits in HFRA will have their remote "reclose blocking" capabilities expanded to include automated high-speed, "fast curve" settings during Red Flag Warnings to further reduce the potential of ignitions from line faults. SCE will also install additional RARs and upgrade selected substation CBs with these advanced protection features, which may reduce the frequency and duration of some PSPS events.

b) Enhanced Situational Awareness

The second important feature of SCE's GS&RP is enhancing existing situational awareness capabilities to more fully assess potential wildfire conditions and develop appropriate operational plans, including preventive power shutoffs to mitigate wildfire risk. This includes deploying additional weather stations along circuits in HFRA, and installing HD cameras that will enable state and local fire agencies as well as SCE emergency management staff to more quickly identify and respond to wildfires. SCE is also deploying advanced computer hardware and state-of-the-art software that will run a sophisticated High Resolution Weather model to support planning and operational decisions to reduce wildfire risk, and increasing staffing of fire management personnel and meteorologists.

c) Enhanced Operational Practices

The third prong of the GS&RP is developing programs to further strengthen operational practices regarding fire prevention and system resiliency. Among these, enhancing SCE's vegetation management program is a priority. SCE intends to focus on proactively assessing and, as needed, mitigating trees that pose a blow-in / fall-in threat to electrical facilities but are located outside existing regulatory-required clearances and are not dead, sick, or dying.

Other operational practices SCE included in this filing include regular infrared inspections of the distribution system. Use of infrared enables identification of "hot spots" that could, if unaddressed, lead to potential wire and equipment failure. SCE began evaluating this technology in 2016, and the results are promising in terms of identifying and proactively addressing potential equipment failures not readily apparent during routine visual inspections—this will also help address many of the equipment / facility failure issues described previously. SCE is also proposing a mobile generator program that will provide electricity to certain essential customers in the event it must initiate the PSPS protocol to address high-risk fire conditions.

GS&RP activities will also improve system reliability over the long term, as circuits in HFRA are hardened against fire risk and subject to more detailed inspections and proactive maintenance. Some activities, like fusing, will have more near term reliability benefits by reducing outage impacts from faults. Other activities, like deployment of mobile generators, will limit reliability impacts associated with potential deployment of PSPS during extreme fire conditions. It should also be noted that by hardening its system, SCE anticipates reducing the need for PSPS deployment in the future.

3. GS&RP Deployment Strategy and Prioritization Considerations

SCE's GS&RP is estimated to span several years, as noted in Chapter I.A. Given the seriousness of this situation, SCE is already deploying some aspects of the GS&RP, such as starting installation of covered conductor on the most critical risk circuits and deploying fuses, weather stations, and HD cameras across HFRA.

In developing the GS&RP deployment timeline, SCE considered multiple factors, including the deployment or cycle time for various mitigation measures, risk reduction, and resource constraints. Each mitigation measure has a unique cycle time, which under targeted conditions can be expedited. Some mitigation measures, such as covered conductor, have longer cycle times due to the amount of design, planning, material procurement, and construction work that is involved. Other measures, such as updating the settings of existing relays, have shorter cycle times and can be completed in a matter of months. To best reduce wildfire risk over this time period, SCE is deploying a mix of mitigation measures that can reduce likelihood of faults that could result in fire ignitions.[58]

4. GS&RP 2018-2020 Incremental Costs

Table II-4 below summarizes each program activity and associated incremental forecast costs for 2018-2020. While the following discussion provides insights into the reasoning behind SCE's proposed spending levels, additional details related to the choice of timing of various mitigation measures and their associated benefits are provided in Chapter IV.

SCE's proposed spending levels for the 2018-2020 period are driven by the scope of measures selected along with resource constraints that govern the speed at which each measure can be deployed. The largest elements of SCE's proposed GS&RP are the Wildfire Covered Conductor Program (WCCP), expanded vegetation management activities, and fusing.

For WCCP, the levels of spend for 2018 and 2019 were primarily limited by the speed at which these new projects could be designed and planned. For 2020 projects, WCCP projects will have greater lead time to enable normal design and planning processes to accommodate larger volumes of work. The marked jump in WCCP spend from 2019 to 2020 is due to SCE's planned accelerated installation of fuse installations in advance of the installation

[58] SCE's RAMP filing will provide additional analysis of the risk reduction benefits of proposed and alternative wildfire mitigation measures.

of covered conductor, to achieve near-term risk reduction across all HFRA. Since these fuse installation projects utilize similar design and planning resources as WCCP projects, the combined volume of work from these two program elements are also constrained by design and planning resources and associated cycle times. Finally, SCE's expanded vegetation management expenditures represent new activities being developed, which SCE anticipates launching in the first quarter of 2019 and expanding through 2020.

Table II-4
2018-2020 Grid Safety & Resiliency Program Costs

Capital (2018 Constant $000)					
Line	Description	2018	2019	2020	Total
1	**Grid Hardening**				
2	Wildfire Covered Conductor	33,936	45,979	204,927	$284,842
3	Remote-Control Automatic Reclosers	-	8,789	18,076	$ 26,864
4	Fusing Mitigation	11,923	44,949	9,362	$ 66,235
5	**Total Grid Hardening**	**$45,859**	**$ 99,716**	**$232,365**	**$377,941**
6	**Enhanced Situational Awareness**				
7	HD Camera	1,123	2,272	741	$ 4,136
8	Weather Station	1,066	5,922	6,345	$ 13,334
9	Advanced Modeling Computer Hardware	2,943	3,722	1,330	$ 7,995
10	Asset Reliability and Risk Analytics	3,380	505	-	$ 3,885
11	**Total Enhanced Situational Awareness**	**$ 8,512**	**$ 12,421**	**$ 8,416**	**$ 29,349**
12	**Capital Total**	**$54,371**	**$112,137**	**$240,781**	**$407,290**

O&M (2018 Constant $000)					
Line	Description	2018	2019	2020	Total
1	**Grid Hardening**				
2	Wildfire Covered Conductor Program	747	951	4,201	$ 5,899
3	Remote-Control Automatic Reclosers	845	457	371	$ 1,673
4	Fusing Mitigation	271	2,640	21,138	$ 24,049
5	**Total Grid Hardening**	**$ 1,862**	**$ 4,049**	**$ 25,710**	**$ 31,621**
6	**Enhanced Situational Awareness**				
7	HD Camera	618	2,572	3,197	$ 6,387
8	Weather Station	142	631	1,200	$ 1,973
9	Advanced Weather Modeling Tool	384	604	604	$ 1,592
10	Advanced Modeling Computer Hardware	50	120	120	$ 290
11	Asset Reliability and Risk Analytics	7	9	-	$ 16
12	Additional Staffing Required	115	480	480	$ 1,074
13	**Total Enhanced Situational Awareness**	**$ 1,317**	**$ 4,416**	**$ 5,600**	**$ 11,333**
14	**Enhanced Operational Practices**				
15	Vegetation Management	-	40,148	77,921	$118,069
16	Infrared Inspection Program	-	459	459	$ 918
17	PSPS Protocal Support Functions	3,165	3,497	3,497	$ 10,159
18	Mobile Generator Deployment	137	137	137	$ 411
19	Portable Community Power Trailers	1,102	9	9	$ 1,120
20	**Total Enhanced Operational Practices**	**$ 4,404**	**$ 44,249**	**$ 82,023**	**$130,676**
21	**Wildfire Mitigation Program Study**	**$ 512**	**$ 521**	**$ 380**	**$ 1,413**
22	**O&M Total**	**$ 8,095**	**$ 53,235**	**$113,712**	**$175,042**

III.

THE GS&RP WAS DEVELOPED USING A RISK-INFORMED DECISION-MAKING PROCESS

This Chapter provides an overview of SCE's risk-informed decision-making process used to develop the GS&RP.[59]

A. Overview of SCE's Risk-Informed Decision-Making Process

SCE's risk-informed decision-making process began with developing an understanding of the fundamental elements that enable fire to ignite, the statistical trends associated with fires across California, particularly those caused by electrical power lines, the historical data surrounding fires associated with SCE's grid infrastructure, and the geographic locations within SCE's service area that represent the greatest wildfire risk (both likelihood and consequence of ignition). From there, SCE identified various mitigation measures that can reduce the likelihood of faults that could cause an ignition and potentially result in a wildfire, and estimated the risk reduction (benefits) associated with each measure. SCE considered multiple factors including each mitigation's effectiveness, deployment timing, resource allocation, alternatives, and other constraints to develop a comprehensive and complementary suite of solutions to reduce wildfire risks.[60]

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[59] SCE's approach has similarities to the policy framework for utility wildfire prevention recently presented by the CPUC's Safety and Enforcement Division Director, Elizaveta Malashenko. Similarities include focus on ignition control, weather preparedness, fuel management (fire triangle), reliance on cause data to guide actions, and use of advanced means to gain situational awareness and analyze/model risk. *See* CPUC, Joint Agency Workshop on Climate Adaptation and Resiliency titled *Climate Adaptation and Utility Wildfire Prevention*, (August 2, 2018); California Legislature, *Conference Committee on SB 901 Informational Hearing: Ensuring a Safe and Reliable Electric Grid,* (August 7, 2018).

[60] SCE's review of the wildfire risk landscape drove—and continues to drive—decisions regarding work undertaken outside the GS&RP, including some enhanced measures that SCE began to implement in advance of this Application. For example, as noted earlier, SCE has already begun proactively re-conductoring portions of selected high priority circuits in HFRA with covered conductor. This provided a means for SCE to meaningfully reduce wildfire risk on select circuits in the near-term and also allowed SCE to gain critical deployment capabilities and experience, in preparation for large-scale deployment as part of the GS&RP.

The specific approach used by the team to develop the GS&RP follows SCE's risk-informed decision-making framework. This framework is a logical six-step process and examines both the likelihood and impact associated with potential risk events such as wildfires:

1. Risk Identification
2. Risk Evaluation
3. Risk Mitigation Identification
4. Risk Mitigation Evaluation
5. Decision-Making and Planning
6. Monitoring and Reporting

The following sections describe how these steps were used to develop SCE's suite of enhanced mitigation measures, its philosophy for selecting and deploying these measures, and how each one addresses the broader wildfire risk landscape for the benefit of the state and the communities in (and surrounding) SCE's service area. As also discussed below, SCE's risk analysis supporting the GS&RP will inform its upcoming Risk Assessment Mitigation Phase (RAMP) of its 2021 GRC, scheduled to be filed in November 2018. In its RAMP filing, SCE will present additional analysis of wildfire risk among other top safety risks facing the utility.

1. <u>Steps 1 and 2: Risk Identification and Evaluation</u>

The first two steps of this analysis involve identifying and evaluating the wildfire risk, the driver(s) and potential resulting negative outcomes. Chapter II discussed the increased wildfire risks facing California and projections for future changes. Addressing these new risks requires both an understanding of the basic drivers of wildfires and how these drivers may change over time.

To understand the fundamental behavior of fire ignitions, SCE looked to the elementary science behind fire ignitions and propagations. The fire triangle in Figure III-4 shows that a fire requires three necessary elements: (1) heat source that starts the ignition; (2) fuel, or dry vegetation in the case of a wildfire; and (3) oxygen, or catalysts such as wind gusts to propel the wildfire. Eliminating or reducing any one of these three elements in turn reduces the risk of fire ignition and its propagation. This provided a framework for SCE to subsequently identify and consider potential mitigation measures that target each element.

Figure III-4
The Fire Triangle

- Heat (ignition source & energy level)
- Fuel (material or dry vegetation)
- Oxygen (catalysts or wind gusts)

Within the context of ignitions associated with SCE's electrical infrastructure, the heat comes from the energy and flow of electricity within the grid. Conditions, such as arcing, are the root ignition source. The fuel in SCE's service area is principally associated with the trees and other vegetation in proximity to electrical facilities, which is exacerbated by drought and other climate changes that increase the quantity of flammable dry fuel. Increased flow of oxygen from strong winds combined with low humidity heightens the risk associated with ignitions that can quickly spread and become difficult to suppress or contain. In late 2017, the state was subjected to "unprecedented" strong winds that have the potential to carry palm fronds and other debris from even greater distances into utility lines.[61]

In addition to understanding the fundamental drivers behind fire ignitions and propagation, SCE looked at historical data on the causes of fire ignitions, starting with all fires

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[61] In December 2017, the state for the first time experienced "purple" (i.e., extreme) winds capable of reaching 80 mph. *See* Associated Press, *California wind hits unprecedented high—and so does fire danger* L.A. Times (December 7, 2017), *available at* http://www.latimes.com/local/lanow/la-me-ln-purple-wind-map-20171207-story.html.

across California. CalFire maintains historical wildfire activity statistics, known as Redbooks.[62] In 2016, 2,816 fires were identified, of which 270 were associated with electrical power, and in 2015, 3,231 fires were identified, of which 251 were associated with electrical power. Overall, the CalFire data indicate that electrical power is generally associated with up to ten percent of statewide fires. But these fires have the potential to be sizable: for example, fires associated with electrical power in 2007, 2013, and 2015 represented 46 percent, 39 percent, and 25 percent of the total acres burned in California in those years, respectively. Additionally, external analysis of California wildfires (1960-2009) indicates that the average size of fires attributed to power lines is approximately ten times greater than the average size for all fires.[63] This is "because the probability of ignition from a power line increases with wind speed. Greater wind speed means conditions more favorable to the spread of wildfire, conditions where suppression is less effective, and conditions in which firefighters are likely to be spread thin."[64] Efforts to mitigate wildfires associated with electrical power lines may reduce the incidence of major wildfires.

To further understand the cause of fires associated with its electrical system, SCE analyzed fires that occurred in its HFRA from 2015 through 2017 that were of significant size and reportable to the Commission.[65] The results indicated that approximately 90 percent of all of the fires associated with electrical equipment in SCE's service area are related to distribution level voltages (33kV and below). As a result, SCE's subsequent risk analyses targeted

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[62] CalFire Redbook, *Historical Wildfire Activity Statistics*, *available at* http://www.fire.ca.gov/fire_protection/fire_protection_fire_info_redbooks. Other top causes of fires include arson, campfires, debris burning, equipment use, vehicles, miscellaneous, and undetermined.

[63] J.W. Mitchell *Power Line Failures and Catastrophic Wildfires Under Extreme Weather Conditions*. *Engineering Failure Analysis*, Vol. (35), pp. 726-735 (December 15, 2013).

[64] Kousky, C., Greig, K., Lingle, B., & Kunreuther, H. *Wildfire Costs in California: The Role of Electric Utilities,* Issue Brief (Aug. 2018), *available at* https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/08/Wildfire-Cost-in-CA-Role-of-Utilities-1.pdf This study was partially supported by an unrestricted gift by Edison International.

[65] Per D.14-02-015, reportable fire events are any events where utility facilities are associated with the following conditions: (a) A self-propagating fire of material other than electrical and/or communication facilities, and (b) The resulting fire traveled greater than one linear meter from the ignition point, and (c) The utility has knowledge that the fire occurred.

distribution infrastructure.[66] Data related to the initiating events for fires associated with SCE's distribution infrastructure in HFRA are shown in Figure II-3 with a detailed breakdown shown in Table III-5. Similar data of the faults on SCE's distribution infrastructure over this same period are shown in Figure IV-7 and Table IV-8.

Table III-5
Breakdown of Contact from Object and Equipment/Facility Failure Related Fires (Distribution Voltage Infrastructure in HFRAs from 2015-2017)[67]

Suspected Initiating Event	**Count**	**Percentage**
Contact From Object	70	53%
Equipment/Facility Failure	40	30%
Other, Unknown, Wire-Wire Contact	22	17%
Total	**132**	**100%**

Contact From Object	**Count**	**Percentage**
Animal	15	11%
Balloons	14	11%
Other	10	8%
Vegetation	22	17%
Vehicle	9	7%
Total	**70**	**53%**

Equipment/Facility Failure	**Count**	**Percentage**
Capacitor Bank	2	2%
Conductor	12	9%
Crossarm	1	1%
Fuse	1	1%
Insulator	5	4%
Other	8	6%
Splice/Clamp/Connector	8	6%
Transformer	3	2%
Total	**40**	**30%**

[66] SCE's GS&RP prioritizes fire risk mitigation for its distribution facilities given their heightened exposure to potential fire conditions. However, while this analysis targeted distribution level voltages, some mitigation measures will reduce fire risk for transmission facilities. These include, for example, situational awareness mitigation measures including HD cameras, weather stations, and advanced weather models. In addition, distribution lines are occasionally located below transmission lines, and, consequently, measures applied to these distribution lines will provide some risk reduction benefit for the overhead transmission lines. SCE intends to further examine fire risk mitigation measures for transmission facilities.

[67] Note, Table III-5 presents data related to fires. See Table IV-8 for data associated with faults.

The two greatest ignition drivers are "contact from object" followed by "equipment/facility failure." These historical statistics are consistent with the suspected ignition source data for California's investor-owned electric public utilities by the CPUC's Safety and Enforcement Division. Accordingly, SCE analyzed these two ignition drivers to develop a nuanced understanding of the precise causal chain that can lead to a wildfire outcome. Specifically, faults on the distribution system primarily occur either due to contact from an object or an equipment/facility failure. Although rare, these faults can result in high-energy and high-temperature arcing between two conductors (phase-to-phase) or between one conductor and the ground (phase-to-ground). Faults can also result in the failure of other electrical equipment. In either case, if arcing contains sufficient energy—given local conditions such as temperature, humidity, and adjacent dry vegetation—ignition could lead to a wildfire.[68]

Next, SCE focused on the portions of its service area where the likelihood and consequence of ignitions pose the greatest threat, i.e., its HFRA, to guide the prioritization of mitigation strategies. Since ignitions in SCE's HFRA represent the greatest wildfire threats and most historical ignitions related to SCE's facilities in these areas are principally associated with overhead distribution infrastructure, SCE's source of ignitions is largely concentrated in its bare overhead distribution facilities within HFRA. This risk falls into two areas: (1) objects contacting bare overhead distribution conductor, which is primarily caused by animals, balloons, and vegetation (these total approximately 72 percent of all contact from object caused fires); and (2) failure of equipment or facilities that is predominately induced by faults associated with overhead conductor.

2. Step 3: Risk Mitigation Identification

SCE next identified potential mitigation measures that could reduce either the likelihood or impact of wildfires. The fire triangle shown above in Figure III-4 helps frame

[68] The concept of fault energy can be described as the electric system's natural reaction to fault conditions. Dominant factors for fault energy are the time duration and the magnitude of electrical current during a fault. In essence, reducing fault energy helps reduce the probability of ignition.

possible mitigation measures for wildfire ignitions by targeting specific sides of the triangle. SCE characterizes mitigation measures that reduce risk by addressing wildfire drivers as "prevention" measures, and those measures that reduce risk by addressing wildfire outcomes and consequences as "resiliency" measures. Table III-6 summarizes how the mitigation measures included in SCE's GS&RP address wildfire prevention and/or resiliency. Additional details regarding the benefits of each measure are provided in Chapter IV.

Table III-6
Summary of Impacts of GS&RP Mitigation Measures on Wildfire Prevention and Enhanced Grid Resiliency

Mitigation Measure	Prevention (Reduced Frequency)	Resiliency (Reduced Impacts)
Wildfire Covered Conductor Program	Mitigates contact from object faults and equipment failure[69]	Fire resistant composite poles reduce outage impacts following wildfires
Remote-Controlled Automatic Reclosers (RARs) and Fast Curve Settings	Mitigates wires down and reduces energy at fault location (potential point of ignition)	Reduces outage impacts from PSPS and other events
Fusing	Mitigates wire downs and reduces energy at fault location	Reduces outage impacts caused by faults
Public Safety Power Shutoff (PSPS)	Eliminates energy source that can cause ignitions in extreme conditions	Primary mitigation focus is prevention
HD Cameras	Primary mitigation focus is resiliency	Speeds fire agency suppression response and aids real-time reactions by grid operators
Weather Station[70]	Improves forecasting and enables more precise PSPS targeting	Reduces potential size of areas impacted by potential PSPS activations
Infrared Scanning and Repairs	Identifies and repairs equipment prior to failure	Primary mitigation focus is prevention
Vegetation Management	Reduces contact faults and trees falling into lines	Reduces fuel supply
Emergency/Mobile Generators	Primary focus is resiliency	Reduces outage impacts during wildfire events and PSPS activations

[69] Covered conductor mitigates contact from object caused ignitions associated with animal, balloons, vegetation, and likely some in the "Other" category. In addition to replacing aged bare conductor, other WCCP program elements will replace other aged components such as conductor, crossarms, insulators, and splices/clamps/connectors, which will mitigate equipment/facility failures.

[70] Includes advanced weather modeling tool and the high performance computing platform.

3. Step 4: Risk Mitigation Evaluation

SCE evaluated a range of potential mitigation solutions warranting serious consideration. SCE corroborated selected mitigation solutions by benchmarking international practices in jurisdictions with comparable wildfire conditions, such as Australia. SCE also reviewed certain international standards related to risk management and asset management to leverage components that could be applied directly to wildfire mitigation.

SCE analyzed faults tracked in its Outage Database and Reliability Metrics System (ODRM) over the 2015-2017 period to better understand how the different types and frequencies of fault incidence relate to the actual occurrence of fire events discussed above. In light of this analysis, SCE evaluated possible solutions based on a number of factors, including both technical capability (i.e., demonstrated ability to reduce the likelihood of fire ignition by, for example, reducing faults) and the operational feasibility of implementing the solution given the current design and configuration of the system. To evaluate technical capability, SCE performed internal testing, commissioned external testing, and consulted with electric/utility industry experts. To assess operational feasibility SCE considered, for instance, how changing protection philosophies might impact reliability, or how using covered conductor in high fire risk areas would affect other components of the system (such as poles) and its long term performance in all the inclement weather and environmental conditions.

Given the significance of contact from objects as a cause of fire ignitions, SCE evaluated a number of potential risk mitigation measures focused on: (1) reducing the population of potential objects (i.e., reducing tree branches, metallic balloons, animals, etc. near overhead lines); and (2) designing the system to be able to withstand such contact without leading to a fire ignition. Regarding the first approach, enhanced vegetation management practices can further reduce the likelihood that vegetation will contact overhead distribution system by increasing clearances and removing even more trees. But this approach has limitations, including the utility's limited ability to increase clearances in certain areas, the fact that wind can often blow debris into lines from significant distances despite appropriate clearances to nearby trees, and that taller trees can fall onto lines even when located well outside of the utility's right of way. Thus, SCE also evaluated mitigation measures focused on the second approach (withstanding contact), concluding that covered conductor is the most feasible mitigation solution for fault and ignition prevention.

And as new technologies emerge, SCE will continue to evaluate the effectiveness of more advanced solutions and how they may complement its existing portfolio of mitigation measures. If new measures prove to be better than existing ones, SCE will work to transition to these improved measures as appropriate. The exploration of some of these new technologies is described in Section IV.E.

4. Step 5: Decision-Making and Planning

In developing the GS&RP, SCE determined that a portfolio of mitigation measures, as opposed to implementing just one or two specific ones, is necessary to comprehensively address wildfire risk across all aspects of the fire triangle. SCE also considered several factors in deciding how, when, and where to implement each selected mitigation measure. These factors included the risk profile for HFRA in SCE's service area, the risk profile of assets that have the potential to cause ignitions, how each activity impacts the frequency and/or impact of wildfires, the potential speed of deployment, interactions between mitigation measures and/or planned work outside of the GS&RP, cost, resource constraints, and material or technology availability.

5. Step 6: Monitoring and Reporting

SCE's grid resiliency and wildfire mitigation efforts are both iterative and dynamic. SCE will continue to evaluate the wildfire risk landscape in SCE's service area and across California. SCE will also implement a variety of processes for monitoring and evaluating the work undertaken as part of the GS&RP proposal. For example, tracking of faults and wildfire ignition events continues to be a critical aspect of the evaluation of wildfire risk. All else being equal, SCE would expect to see meaningful reductions in risk metrics over time as a result of implementing the GS&RP proposal. SCE's monitoring and evaluation will also capture valuable lessons from the initial GS&RP deployment period, which may help in the efficiency and efficacy of the GS&RP initial deployment. These lessons will then inform future program elements that would be the subject of the 2021 GRC.

B. <u>The GS&RP Aligns With, and Will Inform, SCE's Upcoming RAMP Filing</u>

The Commission modified the GRC process to include RAMP as the initial phase of each utility's GRC, incorporating a risk-informed decision-making framework and providing an early indication of the utility's top safety risks and mitigation plans. The Commission's intent was to provide additional transparency and understanding of how top safety risks are identified and prioritized, and accountability for how these risks are managed and mitigated.

SCE's RAMP Application is scheduled to be filed with the Commission by November 30, 2018. SCE's evaluation of risk mitigation effectiveness that informed development of the GS&RP is a modeling input for the RAMP analysis. Over the past few years, wildfire risk has been one of SCE's key enterprise risks, and SCE's RAMP filing will further analyze the effectiveness of mitigation options addressing this risk in the context of other key safety risks facing the utility. SCE's RAMP will also evaluate mitigation options for wildfire risks over a wider timeframe (i.e., the 2021 GRC period) and present those risk analysis results to the Commission.

IV.

GS&RP PROJECTS

In this Chapter, SCE reviews the portfolio of mitigation measures included in its GS&RP, discussing the need for each mitigation measure, what currently exists today, as of this filing (and why it should be enhanced), alternatives considered, the deployment timeline, and estimated costs. Each project fits into SCE's broader wildfire mitigation strategy targeting both wildfire prevention and system resiliency. Table IV-7 below presents SCE's forecast 2018-2020 revenue requirement for the GS&RP projects described in this Chapter.

Table IV-7
Forecast 2018-2020 GS&RP Revenue Requirement

Revenue Requirement (Nominal $000)				
Description	**2018**	**2019**	**2020**	**Total**
Grid Hardening Projects	3,021	12,769	52,977	$68,767
Enhanced Situational Awareness	2,392	7,995	11,344	$21,730
Enhanced Operational Practices	4,560	46,050	86,514	$137,124
Wildfire Mitigation Program Study	518	535	398	$1,451
Total Grid Safety & Resiliency Program	**$10,490**	**$67,349**	**$151,233**	**$229,072**

A. Portfolio Overview

At the center of SCE's wildfire mitigation strategy is an approach and philosophy targeted at preventing ignitions. This approach heavily targets the heat element of the triangle. As described in Section III.A.1, SCE's overhead distribution facilities represent the most likely source of ignitions and those portions of circuits that traverse HFRA present the highest risk, both from a likelihood of ignition and from the potential consequences of an ignition. SCE's approach to minimizing ignitions combines several enhanced grid hardening and operational practices. For these circuits, SCE's Wildfire Covered Conductor Program is designed to reduce the greatest historical source of ignitions, which are associated with faults resulting from contact from objects by covering those spans most prone to contact. This measure will help prevent the faults from occurring in the first place.

While this state-of-the-art covered conductor is very effective at preventing common causes of faults, it cannot prevent every type of fault in every circumstance, particularly if external forces damage or break the conductor. Thus, SCE's enhanced vegetation management efforts aim to reduce trees that can fall into electrical lines and lead to ignitions. These enhanced practices will benefit both the portions of circuits that have been covered and those that will remain bare. SCE's Wildfire Covered Conductor Program (WCCP) and enhanced vegetation management practices are each independently necessary and complementary to one other: covered conductor deployment will occur over several years on certain targeted spans and circuits in HFRA while SCE's enhanced vegetation management program will be implemented in the near term, throughout HFRA.

In addition to measures that prevent faults, SCE will utilize hardening measures and enhanced operational practices to reduce the likelihood of ignition if a fault were to occur by reducing the amount of energy associated with faults. SCE's use of remote-controlled automatic reclosers (RARs) at the boundaries of HFRA will help reduce ignitions on portions of circuits that traverse HFRA by utilizing "fast curve" relay settings that will activate more quickly and reduce fault energy. Additionally, these devices will be programed to prevent automatic reclosing during Red Flag Warning conditions when wildfire risk is elevated. SCE's fusing mitigation will install and replace fuses on smaller branch lines within HFRA. Like the RARs, these fuses have the capability to reduce the amount of energy associated with faults and provide greater protection deeper into the circuits downstream from RARs. Last, SCE is utilizing infrared inspection of overhead equipment in an effort to detect equipment that may fail in the near future and can be replaced prior to causing an ignition. This mitigation measure also complements the WCCP by targeting types of equipment/facility failures not directly addressed by WCCP and will include all of SCE's overhead equipment in HFRA.[71]

While SCE cannot directly affect the oxygen element of the triangle, SCE is taking steps to enhance its situational awareness capabilities to better understand weather conditions that present elevated risks for fires that can grow into large events that are challenging to suppress.

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[71] *See* Chapter IV.D.2 for a details about SCE's infrared inspection program.

The addition of weather stations and advanced weather modeling tools will enable SCE to better anticipate and plan for severe weather events. In the event that conditions are extreme and can result in an ignition that could cause a potentially catastrophic wildfire, SCE will utilize this real-time information along with field monitors to exercise its measure of last resort, the PSPS protocol.

For the fuel element of the triangle, SCE's enhanced vegetation management program will seek to remove additional trees within HFRA that pose a potential risk to electric facilities. This measure is primarily intended to prevent ignitions, but should provide some reduction in overall fuel load. Additionally, advanced modeling and high performance computing, coupled with advanced asset reliability and risk analytics, will aid SCE in performing vegetation and fuel load modeling, and understanding with greater granularity which assets and locations within HFRA present the greatest threat. This will enable SCE to better execute and deploy near-term operational measures and refine and guide longer-term mitigation measures.

Last, in the event that an ignition does occur, new HD cameras can aid fire agencies in responding more quickly to reduce the size and impacts of fires. Other mitigation measures presented in this Chapter aim to reduce the potential impact to customers of outages associated with PSPS, such as mobile generators, portable community power trailers, and exploration of unmanned aerial systems.

B. Grid Hardening Projects

1. Wildfire Covered Conductor Program

a) Program Overview

The Wildfire Covered Conductor Program (WCCP) is the central grid hardening fire mitigation solution for SCE's GR&SP. SCE expects the use of covered conductor in HFRA to meaningfully reduce the wildfire ignition risks associated with overhead electrical distribution system facilities.

SCE takes significant measures to design and maintain its systems to meet all current safety code and compliance requirements. Nevertheless, some risks associated with fire ignition remain. For instance, in HFRA, SCE's overhead distribution system can serve as a potential fire ignition source when anomalies occur. Faults can occur when vegetation, metallic balloons, animals, or other debris comes into contact with overhead conductor, causing short circuit conditions. Fault conditions can sometimes cause intact conductor failures, resulting in energized wire down events, which could involve electrical arcing in air or on the ground, each of which can lead to fire ignition.

SCE has identified covered conductor as an important mitigation solution to reduce the fire risks associated with contact-related faults on overhead conductor. The WCCP seeks to reduce the risk of fire ignition through targeted replacement of existing bare overhead conductor in HFRA with covered conductor. Covered conductor is aluminum or copper wire insulated with a three-layer design, providing robust protection against contact-related faults and the electrical arcing associated with a variety of fault conditions. Covered conductor, unlike bare conductor wire, is specifically designed to withstand incidental contact with vegetation, other debris, and even the ground in a wire down event. Thus, covered conductor achieves many of the same fire mitigation benefits as converting overhead wire to underground cable, but at a fraction of the cost. It also has similar public safety benefits, but does not suffer from the troubleshooting and restoration delays associated with underground systems, meaning faster repairs and shorter outage times for customers.[72] SCE's WCCP will target the installation of covered conductor on certain spans of the overhead distribution system in HFRA that are estimated to pose the greatest risk of fire ignition.

72 Additional limitations of underground systems include that they cannot be visually inspected, they require service interruptions to perform maintenance, are difficult to upgrade and often require excavation, and are difficult to troubleshoot during emergencies, resulting in longer outages.

b) What Exists Today

(1) SCE's Historical Use of Bare Conductor Wire

SCE operates a large overhead electrical distribution system, and a substantial portion of it is located in HFRA.[73] In constructing its overhead distribution system, SCE has historically relied principally on bare conductor over other options, such as undergrounding or legacy-designed covered conductor.[74] This was consistent with the standard practice used by California's other investor-owned public utilities and utilities in many other jurisdictions.

For many electric utilities, including SCE, bare conductor wire has been the traditional design standard for overhead distribution systems throughout their service areas. Indeed, bare conductor is consistent with the requirements of G.O. 95. SCE commissioned an informal survey of utilities across the United States, to confirm that other major utilities outside of California, such as Oncor Electric, Duke Energy, and Xcel Energy, also use bare conductor for their overhead distribution systems. This widespread use of bare conductor is due to a number of factors. It has demonstrated good reliability, supports a high number of customers (due to its high temperature rating), and is cost effective. As part of the WCCP, SCE will use covered conductor in HFRA, but bare conductor will remain the primary design standard for new construction and re-construction work throughout SCE's service area outside of HFRA.

73 SCE has approximately 13,400 distribution circuit miles in HFRA. A large portion, around 73 percent or approximately 9,800 circuit miles, is overhead and around 27 percent, or approximately 3,600 circuit miles, is underground. The underground portion is primarily located in more densely populated urban areas and is generally understood to represent lower wildfire risk.

74 Legacy-designed covered conductor accounts for only a minimal portion (estimated to be approximately 50 circuit miles) of SCE's existing overhead distribution system, which consists of approximately 28,000 circuit miles of primary overhead distribution conductor across SCE's entire service area.

(2) SCE's Use of Covered Conductor and Industry Advances in Covered Conductor Design

Recently, SCE began considering greater use of covered conductor for wildfire risk mitigation in HFRAs in response to the unprecedented damage caused by the 2017 wildfires and the "new normal" of year-round increased wildfire risk. Over time, the industry has continuously improved the design and application of covered conductor, moving from a single layer of insulating material to a robust three-layer design that SCE will deploy in its WCCP. Apart from adding layers, the industry improved the material used for the insulating cover. The three-layer design and material advancements improved the performance and extended the life of covered conductor. In connection with these advancements, the first industry standards for covered conductor were adopted in 2016, specifying design and manufacturing criteria as well as qualification testing and end user usage.[75]

These improvements, together with other advances, solved many of the problems associated with earlier generations of covered conductor such as degradation with UV exposure, inability to withstand more than incidental contact, radio frequency emissions, and burn downs due to vibration fatigue, tracking, and lightning.[76] The advanced three-layer design, specifically the XL-HDPE outer layer, improved covered conductor's tolerance to UV exposure without tracking, sensitivity to radio frequency emissions, and ability to withstand prolonged contact. Additionally, the use of polymer insulators (as opposed to porcelain insulators) and refinement of the system design criteria for covered conductor, namely, appropriate sag and span length, further addressed the problems associated with radio frequency emissions and vibration fatigue. Collectively, these improvements make the newer generation of covered conductor a viable solution for electrical facilities in HFRA to enhance the safety and

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[75] *See* Insulated Cable Engineers Association, Inc., *Standard for Tree Wire and Messenger Supported Spacer Cable*, ANSI/ICEA S-12-733 (2016).

[76] SCE's service area is considered to have low risk of lightning activities compared to other regions of the country. SCE also employs industry prudent practices to mitigate lightning strikes by installing lightning arrestors at strategic locations.

resiliency of SCE's system. An overview of the evolution of covered conductor technology is shown in Figure IV-5.

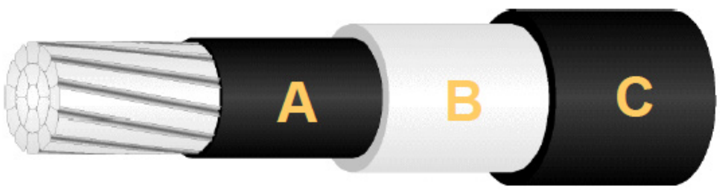
Figure IV-5
Comparison and Evolution of Covered Conductor Technology

Layers: one

Materials: Low Density Polyethylene

Layers: two

Materials: (A) Polyethylene; (B) High Density Polyethylene



Layers: three

Materials: (A) Semi-conducting shield; (B) Cross-link Polyethylene; (C) Cross-link High Density Polyethylene

Historically, neither SCE nor the other investor-owned public utilities in California have relied on covered conductor for fire mitigation. SCE used legacy-designed covered conductor, known as "tree wire" because it was used for mitigating incidental contact with trees under special circumstances. SCE's use of covered conductor was limited in part due to its experience with early covered conductor designs and their associated problems. These aforementioned problems made designing a covered conductor system in SCE's service area difficult and not cost effective.

SCE also used some aerial cable, which is an installation of underground cable on poles for the overhead distribution system. The early version of aerial cable was assembled or bundled in the field. In the 2000s, SCE began using manufacturer assembled or bundled cable, known as Aerial Bundled Cable (ABC). Thus, deployment of legacy-designed covered conductor (tree wire) or ABC was guided mainly by potential reliability benefits, typically considered only in areas of dense vegetation where there are limitations on SCE's ability to trim trees. Before 2018, SCE had a total of approximately only 50 circuit miles of legacy-designed primary covered conductor or aerial cable.

Recently, however, a newer generation of covered conductor has received increased attention for grid hardening efforts because its fault-mitigation properties also reduce the potential for ignitions. For instance, in 2016, regulations in Victoria, Australia began requiring that overhead electrical lines use covered conductor in areas of increased fire risk.[77] There has been recent domestic attention on covered conductor as well, including by utilities in states such as Colorado, for fire mitigation.[78] SCE began considering more extensive use of covered conductor in 2017 to improve reliability stemming from contact-related faults, such as metallic balloons, animals, and vegetation. In light of the growing wildfire and year-round risks, SCE expanded its evaluation of covered conductor for grid hardening and fire mitigation enhancements, with SCE conducting initial research, benchmarking, and testing in the latter half of 2017 and continuing into 2018. This led to changes in SCE's design and construction standards in 2018. The standard now specifies the use of covered conductor for new construction and re-conductoring projects in HFRA. The timing of this evaluation and change in SCE's standard meant that the WCCP was not included in SCE's 2018 GRC.

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[77] *Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016* (Victoria) S.R. No. 32/2016 (Austl.), *available at* http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/93eb987ebadd283dca256e92000e4069/9CC083A75311B617CA257FA100148082/$FILE/16-032sra%20authorised.pdf.

[78] Editors, *DistribuTech 2017: Hendrix showcases aerial cable systems for grid reliability*, ELEC. LIGHT & POWER (January 31, 2017), *available at* https://www.elp.com/articles/2017/01/distributech-2017-hendrix-showcases-aerial-cable-systems-for-grid-reliability.html ("The covered conductors of Hendrix are also ideal for fire mitigation, as they're less apt to spark if a pole happens to come down in a storm or fire."); Hendrix Aerial Cable Systems, *United Power Installs Hendrix Aerial solution to Address Fire Mitigation Needs*, MarmonUtility.com, *available at* https://www.marmonutility.com/Portals/0/Case%20Studies/United%20Power%20Installs%20Hendrix%20Aerial%20solution%20to%20Address%20Fire%20Mitigation%20Needs.pdf?ver=2018-04-02-142940-340.

To gain critical deployment capabilities and experience and further refine SCE's design and construction standards, SCE made the decision to proactively re-conductor portions of ten at-risk circuits in HFRA beginning in 2018. SCE selected these circuits based on a combination of their environmental footprint, asset characteristics, and potential HFRA impact. SCE viewed this as an opportunity to proactively install covered conductor to help reduce existing wildfire risks associated with its distribution system in HFRA.

Since SCE had used covered conductor rarely, and only on an individual, case-by-case basis, this re-conductoring project also allowed SCE to gain greater experience with broader deployment of covered conductor at the circuit level and to provide key insights for the design of the WCCP. For instance, while similar in electrical and mechanical properties to bare wire conductor, covered conductor necessitates greater care when handling for installation to protect the outer covering from damage. The increased diameter associated to covered conductor also increases wind loads resulting in additional pole replacements beyond those of bare wire re-conductoring projects.[79]

(3) The New WCCP and the Existing Overhead Conductor Program

The WCCP is related to the existing Overhead Conductor Program (OCP) that SCE established to re-conductor small wire circuits with the greatest public safety risks from a wire down event. As a long-term program, OCP covers all of SCE's service area, ranking SCE's overhead circuits based on criteria such as specific increased likelihood of wire down events to address safety and reliability risks.[80] Given its focus, OCP generally prioritizes circuits that serve many customers and are located in densely populated areas, where reliability and public safety risks from human contact with a downed wire are greatest. At this early stage of the program, the circuits being addressed are generally located in urban areas, not the wildland-urban interface that is typical of HFRA, as many of the circuits with the highest

[79] *See* Section IV.B.1.e)(2)(a) for details regarding impacts to pole replacements.

[80] The prioritization for OCP is based on circuit breaker operations, customer density, fault duty (short circuit duty) data, and recent history of wire-down events. (A.) 16-09-001 (2018 GRC), SCE-02, Vol. 8, at p. 51.

wildfire risks serve areas more sparsely populated. Even though OCP's primary focus is not specifically wildfire risk mitigation, to the extent it addresses the root causes of wire down events, including potential conductor damage associated with short circuit duty (SCD),[81] OCP also has important secondary wildfire risk mitigation benefits.

Most of the 2018-2020 projects under OCP have already begun, even if only in the early design phases. Realigning current OCP projects to focus more on wildfire mitigation would require unwinding projects that have already started. This would be impractical, uneconomic, and detract from OCP's important safety priorities, including in portions of SCE's service area not designated as HFRA. SCE continues to recognize the importance of OCP's focus on public safety, but also understands the pressing need to address wildfire risk mitigation, especially in HFRA, through re-conductoring. Thus, there is a vital role for incremental re-conductoring that focuses on wildfire risk mitigation to complement the existing work under OCP that is mainly outside of HFRA across SCE's entire service area.

Further, as part of SCE's change in conductor standards, future OCP projects not yet initiated will begin using the newly developed covered conductor standards for re-conductoring work in HFRA. And outside of HFRA, future OCP projects also may use covered conductor for reliability and other benefits based on the recommendation of field subject-matter experts in areas with heavy vegetation, known metallic balloon contact risk, a high frequency of outages due to intermittent contact, or within one mile of the coast.[82]

c) <u>Effectiveness</u>

SCE's WCCP is an important step forward in the mitigation of wildfire risks, specifically the drivers of wildfire ignitions related to electrical equipment. Since covered conductor has robust layered insulation, replacing bare conductor with covered conductor is an effective way to prevent contact-related faults. Preventing the occurrence of faults in turn

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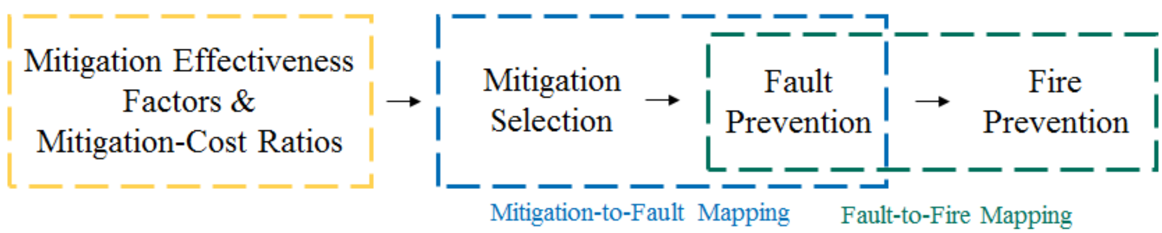
[81] Short circuit duty (SCD) generally indicates the relative ability of a system to supply load, typically measured by the fault current (in amps), at any location within the system.

[82] Conductors situated in close proximity to the coast can be subject to corrosion and deterioration caused by salty fog.

reduces the likelihood of the anomalies that lead to fault-related fire ignitions. As secondary benefits, the thick insulating layer of covered conductor also improves reliability and can reduce the risk associated with human contact with energized conductor, such as during a wire down event.

The detailed risk mitigation analysis to support the use of WCCP followed three sequential steps: fault-to-fire mapping; mitigation-to-fault mapping; and the calculation of mitigation effectiveness factors and cost-mitigation ratios.[83] Figure IV-6 illustrates the sequence of the risk mitigation analysis:

Figure IV-6
Risk Mitigation Analysis

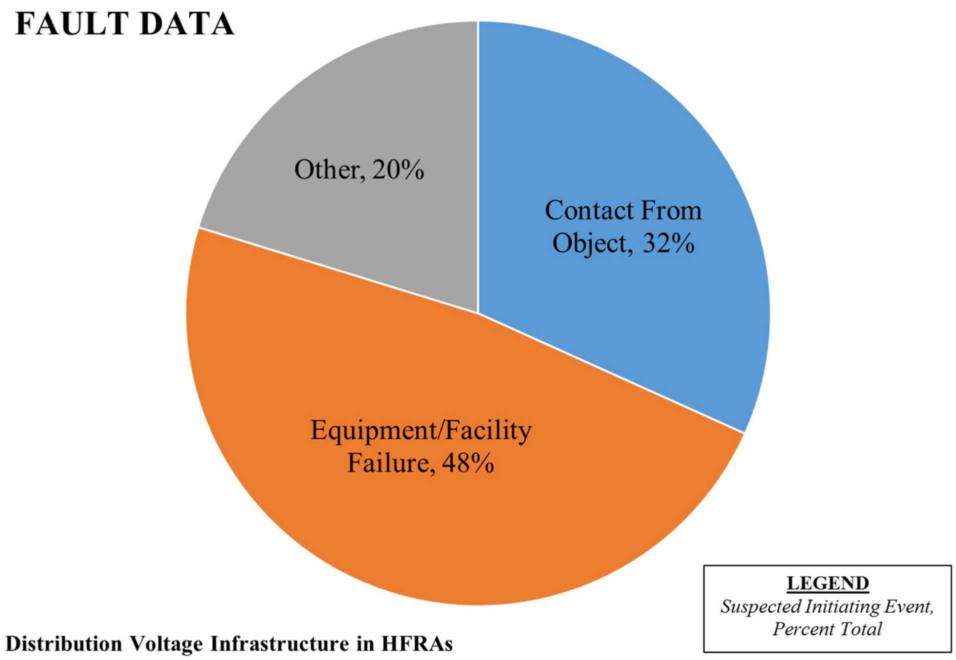


(1) Risk Analysis: Fault-to-Fire Mapping

As described above in Chapter III.A.1, SCE performed a detailed analysis of the fires that occurred in SCE's service area between 2015 and 2017 that were reportable to the CPUC. These fires were categorized based on "suspected initiating event" such as Contact from Object (CFO) and Equipment/Facility Failure. These data are shown in Figure II-3 and Table III-5. Simultaneously, SCE analyzed the fault history during this time period as tracked in its Outage Database and Reliability Metrics System (ODRM). This database includes various cause codes so that each fault is associated with a particular cause (e.g., metallic balloon, vegetation blown, or vehicle hit). These data are shown in Figure IV-7.

[83] Refer to Work Paper Vol. 1 (Mitigation Effectiveness Comparison).

Figure IV-7
Breakdown of Historical Fault Causes (Distribution Voltage Infrastructure in HFRA from 2015-2017)[84]



Further breakdown of the categories of Contact from Object and Equipment/Facility Failure is shown in Table IV-8.

[84] Note, this figure presents data related to faults. *See* Figure II-3 for data associated with fires.

Table IV-8
Breakdown of Contact from Object and Equipment/Facility Failure Related Faults
(Distribution Voltage Infrastructure in HFRA from 2015-2017)[85]

Suspected Initiating Event	Count	Percentage
Contact From Object	895	32%
Equipment/Facility Failure	1,354	48%
Other	571	20%
Total	**2,819**	**100%**

Contact From Object	Count	Percentage
Animal	250	9%
Balloons	152	5%
Other	48	2%
Vegetation	238	8%
Vehicle	207	7%
Total	**895**	**32%**

Equipment/Facility Failure	Count	Percentage
Capacitor Bank	8	0%
Conductor	145	5%
Crossarm	39	1%
Fuse	98	3%
Insulator	24	1%
Other	111	4%
Splice/Clamp/Connector	138	5%
Transformer	791	28%
Total	**1,354**	**48%**

SCE then mapped the fire ignition data, including information regarding the cause of each fire (where known), to the cause codes in ODRM. This process allowed SCE to connect data regarding the frequency of faults of different types to data regarding the frequency of fires associated with those fault types. From this analysis, SCE extrapolated the likelihood that a given type of fault could be associated with a fire ignition event.

[85] Note, this table presents data related to faults. *See* Table III-5 for data associated with fires.

The results showed that contact from object faults have a higher probability of being associated with a fire event: this broad category accounted for less than one-third of total faults in SCE's system (32 percent) but was associated with more than one-half (53 percent) of the suspected wildfire initiating event types. This pointed to a potential opportunity for significantly reducing wildfire risk by focusing on measures that prevent contact-related faults. Vegetation-related CFO faults provides a specific example. In the 2015-2017 period, the ODRM fault analysis shows that there were 2,819 faults per year on the distribution system in HFRA; 238 of these, or eight percent, were identified as vegetation-related CFO faults. In that same period, fire data analysis shows that there were approximately 132 fires associated with the distribution system in HFRA;[86] for 22 of these, or 16.7 percent, vegetation contact was identified as the suspected initiating event. Note that these numbers do not include fires that are still being investigated and for which the suspected origin and cause are still undetermined. Thus, all else equal, there was a relatively greater likelihood that a vegetation-related fault was ultimately associated with a fire event.

(2) Risk Analysis: Mitigation-to-Fault Mapping

The next step in the risk analysis performed by SCE was a mapping of specific mitigation alternatives to the types of faults that can be avoided upon deployment. This analysis relied on engineering subject matter expertise to identify how much of each general fault type—contact from object, equipment/facility failure, and other—would be mitigated by a specific mitigation measure. It focused on three key mitigation measures: (1) re-conductoring with bare conductor sized to meet current design standards; (2) re-conductoring with covered conductor sized to meet current design standards; and (3) relocating distribution lines underground. For example, all three of these mitigation measures were identified as effective at mitigating the splice/connector/tap subtype of equipment failure faults. Two of these three mitigation measures (covered conductor and underground conversion) were identified as

[86] This figure is approximate since some fires during this period are still under investigation.

effective at mitigating the vegetation-related subtype of CFO faults. Only one mitigation measure (underground conversion) was identified as effective at mitigating the overhead transformer subtype of equipment failure faults.

(3) Mitigation Effectiveness Factors and Mitigation-Cost Ratios

Combining the fault-to-fire mapping and the mitigation-to-fault mapping yields a model of mitigation effectiveness factors for each of the three mitigation measures. Based on this methodology, and on a stand-alone basis, bare conductor was calculated as having a 15 percent mitigation effectiveness factor; covered conductor was calculated as having a 60 percent mitigation effectiveness factor; and underground conversion was used as the reference baseline for mitigation effectiveness because it removes all exposures related to overhead power lines. However, it is important to note that underground conversion introduces other negative impacts that are not part of this evaluation, such as much longer troubleshooting and restoration time in the case of system or equipment failures.[87]

A mitigation effectiveness factor could be interpreted as an estimate of the percentage of fires avoided with full deployment of the mitigation measure throughout HFRA, all else equal. Thus, full deployment of covered conductor in HFRA is estimated to mitigate approximately 60 percent of fires associated with SCE's electrical distribution facilities in HFRA. This analysis of mitigation effectiveness does not account for potential benefits with other mitigation measures, such as fuses and automatic reclosers, which also reduce the likelihood of fire ignitions. Thus the mitigation effectiveness factors are appropriately considered as relative—not absolute—measures, with underground conversion providing the baseline for purposes of comparison. In other words, covered conductor could be

[87] Examples of these and other negative impacts were well articulated by President Picker. *See* Statement of President Picker, Conference Committee on SB 901 Informational Hearing: Ensuring a Safe and Reliable Electric Grid (August 7, 2018), at 51:06 to 1:06:15, *available at* https://www.senate.ca.gov/media/conference-committee-s-b-901-20180807/video.

viewed as achieving 60 percent of the fire mitigation benefits of underground conversion, and bare conductor would achieve 15 percent.[88]

In addition to mitigation effectiveness, SCE also considered the cost associated with each mitigation option. For bare conductor, SCE relied on its costs associated with OCP, approximately $301,000 per circuit mile. For comparison, accounting for the differences in material costs for covered conductor as well as the costs of associated upgrades (such as the replacement rate of poles), covered conductor is approximately $428,000 per circuit mile.[89] For underground conversion, SCE relied on its experience with projects under Rule 20A, which cost approximately $3 million per circuit mile. These costs, combined with the relative mitigation effectiveness factors, allows comparison of each measure's mitigation-cost ratio, i.e., the relative mitigation effectiveness (using underground conversion as the baseline) achieved per dollar spent. These results are presented below in Table IV-9:

Table IV-9
Mitigation Effectiveness-to-Cost Ratios for Covered Conductor and Alternatives

Mitigation Option	Relative Mitigation Effectiveness Factor	Cost per Mile ($ million)	Mitigation-Cost Ratio
Re-conductor – Bare	0.15	0.30	0.50
Re-conductor – Covered	0.60	0.43	1.40
Underground Conversion	1.00	3.00	0.33

(4) Risk Analysis Conclusions

SCE's risk analysis shows that application of covered conductor is the most prudent of the three mitigation measures. Specifically, while re-conductoring with bare

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88 It should be noted that this analysis considers all ignition causes associated with overhead equipment only. It does not factor in the additional risks (e.g., cable/equipment failure, vault explosions, longer repair outages, etc.) that would be inherited by converting to an underground system, which would offset the risk benefits attributed to undergrounding.

89 The material cost of covered conductor is significantly more than bare wire. While the overall unit cost is also more, this difference is relatively smaller than the difference in material costs alone would suggest given that material costs account for only a small portion of the overall unit cost per mile. Refer to Work Paper Vol. 2 (Unit Cost - Covered Conductor)

conductor would have lower cost, and underground conversion would have greater benefit, re-conductoring with covered conductor has the greatest overall value. A dollar spent re-conductoring with covered conductor provides nearly three times as much value in wildfire risk mitigation as a dollar spent re-conductoring with bare conductor, and over four times as much value in wildfire risk mitigation as a dollar spent on underground conversion. Moreover, by deploying covered conductor in connection with other mitigation measures included in the GS&RP—including installing remote-controlled automatic reclosers and circuit breakers with "fast curve" settings and fusing strategy—SCE can further bridge the benefit gap between covered conductor and underground conversion.

From these results, SCE selected covered conductor—as implemented in WCCP—as a key component of SCE's GS&RP.

d) Forecast

Table IV-10
2018-2020 Wildfire Covered Conductor Program Costs
($000)[90]

[90] Refer to Work Paper Vol. 2 (Scope - Covered Conductor; Unit Cost - Covered Conductor; Forecast - Covered Conductor; Unit Cost - Tree Attachments; Forecast - Tree Attachments; Scope - Fire Resistant Poles; Forecast - Fire Resistant Poles; Capital Related Expense - WCCP; Development and Delivery - Fire Resistant Poles; Development and Delivery - Covered Conductor)

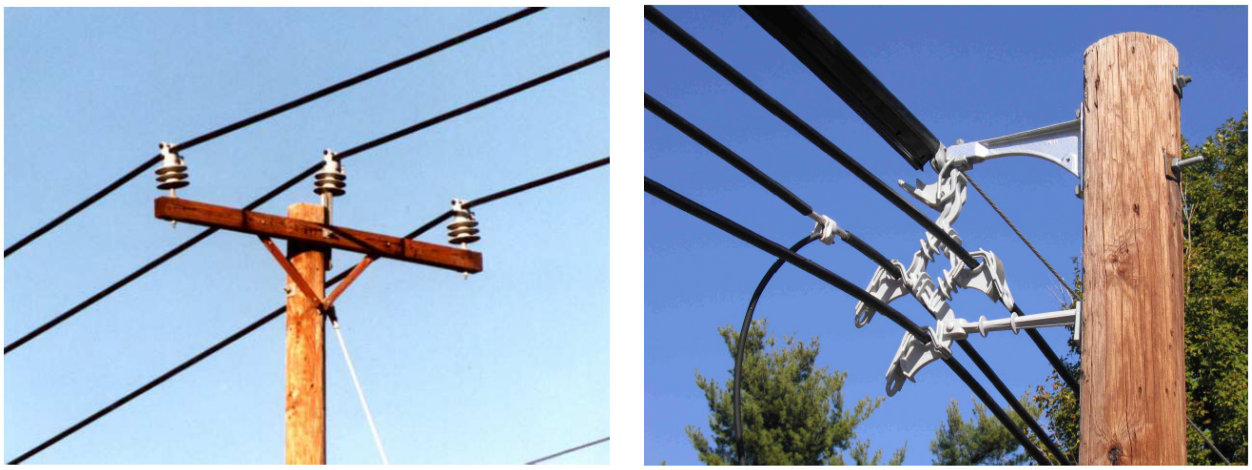
Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Covered Conductor	30,258	41,001	182,355	$ 253,614
Fire Resistant Poles	-	4,978	22,139	$ 27,117
Tree Attachment Remediation	3,678	-	433	$ 4,110
Grand Total	**$ 33,936**	**$ 45,979**	**$ 204,927**	**$ 284,842**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Capital Related Expenses	696	943	4,201	$ 5,839
Fire Resistant Poles Development/Delivery	9	9	-	$ 18
Covered Conductor Development/Delivery	42	-	-	$ 42
Grand Total	**$ 747**	**$ 951**	**$ 4,201**	**$ 5,899**

e) Detailed Program Description

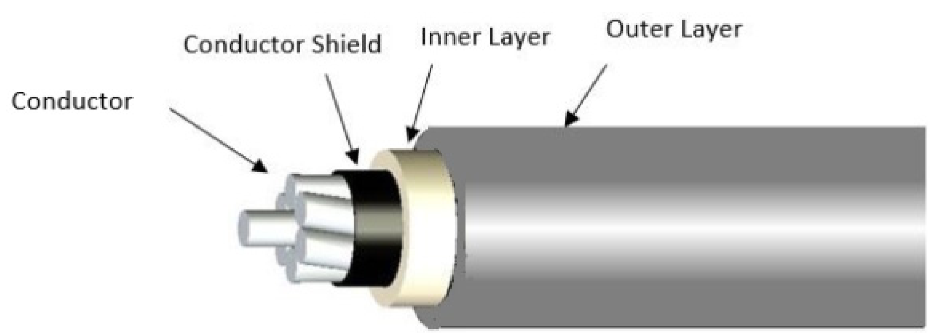
WCCP will harden SCE's overhead distribution system in HFRA by replacing certain existing bare conductor with covered conductor to reduce the fire ignition risk from contact-related faults. In implementing WCCP, SCE will use two different construction methods depending on the individual circumstances of each span. The traditional cross-arm configuration is similar to existing overhead installations of bare conductor and will account for the vast majority of the covered conductor installed under WCCP. In selected situations, SCE plans to use a spacer cable system in which covered conductor is attached to spacer hardware that is suspended from a supporting messenger line (Figure IV-8). The messenger line has high tensile strength, is attached to the pole via side-arm hardware, and supports the weight of the covered conductor at the pole and along the span. The messenger line is specifically designed to withstand the weight of a falling tree branch. Anticipated use of the spacer cable system is primarily limited to heavily forested areas and certain circuit spans in areas of dense vegetation. In particular, the spacer cable system may be used for the replacement of SCE's existing tree attachments, discussed below.

Figure IV-8
Traditional Cross-Arm and Space Cable Configurations



The covered conductor that SCE will use for the WCCP is shown in Figure IV-9.

Figure IV-9
Components of SCE's Covered Conductor



The conductor shield layer is approximately 15-mil thick.[91] It is made of a semiconducting thermoset polymer. Its purpose is to reduce stress concentrations caused by flux lines from the individual conductor strands. By encircling the strands, it effectively transforms the strands into a single uniform conducting "cylinder" as the images in Figure IV-10 illustrate. The reduction of electrical stress, especially if the covered conductor makes contact with another object, helps preserve the integrity of the insulation and lengthen the useful service life of the

[91] 1 mil = 1/1000 inch.

covered conductor. Figure IV-10 shows the internal conductor wire with and without the conductor shield layer.

Figure IV-10
Pattern of Electrical Stress (Flux) With and Without Covered Conductor Shield

Without conductor shield: **With conductor shield:**

The dual insulation layers are each 75-mil thick and made of cross-linked polyethylene. The inner layer is a crosslinked low density polyethylene (XL-LDPE), which is an insulating material. The insulation contributes to the high impulse strength of the covering, protecting from phase to phase and phase to ground contact. The outer layer is a track-resistant[92] crosslinked high density polyethylene (XL-HDPE). It has the same insulating function as the inner layer. But the higher density makes it a tough outer layer that is resistant to abrasion and impact. Its track resistance limits the charging current that flows on its surface. Since electrical tracking erodes the insulation surface over time, the track resistant properties help maintain the integrity of the insulation over time. Additionally, the outer layer is specified for UV stability, making it less susceptible to UV degradation. In particular, as part of the manufacturer's tests, the covering is subjected to UV radiation levels equivalent to the most extreme summer weather in Florida, which is equivalent to, or more extreme than, the UV intensity in Southern California. SCE's past operating experience with underground cable and other covered conductor suggests

[92] Tracking is a path connecting electrons created from charging current on the covering surface. If the charged electrons connect and flow, it can erode the insulating cover over time. Covered conductor is designed to resist tracking, i.e., to stop electrons from connecting and flowing, and thereby prevent erosion and failure of the insulation layers.

that failure due to cover deterioration is minimal. And SCE believes that the covering on covered conductor will continue to provide partial protection beyond its service life.

Together, the inner and outer insulation layers of covered conductor help protect the internal conductor wire and conductor shield layer from phase-to-phase and phase-to-ground contact, mitigating intermittent contact-related faults. As such, covered conductor is able to withstand intermittent contact with vegetation, including tree limbs and palm fronds, metallic balloons, animals, other conductor wire, and the ground without faulting. SCE's analysis shows that if a tree branch falls on two covered conductors with 150 mil (0.15 inch) of insulation, a 0.18 milliampere (mA) current will be produced, resulting in an energy level of 0.00019 Watts.[93] This very low energy is insufficient to initiate an electrical arc, compared to bare conductor.[94] The insulation layers of covered conductor also reduce the charging current and reduce the public safety risks associated with human contact. If energized conductor wire comes down, human contact results in, at most, a slight shock. For instance, tests performed at the National Electric Energy Testing, Research and Applications Center (NEETRAC), Georgia Institute of Technology, demonstrate that human contact with a downed covered conductor would result in current below 1 mA.[95] The effect of this current level is considered "generally not perceptible."[96]

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[93] Refer to Work Paper Vol. 1 (An Engineering Analysis on Impacts of Contact from Objects (CFO) on Bare vs. Covered Conductor)

[94] The energy produced when a tree limb falls on bare conductors is on the order of magnitude of tens of kW, or more than 10 million times the energy produced when a limb falls on two covered conductors. This higher energy level can heat the tree limb and potentially create a carbon-ionization pathway as the limb starts to burn, to complete a phase-to-phase fault on air in the bare conductor situation.

[95] Refer to Work Paper Vol. 1 (NETRAC Study and Associated SCE Developed Study Summary)

[96] Dept. of Health & Human Services, Centers for Disease Control & Prevention, *Electrical Safety , Safety and Health for Electrical Trades Student Manual*, (Apr. 2009), at p. 7, *available at* https://www.cdc.gov/niosh/docs/2009-113/pdfs/2009-113.pdf.

(1) Program Scope

SCE has approximately 4,500 distribution circuits in its overall service area and approximately 1,300 circuits traverse HFRA.[97] WCCP will focus on certain spans located in HFRA that pose the greatest risk of fire ignition on these approximately 1,300 circuits. As discussed in Chapter III, SCE has taken a more expansive approach regarding designating portions of its service area as HFRA beyond those identified in the Commission's fire threat map, including for purposes of WCCP.

In this Application, SCE proposes to begin a multi-year effort that SCE will subsequently include in future GRCs. SCE has identified approximately 4,000 circuit miles of bare overhead conductor in HFRA best suited for re-conductoring with covered conductor between 2018 and 2025 to mitigate contact-related faults and the risk of wire down events during fault conditions. In this Application SCE requests to begin replacement of approximately 592 circuit miles throughout 2018-2020[98]. The balance of the WCCP work (2021-2025) will be addressed in a future rate case. SCE has focused WCCP on only the primary overhead distribution system. This is because the current standard for secondary voltages requires triplex covered conductor and the secondary overhead distribution system accounts for a much smaller proportion of the overall risk of fire ignition. But SCE may

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[97] SCE's distribution circuits were not designed around the portions of SCE's service area that are considered to be HFRA. As a result, significant variation exists in each circuit's HFRA exposure. For instance, some circuits are located entirely in a HFRA while others have only a small portion that traverses a HFRA. The below table shows HFRA circuits, grouped by quartile, based on the percentage of each circuit's length that resides within HFRA.

Breakdown of Circuits with Varying HFRA Exposure		
Percent of Circuit Length within HFRA by Quartile	**Number of Circuits**	**Percent of Total**
> 75 percent	759	58
50 to 75 percent	138	10
25 to 50 percent	152	12
< 25 percent	267	20
TOTAL	**1316**	**100**

[98] Refer to Work Paper Vol. 2 (Scope - Covered Conductor)

consider proactively replacing existing bare overhead secondary conductor with covered conductor as part of future GRC requests.

The circuit miles, referenced above, that SCE will target for re-conductoring were derived from an analysis that accounted for the risk of fire ignition for various portions of HFRA circuits. Specifically, this scope falls into two main categories: (1) spans with vintage small conductor at risk of damage during fault conditions and (2) spans with elevated risks of vegetation-related contact from object faults.

First, as discussed earlier regarding the OCP, certain vintage small conductor is especially vulnerable to damage during fault conditions and at risk of causing a wire down event. While these individual spans do not necessarily pose a higher risk of experiencing contact-related faults as compared to other spans, replacing spans of vintage small conductor in HFRA with covered conductor will significantly reduce ignition risks since these spans are the most susceptible to damage and burn down during fault conditions due to short circuit duty. This focus also aligns with the recent change in SCE's standard to require covered conductor for re-conductoring work in HFRA.

In the second category, there are particular circuits that have a history of vegetation-related faults. In some cases, these circuits are concentrated in areas where SCE has limited ability to trim trees or where there is greater likelihood that vegetation will be blown into overhead equipment from trees outside of SCE's right-of-way. Indeed, SCE's enhanced vegetation management practices cannot eliminate all risk of vegetation-related contact faults, especially during high wind conditions, so WCCP is needed to complement SCE's enhanced vegetation management practices. As a result, SCE will target circuits that had two or more vegetation-related faults in the 2015-2017 period. For these circuits, WCCP will install covered conductor over the full length of the portions of these circuits that reside within HFRA.

In addition to defining the scope of WCCP (i.e., which spans and circuits are subject to re-conductoring), SCE also developed a circuit prioritization methodology to guide the order in which circuits would be hardened via WCCP.[99] This approach enables SCE to maximize the risk reduction benefits over time and is designed to prioritize circuits with greater wildfire risk, which includes both ignition frequency as well as ignition consequence, and the greatest estimated mitigation effectiveness when covered conductor is installed.

The risk analysis to support WCCP was a system-level analysis, in other words an articulation of the overall risk benefit that could be attained by covered conductor application. As discussed, to implement WCCP, SCE defined the program's scope and implementation prioritization. The combination of segment targeting and circuit prioritization is intended to allow SCE to approach the calculated system-level benefits as rapidly as practicable via covered conductor deployment over the 2018 to 2020 period. However, the work undertaken during this initial time period will not be enough to re-conductor all existing bare conductor in HFRA that require replacement, only a portion the total circuit spans. Nevertheless, by re-conductoring 592 circuit miles, or around six percent of the total overhead primary circuit miles in HFRA, SCE will be able to reduce wildfire risk over this initial period on the highest priority circuits—which is why it is critical to start this incremental work in the immediate future as opposed to waiting several years until the next GRC to roll out this necessary program.

SCE's decisions regarding the scope of WCCP and the methodology for prioritizing the HFRA circuits accurately account for both the relative risk of wildfire ignition and the relative effectiveness of installing covered conductor as a wildfire risk mitigation, so the most impactful projects are undertaken first and resources are effectively deployed. By using a circuit prioritization methodology, SCE expects to maximize the operational efficiencies of concentrating work on a circuit-by-circuit basis. SCE considered other options to guide installation of covered conductor. For instance, another option would be to prioritize HFRA separately and work through the list by beginning only with spans in Tier 3, then moving to spans in Tier 2, and then moving to any remaining spans that SCE considers to

[99] Refer to Work Paper Vol. 1 (Circuit Deployment Prioritization.

be in HFRA. SCE found this alternative inferior for several reasons. First, operational efficiencies would be negatively impacted by addressing only the Tier 3 spans on a given circuit first and then returning to the same circuit to address Tier 2 portion of the same circuit after the Tier 3 spans of other HFRA circuits.[100] Second, there would also be permitting inefficiencies since in SCE's experience it is sometimes easier and faster to permit, for instance, ten miles on a single circuit as opposed to eight miles on one and two miles on another circuit. Third, it would increase the inconvenience and disturbance for individual municipalities and customers since SCE would need to return to an individual circuit within a relatively short period of time to re-conductor the remaining high risk Tier 2 or other HFRA spans after Tier 3 spans have been addressed.

(2) Program Components

WCCP will involve more than simply replacing existing bare conductor with covered conductor. Rather, SCE will simultaneously complete a number of related grid hardening improvements on the relevant portions of the distribution system that go hand-in-hand with re-conductoring using covered conductor. For instance, re-conductoring work will include the installation of composite cross arms and wildlife protection, such as covers, tubing, and covered jumper wire. Covers protect a variety of overhead equipment (transformer bushings, recloser bushings, fuses, cable terminations, insulator, fuses, arrestors, etc.). When appropriately applied, wildlife protection covers mitigate animal-related contact faults, as well as other contact-related faults associated with vegetation and metallic balloons. In addition, for dead-end poles where covered conductor is open for termination onto the cross arm, wildlife protection covers will also help protect these areas of exposed conductor.

Two specific upgrades associated with WCCP are discussed in more detail below: poles and tree attachments.

[100] For example, given a hypothetical circuit of ten miles in length, a portion of the circuit, say eight miles, is in the Tier 3 area, with the remaining two miles in the Tier 2 area.

(a) Poles

WCCP will require pole upgrades in certain circumstances. Since there are material weight and wind load differences between bare conductor and covered conductor, implementing WCCP will require SCE to determine that existing poles are able to support this extra weight and wind loading. As part of this re-conductoring work, SCE will conduct a pole loading assessment on existing poles where covered conductor is to be installed to determine if pole replacement is required. If the pole loading analysis shows that minimum safety factors would not be met by installing covered conductor, SCE will also install new poles able to support covered conductor. The primary driver for pole replacement rates is attributed to larger conductor diameters that increase the wind forces that are transmitted from the conductor to the pole. Additionally, when appropriate, pole replacements as part of WCCP will use fire resistant composite poles with a fire protective shield.

SCE's Pole Loading Program (PLP) was adopted in the 2015 GRC as a comprehensive way to address pole overloading issues. The objective of the PLP is to assess SCE's poles to identify and repair or replace those poles that do not meet G.O. 95 minimum safety factors. In combination with SCE's other infrastructure replacement programs, SCE has replaced approximately 54,000 poles in HFRA since the inception of PLP.

As a result of PLP, SCE anticipates that a majority of the recently replaced poles in HFRA will pass a pole loading assessment and will not require replacement as part of WCCP. However, SCE will need to replace some poles. SCE anticipates that there will be two primary categories of poles needing replacement: (1) poles that were not designed for 1/0 ACSR (Aluminum Conductor Steel Reinforced) (i.e., primarily pre-2014 poles) and (2) poles designed for 1/0 ACSR that nevertheless require replacement (i.e., primarily poles subject to particularly high winds).

SCE analyzed a statistically valid random sample of existing poles in HFRA to estimate the percentage of poles of each type that will need replacing as part of WCCP.[101] This analysis found that approximately 24 percent of the population of existing poles in HFRA are not capable of carrying increased load associated with 1/0 ACSR covered conductor wire and will require replacement. The specific poles that require replacement will disproportionately be those with higher wind loading conditions. This replacement rate is higher than the expected 13 percent replacement rate for these poles if SCE were to install 1/0 ACSR bare conductor wire to meet SCE's current standard, such as for work under OCP.

SCE's analysis also showed that the anticipated replacement rate for poles in HFRA designed for 1/0 ACSR will be significantly lower. These poles were designed for SCE's current standard for bare wire conductor (1/0 ACSR) and have already accounted for new installation safety factors. As a result, for the approximately 54,000 recently-replaced (i.e., since 2014) poles in HFRA, SCE anticipates replacement rate of less than 3 percent for the subset of those poles that are subject to the re-conductoring work under WCCP.

At locations where SCE is installing covered conductor in HFRA and pole replacements are required, SCE will use fire-resistant composite poles, where appropriate, instead of traditional wood poles. These poles are specifically designed to withstand wildfires, which will harden the distribution system and reduce the risk of a wire down event. SCE plans to use fire-resistant composite poles with a fire shield, as shown in Figure IV-11. SCE has experience with similar composite poles, including the sectional composite pole without a fire shield.[102] Compared to steel poles, composite poles are non-conductive and resistant to corrosion. And compared to wood poles, composite poles are less susceptible to wildlife damage (e.g., woodpeckers), rotting, and fires, and are also lighter in weight and have the capacity to carry more load (when compared to wood poles of the same class and size). In general,

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[101] Refer to Work Paper Vol. 1 (Pole Replacement Rate).

[102] For instance, SCE currently has over 5,000 composite poles in service as part of its distribution system. These composite poles are primarily used in areas where wood poles are prone to damage from woodpeckers, areas of environmental or other archeological conditions, and in rear property lines without truck access.

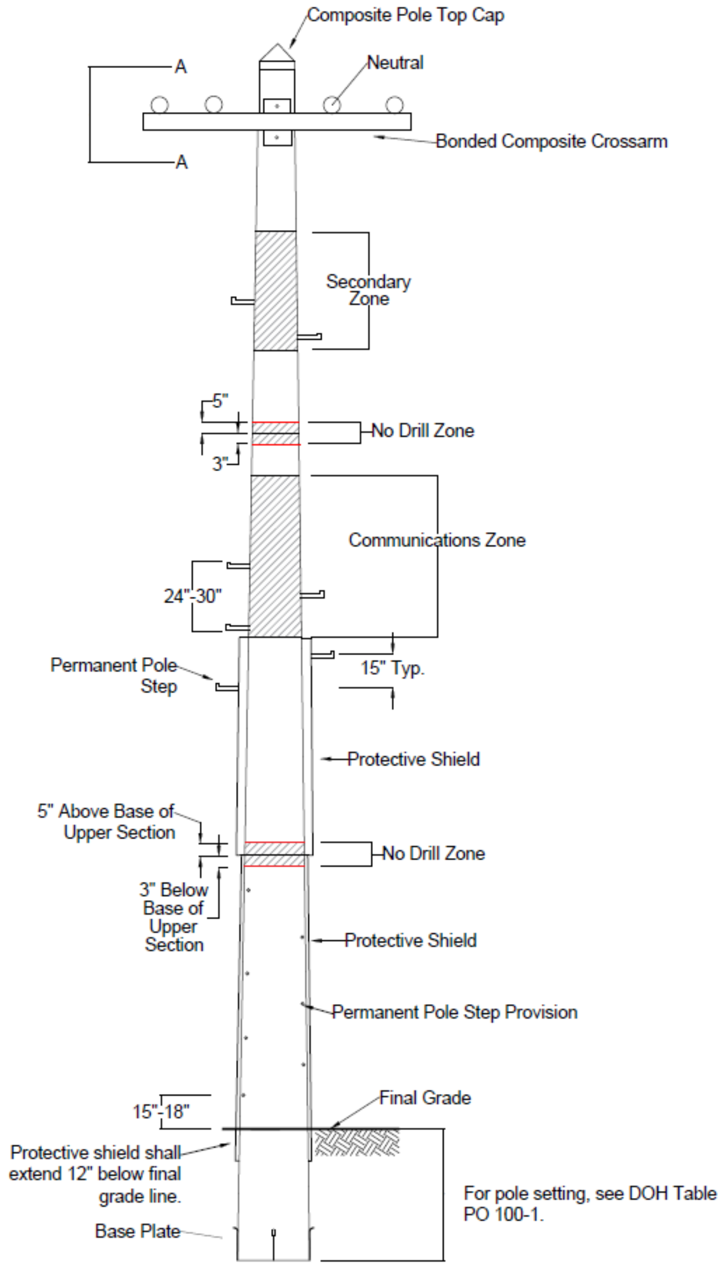
composite poles are preferred to wood poles in a variety of contexts, such as restricted vehicle access (for sectional composite poles) and areas of accelerated pole degradation.

The composite poles SCE plans to install are manufactured using polyurethane resin and E-glass fiber to create a fiber reinforced polymer (FRP) laminate. Manufacturer testing has proven that the laminate is self-extinguishing (i.e., fire resistant).[103] In addition, a shield manufactured from the same fire-resistant material is wrapped around the composite pole sections at the manufacturing plant. Upon installation of the pole, the shield is embedded 12 inches below the ground line of the final grade. Extensive fire testing studies have shown that the shield will protect the pole and further increases fire resistance, enabling the pole to withstand an "extreme" wildfire.[104] Thus, a shielded composite pole can resist ignition and maintain its strength when installed in HFRAs as the shield acts as a sacrificial layer from fire and the pole laminate will self-extinguish once the heat source is removed.

[103] RS Technical Bulletin: 17-010, *RS Poles and Fire Shields Fire Performance*, at p. 1 (February 1, 2018), *available at* https://www.rspoles.com/sites/default/files/resources/C801---17-010---RS-Poles-and-Shields-Fire-Performance-01-Feb-18.pdf.

[104] *Id.* at p. 13. "Extreme" wildfire exposure is defined as gas temperatures between 800 to 1,200°C and exposure of 121 to 180 seconds. *Id.* at p. 4.

Figure IV-11
Diagram of Composite Pole with Fire Shield



(b) Tree Attachments

As part of WCCP, SCE also will install new poles in order to eliminate instances where existing electrical equipment, including overhead conductor, is attached to trees. Approximately 114 tree attachments will be replaced as part of WCCP in the

2018-2020 time period.[105] Generally, SCE plans to follow the same circuit prioritization methodology and replace tree attachments together with covered conductor deployment. But SCE also plans to address a single initial circuit in 2018 to gain experience and inform future work. This circuit is Dinkey Creek and was identified by local field subject-matter experts as having tree mortality and insulation degradation issues.

Since these tree attachments are generally located in forested areas, often with dense vegetation where there are limitations on tree trimming, SCE plans to use the spacer cable system construction for covered conductor on these spans. Spacer cable, shown in Figure IV-12, is a more compact construction and has a steel messenger wire that helps to strengthen and support the covered conductor in forested areas. This design has been known to withstand trees falling on the wire without coming down. It is a popular construction design in many parts of the United States and Canada where electric lines pass through forest, where trees and vegetation well outside the utility right-of-way pose threats.

[105] SCE also plans to relocate secondary lines at the same time that primary lines are relocated since, in many instances, secondary lines are often attached to the same cross arm as the primary line.

Figure IV-12
Spacer cable traversing dense vegation in Perth, Australia (Western Power)

As part of its decision-making process, SCE considered a number of alternatives to covered conductor for mitigating the fire ignition risks associated with contact-related faults on SCE's distribution system in HFRA. As discussed in Section IV.B.1.c) above, covered conductor emerged from this process as the clear preferred mitigation measure over two primary alternatives: re-conductoring with bare conductor and underground conversion. In particular, SCE's analysis demonstrated that covered conductor provides the greatest overall value for wildfire risk mitigation as compared to these two alternatives.

SCE also initially considered another alternative: the installation of insulating retrofit conductor wrap.[106] SCE likewise evaluated this alternative in

[106] SCE considered two types of insulating wrap: 1) silicone rubber conductor wrap, and 2) High-density polyethylene/co-poly conductor cover.

terms of wildfire mitigation effectiveness and cost. But insulating retrofit conductor wrap was rejected due to its limited application, cost, and potential for failure.[107]

Additionally, as an alternative option for covered conductor deployment, SCE also considered the possibility of installing covered conductor on only one or two of the three phases on SCE's overhead distribution system. This partial installation of covered conductor was rejected because it is less effective at mitigating faults, can lead to potential issues associated with using bare and covered conductor on a single span, and is inconsistent with the prudent practices of utilities in other jurisdictions.

f) Deployment Time

SCE has already begun to install covered conductor on portions of ten circuits in HFRAs. SCE's GS&RP plans to move forward with the re-conductoring work under WCCP that is part of this Application at an accelerated pace through the rest of 2018, 2019 and 2020. As shown in Table IV-11, the work will cover 71 circuit miles in 2018, 96 circuit miles in 2019, and 426 circuit miles in 2020. At this rate, SCE anticipates installing 592 circuit miles of covered conductor under WCCP by the end of 2020.

Table IV-11
WCCP Deployment 2018-2020

Category (Circuit Miles)	2018	2019	2020	Total
Short Circuit Duty: Vintage Small Conductor	-	44	157	201
Contact From Object	71	52	269	391
Total	71	96	426	592

While this timeline is ambitious and accelerated, it is operationally feasible for SCE to ramp up and complete this target in addition to its other related activities. Indeed, one purpose of creating the PMO was to consolidate SCE's grid hardening projects to

107 The manufacturer of the silicone rubber conductor wrap recommends application where protection of less than 20 feet is required, making it unsuitable for most applications. In field tests, it also proved difficult to install and presented the possibility of failure if the wrap were to come off over time or during high wind conditions. The high-density polyethylene/co-poly conductor cover is significantly more expensive than covered conductor (approximately $5.75 per foot as compared to $0.80 per foot) and requires the same ancillary upgrades to the other components of the distribution system, such as poles, due to added weight.

enable more streamlined and expeditious deployment. As part of this effort, SCE carefully considered how quickly it could move forward with WCCP, and this timeline represents a prudent approach given the importance of grid hardening activities, specifically covered conductor.

g) Benefits

In general, WCCP is intended to mitigate wildfire risk by addressing the drivers of wildfire ignitions associated with the electric power lines. Therefore, the most effective way to measure the benefits of the program is to directly measure frequency of wildfire drivers and frequency of wildfire triggering events within HFRA. Faults (tracked in ODRM) and wildfire ignition events (tracked in SCE's annual report to the CPUC) can be directly measured after covered conductor deployment to measure effectiveness. As a result of WCCP, the number of faults leading to ignition events—and, by extension, the risks associated with wildfires—would be expected to decrease in a meaningful and measurable way over time.

2. Remote-Controlled Automatic Reclosers (RARs) And Fast Curve Settings

a) Program Overview

SCE intends to install 98 additional RARs[108] on its HFRA circuits for increased circuit protection and reliability. The RARs will be used to provide faster or more selective "fault clearing" to further reduce fire ignition risks and lessen service interruptions for SCE customers. These assets will assist SCE in four important ways:

1. **Fault Interruptions -** the RARs will be applied to automatically interrupt faults on HFRA circuits, limiting the amount of customers affected by faults and sectionalizing faulted circuits to smaller portions;
2. **Fast Curve Operating Settings -** during Red Flag Warnings, the RARs will be remotely configured to operate with "Fast Curve

[108] Refer to Work Paper Vol. 2 (Scope - New RARs)

Settings,"[109] thereby isolating many faults faster, limiting total energy delivered to these faults, and reducing ignition risks;

3. **Reclose Relay Blocking -** RARs will permit SCE to remotely block reclosing to SCE's HFRA during Red Flag Warnings while permitting reclosing to non-HFRA, thus enable a lesser degree of outage and public impact in the event of a fault; and

4. **Public Safety Power Shutoff (PSPS) -** as a mitigation of last resort, if SCE must proactively de-energize circuitry due to extreme fire conditions, SCE will be able to utilizing these additional RARs in order to further limit the number of customers impacted.

Having additional RARs will also provide the much needed operational flexibility to reconfigure circuits quickly during extreme fire conditions.

In addition to the installation of the new RARs, SCE will be updating the relay and/or settings on approximately 300 existing RARs and 764 Circuit Breakers (CBs) with Fast Curve operating settings.

b) What Exists Today

SCE currently has approximately 930 RARs installed on 520 circuits in HFRA. These RARs provide the traditional benefits of fault interruption and sectionalizing circuits to smaller portions. However, there are locations in HFRA that do not presently have RARs installed, but where additional RARs could provide more benefits in alignment with the four key benefits outlined above.

SCE has also been reconfiguring relay settings on existing RARs and CBs with Fast Curve configurations to allow for increased fault clearing speeds and fault energy reduction during Red Flag Warning events. Approximately 630 of the 930 existing RARs in

[109] Fast Curve Setting modifies the relay fault detection curve providing faster fault detection and interruption. Once the updated settings are installed, the Fast Curve can be remotely activated or de-activated through SCE's monitoring and control radio network. This is described in the Detailed Program Description section below.

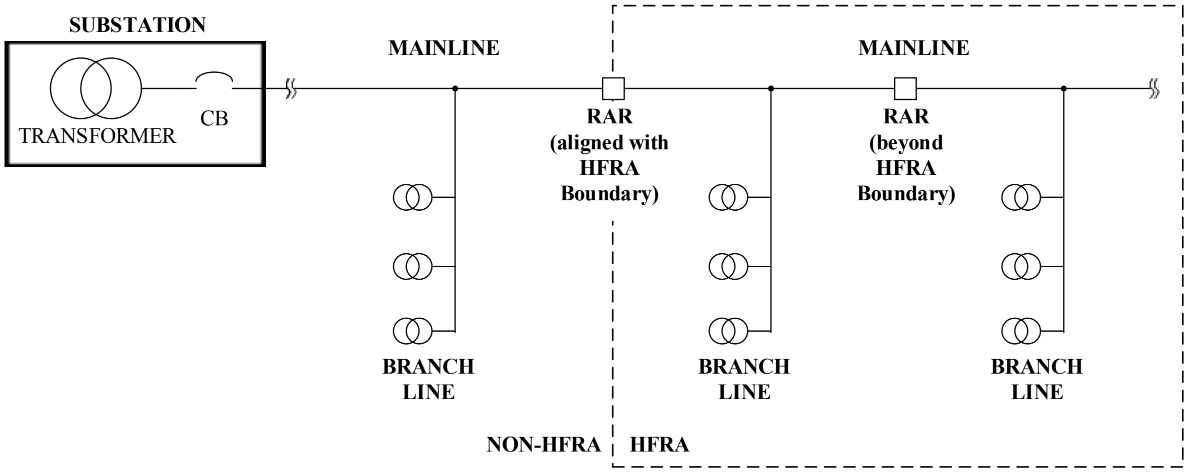
HFRA have already been upgraded with Fast Curve configurations, with 300 remaining to be updated. Approximately 400 existing relay settings on CBs have already been updated with Fast Curve operating capabilities thus far this year, with 764 remaining to be updated.

c) Effectiveness

These additional RARs will provide additional isolation points with fault interrupting capabilities, reclose relay blocking practices during Red Flag Warnings, and assist in implementation of PSPS and Fast Curve settings. In particular, SCE's PSPS protocols will benefit from additional RARs in that less customers will be impacted if SCE is able to de-energize only a smaller portion of a circuit utilizing RARs. Additionally, SCE has revised its policies and procedures to require Fast Curve settings during Red Flag Warnings to isolate most faults faster, thus limiting total energy delivered to these faults and reducing ignition risk. The new RARs will have such settings already configured.

In many cases, the RAR installation aligns with the HFRA boundary; however, SCE has also identified circuit sections beyond HFRA boundaries which would benefit from an additional RAR. The simplified circuit diagram in Figure IV-13 illustrates RAR installations both aligned with the HFRA boundary and beyond the HFRA boundary. RARs provide the ability to remotely de-energize portions of circuits for a PSPS event.

Figure IV-13
Illustration of RARs Relative to HFRA Boundaries



d) <u>Forecast</u>

As noted above, SCE has been reconfiguring existing relay settings on RARs and CBs with Fast Curve configurations. In this Application, SCE is only seeking to recover future costs incurred. SCE's goal is to have all new and existing relay settings for RARs and CBs configured with these settings by 2020 to help mitigate fire ignition risks during Red Flag Warnings and enhance its PSPS protocol.

Table IV-12 below summarizes the forecast incremental costs in SCE's request. For capital items, the "New RARs" line item pertains to the 98 additional RARs that SCE intends to install.[110] The CB Relay Hardware for Fast Curve line item refers to additional hardware upgrades for 378 CBs, which will include Fast Curve settings for these devices. For O&M items, the RAR and CB Relay Fast Curve Settings line item consist of updating settings for 300 RARs and 386 CB relays. The line items pertaining to development/delivery relate to training activities to support both the new hardware installation and changes to device settings.

[110] SCE performed an engineering study to determine the need for 73 additional RARs. Additionally, SCE anticipates the need for an additional 25 RARs to lessen the impact of potential PSPS outages, especially taking into consideration input from fire agencies, offices of emergency management, and other emergency response entities (*See* Section IV.D.2).

Table IV-12
2018-2020 Remote-Controlled Automatic Reclosers (RARs) and Fast Curve Setting Costs[111]

Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
New RARs	-	-	9,287	$ 9,287
CB Relay Hardware for Fast Curve	-	8,789	8,789	$ 17,577
Grand Total	**$ -**	**$ 8,789**	**$ 18,076**	**$ 26,864**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
RAR and CB Relay Fast Curve Settings	777	277	-	$ 1,054
Capital Related Expenses	-	180	371	$ 551
New RARs Development/Delivery	19	-	-	$ 19
RAR/Relay Fast Curve Settings Development/Delivery	49	-	-	$ 49
Grand Total	**$ 845**	**$ 457**	**$ 371**	**$ 1,673**

e) Detailed Program Description

(1) RAR Configurations and Installations

The installation of RARs include switches to provide the capability to bypass and electrically isolate the recloser (see Figure IV-14). A three-phase gang operated switch provides the means for bypassing the RAR during maintenance. The bypass switch can also be operated closed to maintain the power flow in the event the RAR is faulted and/or needs to be bypassed. Line side and load side single phase disconnect switches are installed to provide means to disconnect and isolate the RAR during maintenance. The disconnect switches also provide means for isolating an RAR due to a failure or for replacement. When working on a distribution line beyond an RAR where the line is required to be de-energized, the disconnect switch is used to keep the line section de-energized as part of clearance requirements for safe-working practices.

[111] Refer to Work Paper Vol. 2 (Scope - New RARs; Forecast - New RARs; Unit Cost - CB Relay Hardware for Fast Curve; Forecast - CB Relay Hardware for Fast Curve; Forecast - Fast Curve Settings for RARs and Circuit Breakers; Capital Related Expense - Remote-Control Automatic Reclosers; Development and Delivery - Fast Curve Settings for RARs and Circuit Breakers; Development and Delivery - New RARs)

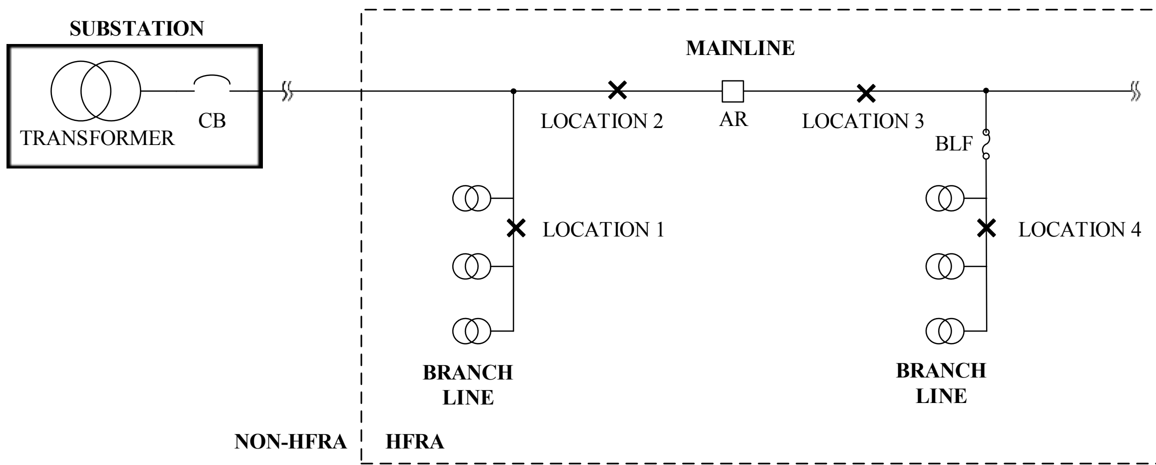
Surge arresters are applied on both sides of RARs. Surge arresters are not unique to RARs and provide voltage protection for the system and surrounding equipment. Surge arrester applications also serve a specialized purpose for RARs by limiting voltages across the device when interrupting faulted conditions.

Figure IV-14
Typical RAR Installation

(2) Fault Interruption

When applying an RAR to an existing circuit, a variety of parameters are considered in configuring the operating settings and managing coordination between protective devices. CB settings, fusing, customer loading, and system fault current are dominant parameters in configuring the RAR settings. The mentioned parameters generally restrict RAR application to three or less RARs in series on a circuit. Inverse-time overcurrent operating settings are the typical method of operation SCE applies to maintain coordination between CBs, RARs, and fuses. Coordination can be functionally summarized as follows: the closest upstream device to a fault, and only the closest upstream device to the fault, operates to interrupt a fault. The concept of protection coordination is illustrated in Figure IV-15 below. In this figure, faults at branch line “Location 1” and faults at mainline “Location 2” would be cleared by the substation CB, the closest upstream protective device to these locations. Faults at mainline “Location 3” would be cleared by the AR, and faults at branch line “Location 4” would be cleared by the BLF.

Figure IV-15
Illustration of Protection Coordination



As part of device coordination during normal operating conditions, SCE believes that RARs will provide faster fault isolation than source CBs which will provide improvements in service reliability by reducing the number of customers experiencing outages. Compared to CBs, the anticipated faster fault isolation and improved sensitivity of RARs offer a benefit for reducing fault energy for faults on their downstream circuitry. The related energy reduction during a fault also provides a benefit by decreasing fire risks. Reliability is further improved by the reclosing capabilities of RARs which can remotely and automatically restore electric service following temporary faulted conditions.

Because SCE intends to change operating settings for CBs and RARs during red flag events as discussed below, it is important to distinguish the normal fault interrupting operating conditions and automatic reclosing during most of the year, with the operating performance expectations for fault interruption and automatic reclosing during red flag conditions. The following two sections describe the expected benefits and drawbacks when modifying the operating strategies during Red Flag Warning conditions and explain the additional installation placement criteria related to such operating practices.

(3) Fast Curve Operating Settings

During Red Flag Warning conditions, the Fast Curve settings will be remotely enabled by SCE's Distribution Control Center operators, resulting in typical faults being cleared more quickly.[112] These settings can be toggled remotely when Red Flag Warnings occur. Fast Curve settings reduce fault energy by increasing the speed with which a relay reacts to most fault currents. Compared to conventional settings, reduced fault durations anticipated with Fast Curve operating settings are expected to reduce heating, arcing, and sparking for many faults. The Fast Curve reduction in fault energy is dependent on the fault magnitude and existing settings; as a general estimate, the configuration is expected to result in a 50 percent reduction in fault energy.

Though SCE has not found published articles directly correlating the reduction in fire ignitions to reduction in fault energy, SCE believes such reduction will occur given the science involved. The explanation of the expected benefits of operating with Fast Curve settings is simplistic; however, there are a variety of electric service impacts of applying these operating settings to CBs and RARs due to changes in the way SCE must operate the electric system. Coordination of downstream overcurrent devices and either the CB or RAR with Fast Curve setting is impacted.

Device coordination in response to faults is the primary operational impact of Fast Curve settings. Faster operation of CBs and RARs may not allow time for fuses to operate. Coordination between CBs and RARs with Fast Curve is also impacted, though SCE expects some selective coordination between these devices. With the faster interruption of faults and associated impacts to coordination of devices, SCE expects an increase to the System

[112] SCE is currently exploring the application of Fast Curve settings for sub-transmission lines within HFRA. Incremental costs associated with line patrols following device operations when Fast Curve settings are enabled may be recorded to the GS&RPMA.

Average Interruption Duration Index (SAIDI) of 1.45-1.95 minutes annually, depending on whether or not the RAR will coordinate with the CB Fast Curve during red flag conditions. The fusing mitigation detailed in the below section, and specifically the use of current limiting fuses helps to minimize impacts to customer electric service reliability from Fast Curve operating settings.

The additional RAR installations will assist in reducing the impact of the mentioned device coordination and associated electric service interruptions which are created by implementation of the Fast Curve at the CB. The RAR installations further improve the sensitivity of fault detection by allowing lower magnitude fault current thresholds to be detected, significantly reducing these fault energy levels.

(4) <u>Public Safety Power Shutoff</u>

When facing dangerous fire conditions, CBs at the substation and RARs are expected to be the primary switching devices should SCE initiate proactive de-energizing of circuitry under the PSPS protocol. As the Commission recognized in approving Resolution ESRB-8, "de-energizing electric facilities during dangerous conditions can save lives and property and can prevent wildfires." By placing RARs at the boundaries of SCE's HFRA, and also within critical HFRA regions, when SCE de-energizes for public safety, it will only de-energize a portion of the circuit that is located within the HFRA as opposed to de-energizing the entire circuit. As a result, there will be less impact to customers due to the reduced amount of customers de-energized.

The functionality of a CB and RAR on the distribution system are similar in that they interrupt faults, are used to sectionalize circuits, and can be remotely operated. RARs are typically mounted on poles; however, SCE also has standard pad-mounted designs and substation rack mounting provisions for RARs. CBs are typically in the confines of the substation fence and installed on a concrete pad with a supportive metal frame that maintains safe electrical clearances of the energized parts. CBs in general have higher ratings and different operating parameters given their application at the substation. For example, typical CB minimum trip levels are expected to be higher than those of an RAR for proper coordination. The substation is generally referred to as the source location of a circuit; thus, the CB is applied at the source.

SCE intends to utilize PSPS for particularly high risk segments of circuits. The use of CBs to de-energize will impact all the customers on a circuit because the CB is located at the source of the circuit. RAR additions for PSPS may aid in confining the outage impacts related to a PSPS event as opposed to the CB.

(5) Recloser Relay Blocking

During Red Flag Warnings, SCE will utilize the RARs to remotely block relay reclosing to HFRA. This is critical for SCE to be able to target its mitigation efforts specific to HFRA. Under normal circumstances, SCE automatically recloses its circuits after they are de-energized from a fault interruption, commonly referred to as a trip operation or relay event. Automatic reclosing is used to allow electric service to be restored quickly following a fault which is momentary or temporary. Many electric distribution system faults are temporary, such as from wind blowing a branch into a line or an animal-caused short circuit. Analyzing the past three years of outage events associated with RARs, SCE shows the applications of RARs average an approximate 50/50 split between faults that produced momentary versus sustained outages.

Momentary faults are commonly cleared by CBs or RARs and then, following a brief de-energized period (15-30 seconds), the reclosing relay requests a test of the line (closing CBs or RARs attempting to energize the circuit) to see if the fault has cleared. During Red Flag Warning conditions, SCEs Distribution Control Center remotely blocks the automatic reclosing relay for CBs and RARs within its HFRA. For these circuits, the reclosing relay is disabled and following a fault, the circuit remains de-energized until a patrol is performed to inspect for sources of the fault. Following a patrol, the circuit may then be energized, restoring electric service.

Without the use of RARs, SCE would have to block relay reclosing at the CB located at the substation. Thus, when a fault occurs, the entire circuit (even portions of the circuit not located in the HFRA) would be de-energized.

Also, the RAR's capability to automatically sectionalize only a portion of the circuit (as opposed to the entire circuit such as with a CB) indicates that a fault originated beyond the RAR and improves the troubleshooting process to search for the fault location(s) and cause(s).

f) <u>Alternatives</u>

(1) <u>Use Remote Controlled Switches (RCS) instead of RARs</u>

Remote Controlled Switches permit circuit sectionalizing with remote and local operation capabilities. However, these switches are not equipped with fault interrupting capabilities; therefore, RCSs cannot be configured with Fast Curve operating modes to aid in fault energy reduction. Overhead RCS devices (pole switches fitted with motor operators) produce hot gasses and sparks when operated while energized. In contrast, an RAR does not produce external sparks or hot gasses. Thus, SCE recommends installing RARs as opposed to switches to minimize fire ignition risks. The fault interrupting capability of RARs further aids in electric service restoration by providing information on the fault location which is not available from an RCS.

(2) <u>Install RARs widely across HFRA circuits maximizing reliability and fault energy reduction</u>

Currently, an average of 1.79 RARs per circuit exist on approximately 47 percent of circuits identified in HFRA. Application of 1-2 RARs on a circuit can likely still be coordinated with existing relay settings for CBs. A higher quantity of RARs can be applied to further improve reliability, allowing greater circuit sectionalizing. The additional benefit of energy reduction is expected as described above, in that a given fault will generally be isolated faster by an RAR than a CB. Using the average quantity of RARs on a circuit today, the remaining 53 percent of HFRA circuits which do not contain RARs (approximately 583) would result in an increase of 1,040 installations at a cost of $104,000,000. This approach would essentially double the SCE installations of RARs in HFRA, help improve electric service reliability, and may result in a reduction of fire ignitions related to electrical facilities. But the additional expense may yield limited overall reliability gains as HFRA circuits are generally less densely populated compared with circuits in non-HFRA. Thus, SCE believes the proposed targeted approach of deploying only a limited number of new RAR installations, along with other program proposals such as the Branch Line Fusing program used to maximize benefits of the four critical areas (PSPS, Fault Interruptions, Fast Curve Operating Settings, and Recloser Relay Blocking) is the most prudent approach for public safety and electric service reliability.

3. Fusing Mitigation

a) Program Overview

SCE proposes to install fusing at 8,855 new Branch Line Fuse[113] (BLF) locations and replace fuses at up to 6,758 existing BLF locations on circuits which traverse the HFRA.[114] This accounts for all 15,613 radial branches located within SCEs HFRA. In addition, SCE proposes to install 21 Substation-Class Electronically Controlled Fuses on these same circuits.[115]

This fusing program is intended to reduce the risk of fire ignitions associated with SCE's distribution lines and equipment by reducing fault energy. SCE has traditionally used conventional expulsion type fuses (conventional fuses) for BLF applications. For this program, SCE intends to utilize Current Limiting Fuses (CLFs) for most applications in the HFRA. In rare instances, fault current levels and device coordination may require the

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[113] SCE uses the term "Branch Line Fuse" to refer to a set of fuses applied between main line circuitry and a lateral and can consist of two or three fuses, depending on the application.

[114] Refer to Work Paper Vol. 2 (Scope - Current Limiting Fuses)

[115] Refer to Work Paper Vol. 2 (Forecast - Substation Class Electronically Controlled Fuses)

application of conventional fuses or Branch Line Reclosers (BLRs)[116] as opposed to CLFs. CLFs are selected for this application because they can provide faster fault clearing for most faults and a reduction in fault energy,[117] compared to a conventional fuse.[118] In addition to the fault energy reduction, the placement of BLFs is expected to improve electric circuit reliability by segmenting faulted circuits to smaller line sections.

Historically, SCE has not utilized Substation-Class Electronically Controlled Fuses, but now intends to use these advanced fuses in the HFRA as a program study. Substation-Class Electronically Controlled Fuses offer similar fault energy reduction benefits as CLFs but allow for significantly more loading.[119] This enables these devices to be used on the mainline portions of SCE's circuits as opposed to the branch lines with conventional distribution class CLFs. Again, the goal is to reduce fault energy on SCE circuits and thus, lower the risk of possible ignition when a fault occurs.

b) What Exists Today

SCE has traditionally applied BLFs to improve electric service reliability by limiting the number of customers affected by a fault as opposed to upstream RARs. This practice has resulted in BLF applications on approximately 43 percent of the HFRA-related branch circuits. The simplified circuit diagram in Figure IV-16 below illustrates branch circuitry both with and without installed BLFs within the HFRA boundary.

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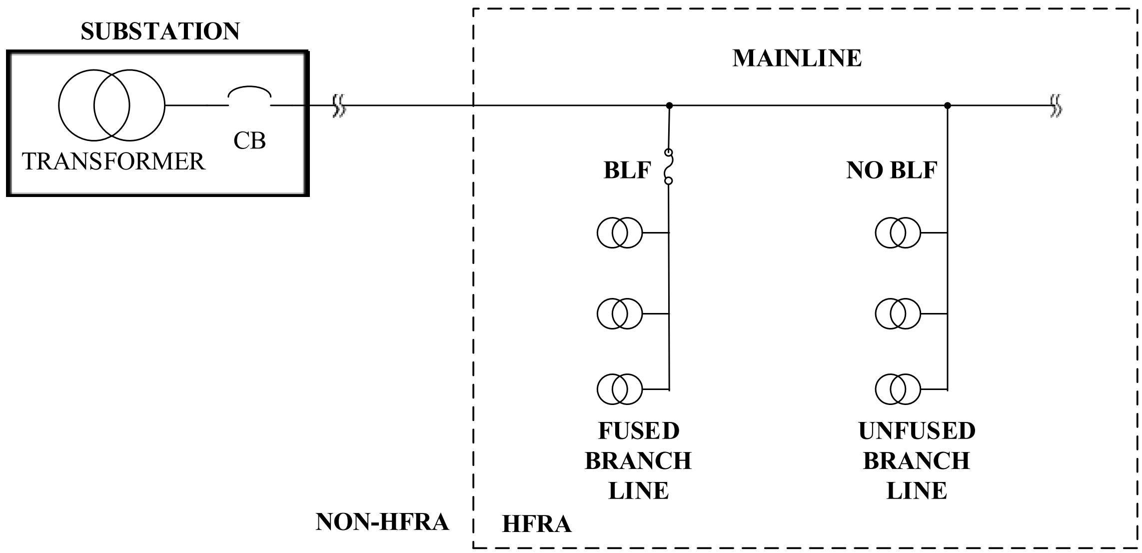
[116] SCE uses the term "Branch Line Recloser" to refer to a set of single phase reclosers applied between main line circuitry and a lateral and can consist of two or three reclosers, depending on the application.

[117] Various vendor and industry documentation suggest the CLF energy reduction is typically up to twenty-five (25) times compared to a conventional fuse for high magnitude fault currents.

[118] Refer to Work Paper Vol. 1 (IEEE Fusing Support).

[119] SCE is investing the use of Substation-Class Electronically Controlled Fuses and CLFs cannot be applied to main line circuits and RARs cannot provide current limiting capabilities due to rating limitations.

Figure IV-16
Illustration of Fused and Unfused Branch Lines



c) Effectiveness

De-energizing branch lines that experience faults due to vegetation contact, animal contact, or contact with other objects, is critical to mitigating fire ignition risk. In addition, the ability to limit the amount of energy associated with a fault is expected to further minimize the ignition potential. Given that SCE's HFRA circuits have 8,855 un-fused branch lines, a substantial reduction in high fault energy events can be realized with CLF applications for these locations. Furthermore, replacement of conventional BLFs with CLFs can further aid in reducing fault energy on branch circuits.

SCE has evaluated various fusing technology and interrupting devices that had the potential to further reduce the risk of ignitions in HFRA. In evaluating the various options, SCE took into consideration energy reduction capabilities, maintenance requirements, and cost. SCE's proposed fusing approach allows for rapid deployment across all of SCE's HFRA distribution circuits with relatively minimal costs to alternate strategies. Specifically, the BLFs work in conjunction with other SCE mitigation programs such as Fast Curve operating settings, recloser relay blocking, and covered conductor.

SCE intends to use CLFs as opposed to conventional fuses for BLF applications in HRFAs, as CLFs not only provide higher reduction in fault energy for high current faults compared to conventional fusing, but the CLF design minimizes the release of materials and gases during operation. SCE may use conventional fuses as an alternative application when CLFs offer no advantages in terms of energy reduction and where the conventional fuse can provide comparable coordination benefits.

d) Forecast

Table IV-13 below summarizes the forecast incremental costs in SCE's request for Fusing Mitigation.

Table IV-13
2018-2020 Fusing Mitigation Costs[120]

Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Current Limiting Fuses	11,923	44,779	5,962	$ 62,664
Substation Class Electronically Controlled Fuses	-	170	3,401	$ 3,571
Grand Total	**$ 11,923**	**$ 44,949**	**$ 9,362**	**$ 66,235**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Current Limiting Fuses	-	1,710	20,946	$ 22,656
Capital Related Expenses	244	921	192	$ 1,358
Substation Class Fuse Development/Delivery	26	9	-	$ 35
Grand Total	**$ 271**	**$ 2,640**	**$ 21,138**	**$ 24,049**

e) Detailed Program Description

CLFs will be added to distribution circuit branch lines in HFRA which are not presently fused, or that may benefit from further segmentation via additional fuse installations. In addition, SCE will replace certain conventional fuses with CLFs to further minimize ignition risk. Two general groups of fuse replacements are expected to be part of the

[120] Refer to Work Paper Vol. 2 (Scope - Current Limiting Fuses; Unit Cost - Current Limiting Fuses; Forecast - Current Limiting Fuses (O&M); Unit Cost - Substation Class Electronically Controlled Fuses; Forecast - Substation Class Electronically Controlled Fuses; Capital Related Expense - Current Limiting Fuses; Development and Delivery - Substation Class Electronically Controlled Fuses; Forecast - Current Limiting Fuses (Capital))

program. The first group of existing fuses for replacement includes expulsion fuses which require brush clearing at the base of the pole to remove potentially flammable vegetation per the CalFire Power Line Fire Prevention Field Guide. The second group of fuse replacements include locations that would benefit from the current limiting technology for energy reduction, but would otherwise be exempt from brush clearing per CalFire Power Line Fire Prevention Field Guide. SCE does not intend to replace existing conventional fuses with CLFs where the fault energy is not reduced by the replacement or where there is no risk of materials released during fuse operation.[121]

Conventional industry practice as well as SCE historical use for branch line protection devices have primarily focused on coordinating protective devices to maximize electric service reliability. To address the new heightened wildfire risk, SCE's GS&RP proposal for branch line protection specific to HFRA circuits place an additional emphasis on limiting fault energy, while maintaining protective device coordination as a secondary measure.[122] This approach is expected to also result in improvements to electric service reliability by further segmenting the circuit by isolating only the smallest section of the circuit impacted by the fault. The 8,855 BLF locations are expected to provide approximately a two-minute reduction to SCE's SAIDI reliability metrics.[123] Figure IV-17 represents the energy reduction (i.e., peak current and fault duration) comparison between current limiting fuses vs. conventional fuses.

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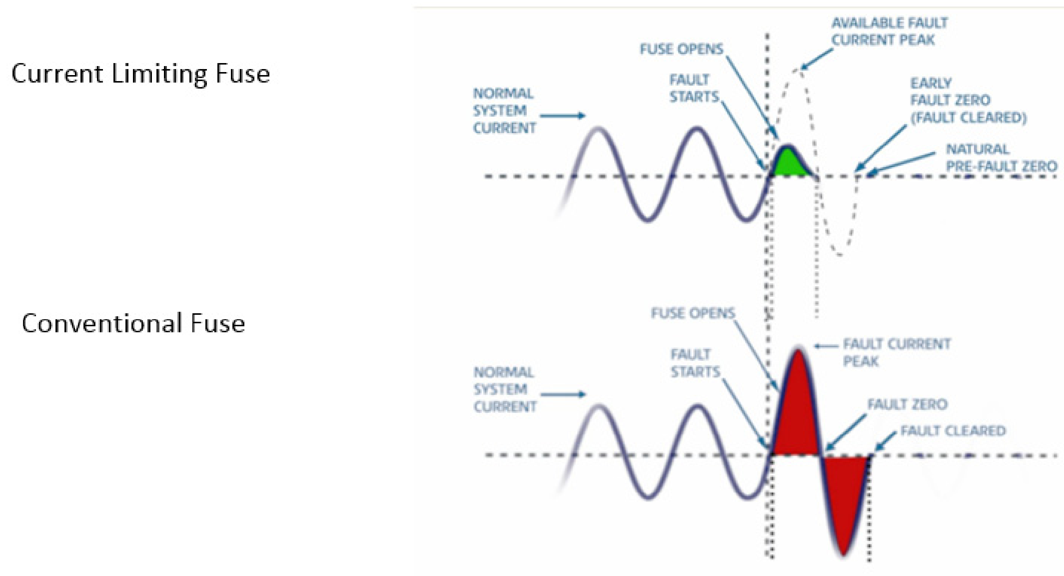
[121] SCE may install a limited number of conventional fuses where loading levels require use of conventional devices or where CLFs offer no advantages in terms of energy reduction and the conventional fuse can provide a coordination benefit. BLR devices may be selected instead of CLFs for longer heavily loaded branch circuits.

[122] "Coordination" in this context refers to the application of the fuse-blowing strategy whereby operational sequence of multiple protective devices on the same circuit in such a way to always isolate the smallest portion of the circuit with minimum number of customers to clear the fault first, yet preserve the backup protective function of devices further upstream of the circuit should the initial protective device failure to operate. *See* also Section IV.B.2.e)(2).

[123] While SCE believes that replacing existing conventional fuses with CLFs will improve overall SAIDI, it acknowledges that outages caused by a transformer failure may have slightly greater customer impacts due to possible fuse mis-coordination.

Figure IV-17
Energy Let Through Comparison of Current Limiting Fuse vs. Conventional Fuse



The majority of SCE's branch lines within the HFRA do not currently have fuses installed. The reduction in fault energy and increased sectionalizing provided with the installation of fuses is expected to reduce the risk of fire ignitions caused by the following events:

1. Arcing/sparking at a fault location (e.g., equipment failure) in which hot-sparking material can fall to the ground;
2. Conductor and conductor supporting components (e.g., dead end, insulator, splice) melting at a fault location or another location; and
3. Upstream CBs or RARs reclosing into faulted circuits.

Branch lines equipped with CLFs also help to avoid potential fire ignitions at the base of the pole related to the release of materials and gases during the operation of a conventional fuse. During operation, the conventional fuse visibly releases materials and gases while the CLF does not.

SCE also seeks to apply Substation-Class Electronically Controlled Fuses to provide mainline circuitry with fault energy reduction similar to SCE's approach on smaller branch circuits. These devices are significantly more complex than conventional fuses or CLFs and require adjoining electronics to operate the fuse for a fault event; however, these electronics allow SCE to selectively activate the increased energy reduction capability during high risk situations, such as during Red Flag Warnings. Further product development is needed to analyze and allow execution of this equipment throughout SCE's HFRA. A single trial installation is planned for 2019 so that SCE can evaluate its use, as SCE intends on installing Substation-Class Electronically Controlled Fuses at an additional twenty locations in 2020.

f) Alternatives

Branch Line Reclosers: Branch line reclosers are available in single and three phase configurations. The latest designs utilize vacuum interrupter technology for improved fault interruption performance. They offer similar fault energy reduction as conventional fuses and, similar to CLFs, do not release materials or gases during interruption. Due to their automatic reclosing feature, SCE requires remote control capability to block reclosing during red flag conditions for HFRA; however this capability is not currently available from all equipment suppliers. The application of BLRs is further limited compared to fusing by their reduced interrupting ratings. Additionally, the unit cost for BLR installations is significantly greater material costs for BLR installations. Most important, BLRs do not provide the same level of fault energy reduction as CLFs for high current faults. Therefore, due to higher cost and lessened fault energy reduction benefits, this device is not recommended for mass scale deployment. Instead, SCE will apply this technology in specific situations when appropriate.

Conventional Fusing**:** Conventional fusing was considered as an alternative to CLFs. Installation costs are similar for conventional fuses though CLF materials are twice the cost. Conventional fuses offer the ability for increased branch loading for a given fuse size and slightly faster operation at the lower fault current levels which helps with device coordination as discussed earlier in the fuses section. CLFs, on the other hand, offer substantial energy reductions for the expected higher fault currents. CLFs further mitigate concerns with potential fire ignitions related to materials and gasses released during the operation of a conventional fuse. Given the reduction in fault energy and the lower risk of potential fire ignitions, SCE intends to deploy the vast majority of fusing utilizing CLFs. However, conventional fuses may be used where circuit loading or other factors may preclude the use of CLFs.

SCE's selected approach allows for rapid deployment across HFRA with relatively minimal expense and works in conjunction with other programs such as covered conductor, recloser relay blocking, and RAR Fast Curve operating settings. The other alternatives discussed above do not have these advantages. Given the uncertainty of future fault locations on the distribution system, 8,855 additional BLF installations along with the 6,758 BLFs help to mitigate the consequence of fault events. SCE is prioritizing the installation of the BLFs at unfused branches followed by replacement of existing BLF locations.

C. Enhanced Situational Awareness

Below, SCE discusses enhancements to its situational awareness capabilities. Situational awareness is an integral part of emergency management, as it is imperative SCE has a granular understanding of what is happening across its service area prior to, and during, emergency events. SCE has already made significant enhancements in this area over the last few years. Today, SCE has a Watch Office that monitors activities on a 24/7 basis, notifying response teams when action is needed, and updating SCE's management on evolving events. The Watch Office is co-located within the Emergency Operations Center (EOC), which was recently upgraded in 2016[124] and also serves as the training center for Incident Management Teams. SCE also has meteorologists on staff, and uses various measures to monitor evolving weather, fuel, and other conditions that might lead to fire events and other hazardous conditions.

As explained below, SCE is further enhancing its situational awareness capabilities to address increasing fire risks throughout its service area. SCE is focused on accessing more detailed information about wildfire risk at the individual circuit level, to better understand how

[124] 2016 EOC upgrades included re-configurating the facility to better support incident management teams, new space for the Watch Office, installation of video walls, and new PC hardware at each workstation.

weather conditions might impact utility infrastructure and public safety in high fire risk areas. This plan includes contracting with IBM to access a high resolution weather model, and strategically installing weather stations to enhance the IBM high resolution model with real time data near circuits in high fire risk areas. SCE is also installing HD cameras in high fire risk areas to help both fire responders and staff maintain visual awareness of potential fire events in real time.[125] This data will be sent into a newly-established Situational Awareness Center co-located in SCE's EOC with the SCE Watch Office. This is where meteorologists and Geographic Information System (mapping) specialists will aggregate the data into useful programs. SCE will also purchase a high-performance computer platform that will enable aggregation of complex data to generate geographically based fire potential indices to approximate wildfire risk across its service area.

These new capabilities will better inform operational decisions, help SCE's emergency management staff determine how best to reduce potential wildfire risks, and make the utility even more effective in responding to fire events when they occur. Because technology is critical to this effort, and always evolving, SCE is exploring the use of alternate technologies in parallel to the proven technology being used today. This includes a program study in support of a high-resolution weather forecast tool, as well as additional technologies described in Section IV.E.

[125] To immediately enhance its situational awareness capabilities, SCE has begun installing weather stations and HD cameras, prioritizing CPUC Tier 2 and Tier 3 areas first. SCE will continue to install this equipment throughout 2019 and 2020, as explained in additional detail below.

1. HD Cameras

Figure IV-18
HD Cameras Deployed at Santiago Peak

a) Program Overview

SCE is installing pan-tilt-zoom (PTZ) HD cameras throughout its HFRA to enable fire agencies and SCE personnel to more quickly address emerging wildfires, helping mitigate potential safety risks to the public and prevent damage to electric infrastructure. HD camera views will transmit into SCE's Situational Awareness Center, and will be used by its IMTs to decide how to deploy crews and in make other operational decisions, such as PSPS activation. Without HD camera capability, SCE and local fire agencies would not have real-time access to guide fire related decisions and risk losing critical time during potential fire events.[126] Between 2018 and 2020, SCE is targeting installation of up to 160 PTZ HD cameras[127] on approximately 80 towers within HFRA to achieve up to 90 percent coverage of SCE's HFRA.

b) What Exists Today

Today, SCE primarily relies on fire agency and news media reporting[128] and on-scene observations by SCE's crews to address wildfire activity in its service area. However, SCE has installed a test HD camera pilot at Santiago Peak, located in its service area. The test cameras have operated successfully, and were used by fire agencies for recent fires.[129]

c) Effectiveness

Deploying HD cameras throughout its HFRA will enhance SCE's situational awareness capabilities and enable emergency management personnel, including fire agencies, to more quickly respond to emerging wildfires. In particular, HD camera images save additional time in verifying and assessing a fire's severity as compared to sending fire crews to perform this assessment.

SCE in reviewing HD Camera deployment reviewed statements received from the United States Forest Service, Fire Protection Districts, Bureau of Land Management, and San Diego Fire Rescue, and these agencies all agreed this approach is beneficial. SDG&E also has experience deploying HD cameras, and confirmed the benefits of this approach.[130] Thus, the HD cameras not only provide benefit to the utility in helping provide real-time

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[126] As noted earlier, SCE's HD cameras deployed at Santiago Peak help fire agencies respond to wildfires, and were able to capture what are believed to be the first images of the Holy Fire. *See* Kevin Sablan, *Holy fire time-lapse GIF captures smoke exploding into blaze*, O.C. Register (August 13, 2018), *available at* https://www.ocregister.com/2018/08/13/these-holy-fire-gifs-show-how-quickly-the-blaze-grew-and-how-winds-pushed-it-forward/

[127] Refer to Work Paper Vol. 2 (Forecast - HD Cameras)

[128] Fire agencies rely on 911 dispatch calls and land/aerial surveillance.

[129] Santiago Fire reported June 11, 2018 and Holy Fire reported August 6, 2018.

[130] SDG&E has partnered with CalFire agencies to deploy a network of HD cameras throughout high fire risk areas within its service area. SDG&E indicated that HD cameras have been successfully used by first responder agencies to quickly assess and respond to active wildfire ignitions, mitigating the potential for these incidents to grow into larger wildfires.

information regarding whether utility equipment is in jeopardy during fire events, but they also provide important information to state agencies that may help in the speed and efficacy in responding to fire events.

d) Forecast

Table IV-14 below summarizes the forecast incremental costs in SCE's request for HD Cameras.

Table IV-14
2018-2020 HD Camera Costs[131]

Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
HD Cameras	1,123	2,272	741	$ 4,136
Grand Total	**$ 1,123**	**$ 2,272**	**$ 741**	**$ 4,136**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
HD Camera Leases	618	2,572	3,197	$ 6,387
Grand Total	**$ 618**	**$ 2,572**	**$ 3,197**	**$ 6,387**

e) Detailed Program Description

SCE is partnering with the University of California San Diego and the University of Nevada Reno to deploy HD cameras throughout HFRA. Specifically, SCE will deploy two PTZ cameras: one will perform 360˚ sweeps approximately every minute, with twelve high definition frames per sweep; the other will be web-controlled for early fire detection and situational awareness. SCE's Fire Management Organization will control the second camera and will set it to "Home" in an appropriate location to minimize any blind spots.

SCE's Fire Management Organization and approved public agencies can access the cameras via an electronic platform and can pan, tilt, and zoom for early fire detection, confirmation, and situational awareness. The public will be able to view live images of the cameras via the AlertWildfire.org website and view time lapse videos, but will not be able to control the cameras. All data will be deleted from the cloud buffer after 12 hours.

[131] Refer to Work Paper Vol. 2 (Forecast - HD Cameras)

For 2018, SCE targets installing up to 70 PTZ cameras on approximately 35 towers, covering up to 50 percent of Tier 2 and 3 areas. These cameras will be installed on third-party towers and strategically placed in areas providing maximum visibility of HFRA. In 2019, SCE plans to install up to 70 additional PTZ cameras on another 35 tower locations, covering up to 80 percent of Tier 2 and 3 areas.

In 2020, SCE targets installing up to 20 cameras on 10 additional towers to bring coverage up to 90 percent of Tier 2 and 3 areas, and to increase resiliency by creating multiple backhaul pathways using the microwave network.

f) <u>Alternatives Considered</u>

SCE can obtain fire progression images by other public means (e.g., monitoring news channels and 911 calls). Fire crews can also be dispatched to determine fire severity and report back. SCE prefers deploying HD cameras over these other options because those other options take longer to obtain information regarding fire progression. Moreover, SCE understands from SDG&E's experience that the fire agencies also find the HD cameras beneficial because no other agency or public entity has installed such devices.

2. Weather Stations

Figure IV-19
SCE Weather Station on Distribution Pole

a) Program Overview

SCE intends to enhance its existing weather models by installing weather stations on circuits within HFRA. SCE intends to install up to 850 weather stations in the HRFA between 2018-2020. [132] These additional weather stations will enhance the resolution of existing weather models and provide real-time information to assist with making key operational decisions during potential fire conditions, including PSPS deployment.

b) What Exists Today

SCE has approximately 24 legacy weather stations installed at various substations. These stations are less precise and have less functionality than current weather station models. SCE can also use publicly-available weather station data to monitor conditions; however, these data do not cover many rural areas within its HFRA, limiting its situational awareness capabilities in those areas.

[132] Refer to Work Paper Vol. 2 (Scope - Weather Stations)

c) Effectiveness

The deployment of additional weather stations will significantly enhance SCE's existing weather forecast models to provide more expansive, accurate weather data throughout SCE's HFRA. In today's higher risk fire environment, this information is crucial to informing operational decisions during severe fire conditions. This includes potential deployment of PSPS. The Commission recognized in Resolution ESRB-8 that de-energizing electric facilities for public safety is complex, and depends on many factors including "local meteorological conditions of humidity and winds."[133] SDG&E utilizes a similar program, with at least 170 weather stations within its service area, and SCE's understanding is that fire agencies in SDG&E's service area support this program.[134]

d) Forecast

Table IV-15 below summarizes the forecast incremental costs in SCE's request for Weather Stations.

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[133] *See* Resolution ESRB-8, p. 8, *available at* http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M218/K186/218186823.PDF.

[134] *See* Weather Awareness System, *#10 Weeks of Summer: Behind the Forecast*, SDG&E's Weather Team dated July 11, 2017, *available at* http://weather.sdgeweather.com/ (accessed August 21, 2018).

Table IV-15
2018-2020 Weather Station Costs [135]

Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Weather Stations	1,066	5,922	6,345	$ 13,334
Grand Total	**$ 1,066**	**$ 5,922**	**$ 6,345**	**$ 13,334**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Weather Station Maintenance	94	631	1,200	$ 1,925
Weather Station Development/Delivery	48	-	-	$ 48
Grand Total	**$ 142**	**$ 631**	**$ 1,200**	**$ 1,973**

e) Detailed Program Description

SCE intends to install up to 850 weather stations within HFRA between 2018-2020. To date in 2018, SCE has installed approximately 60 new stations and SCE's fire meteorologists will continue identifying potential locations for up to 790 additional weather stations, for a total of up to 850 weather stations. SCE is prioritizing circuits where these stations will be installed within HFRA by targeting locations in the downslope area of mountain ranges that would capture north-to-northeast winds.

SCE partnered with Western Weather Group (WWG) to identify the best weather station solution for improving fire weather prediction and real-time observation capabilities. WWG has extensive experience helping utility companies to implement solutions to monitor weather. WWG focused on preventing disasters such as downed power lines caused by high winds. WWG worked with Campbell Scientific[136] to build out a customized weather station kit for SCE, focused on timely and site-specific weather information for predicting and observing fire weather. The kit was designed with advanced sensors to measure wind, temperature, humidity, and other key variables that provide meteorologists and incident management teams

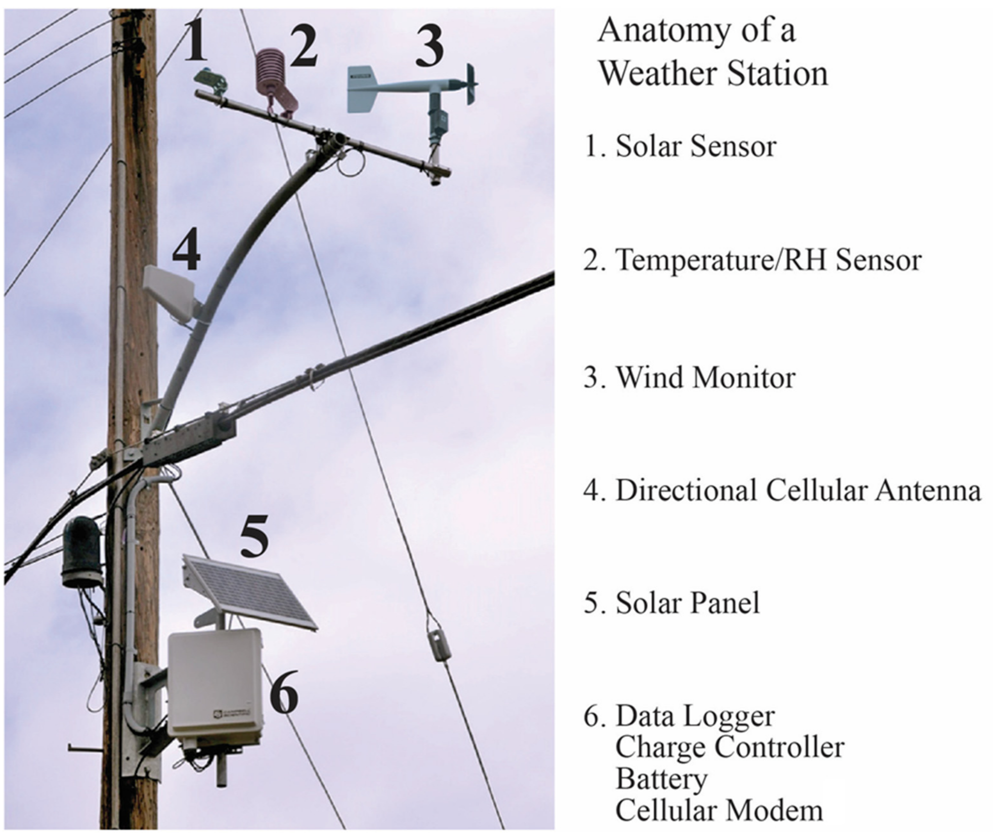
135 Refer to Work Paper Vol. 2 (Forecast - Weather Stations; Forecast - Weather Stations Maintenance; Scope - Weather Stations; Development and Delivery - Weather Stations)

136 Campbell Scientific is a worldwide provider of rugged, reliable dataloggers and data acquisition systems for long-term, unattended monitoring and is experienced in building automated weather stations specifically for fire weather.

with information to make accurate and timely decisions to address heightened wildfire risk conditions.

When installed, weather stations use various sensors and communications to provide meteorologists with real-time weather data including temperature, relative humidity, dew point, wind speed, wind direction, wind gust behavior, wind gust direction, and other variables. The weather station equipment includes the components depicted below in Figure IV-20. This includes a datalogger (the central component of the weather station, which measures signals coming from the weather station sensors); sensors to measure wind speed and direction, and temperature and relative humidity; and a solar panel and back up battery for power.

Figure IV-20
Weather Station Anatomy



f) Alternatives Considered

Forecasting information is available from weather models or through public information such as the Remote Automatic Weather Stations, National Weather Service, and Federal Aviation Administration airports. But these alternatives are less accurate and will limit SCE's ability to make more fully-informed operational decisions in today's higher-risk fire environment.

3. Advanced Weather Modeling Tool (IBM Forecast on Demand System)

a) Program Overview

SCE is procuring IBM's Forecast on Demand System, a comprehensive, advanced weather monitoring platform with faster weather data incorporation and higher resolution compared to other available systems.[137] The IBM system provides several benefits, including enhanced resolution and more accurate forecast data to better inform deployment of SCE's PSPS protocol and provide overall support to SCE's IMT in developing HFRA forecasts and fire response plans. SCE tested a "proof of concept" for this system and anticipates fully deploying it in production environment in 2018-2019.

b) What Exists Today

SCE currently uses lower-resolution modeling systems, specifically publicly-available weather models and vendor models that provide information for weather monitoring. These models are mainly run on six- or twelve-hour cycles and at resolutions of 3km or greater. To further enhance our existing capabilities, SCE is obtaining more advanced technologies that enable forecasting capabilities with higher granularity and precision to identify more localized weather conditions.

c) Effectiveness

The Forecast on Demand System provides several benefits, but the primary one is the ability to better inform operational decisions during potential fire conditions, including PSPS deployment. As Resolution ESRB-8 recognized, de-energizing electric facilities for public safety is complex, and depends on many factors including local meteorological

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[137] SCE contracted with IBM because it is a leader in weather forecasting modeling and observational weather information. As opposed to other weather modeling companies, IBM also can create a tool to house the Forecast on Demand data.

conditions of humidity and winds.[138] The proposed modeling tool addresses this issue by providing more frequent, higher-resolution forecast data on one comprehensive platform.

d) Forecast

Table IV-16 below summarizes the forecast incremental costs in SCE's request for Advanced Weather Modeling.

Table IV-16
2018-2020 Advanced Weather Modeling Tool Costs [139]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Advanced Weather Modeling Tool	384	604	604	$ 1,592
Grand Total	**$ 384**	**$ 604**	**$ 604**	**$ 1,592**

e) Detailed Program Description

In May 2018, SCE contracted with IBM, an international leader in weather modeling, to develop an advanced modeling tool to provide more frequent, higher-resolution forecast data on one comprehensive platform, including information gained from SCE's Weather Stations. This tool will provide higher resolution forecast information down to 500m, and short-term forecast updates as frequently as every 15 minutes. This is faster than SCE's current models, which are mainly run on six- or twelve-hour cycles and at resolutions of 3km or greater. The model will forecast weather parameters such as temperature, wind speed and gusts, humidity, and precipitation. This system will provide these benefits:

- Enhanced resolution and more accurate forecast data to better inform deploying SCE's PSPS protocol;
- Severe weather forecasting including wind, thunderstorms, heavy rain events along with extreme temperatures;
- Visualization of weather conditions and forecasts around SCE infrastructure; and

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138 *See* Resolution ESRB-8, p.8, *available at* http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M218/K186/218186823.PDF.

139 Refer to Work Paper Vol. 2 (Forecast - Advanced Weather Modeling Tool)

- Overall support to SCE's IMT in developing HFRA forecasts and fire response plans.

IBM has delivered an initial functional forecasting model and visualization tool. IBM is currently working on developing enhancements to the initial release of the software, and will add additional capabilities and features in future phased releases in the coming months. Key features will include improved GIS capabilities, incorporation of additional variables into forecasts (e.g. fuel moisture levels), development of forecasting capabilities to assess the risk of fire ignition and other end user improvements. The next release of the software is scheduled for October, 2018.

f) Alternatives Considered

Other weather models provide similar data (e.g., American GFS Model and European ECMWF Model), but with lower resolution and/or less frequent time increments compared to the IBM system. For example, typical operational weather models can be run at a 2km resolution at their lowest and at a time step of one hour. For these reasons, SCE chose not to pursue these models because the degree of enhanced functionality above the existing systems was not as great. SCE also evaluated whether it could continue using its current systems without modification, but determined that the new heightened risks call for more sophisticated technologies to better predict such weather conditions under the "new normal" conditions of year-round fire risk and more extreme climate extremes.

4. Advanced Modeling Computer Hardware

a) Program Overview

SCE intends to deploy a high-performance computing platform to improve its ability to scientifically quantify the risk of wildfire ignitions in different geographic regions throughout its service area. SCE will procure advanced computer hardware and deploy state-of-the-art software that will run a sophisticated Fire Potential Index model that will account for various factors including weather, live fuel moisture, and dead fuel moisture to assess the level of risk of wildfire ignitions. This platform will also enable software to analyze decades of data for fuel and weather characteristics from past wildfire ignitions, and compare and contrast those variables against current conditions to forecast the Fire Potential Index. The output from this model will be used to inform operational decisions, implement work restrictions, and optimize resource allocation for emergency situations.

SCE is obtaining the hardware and software for its high performance computing platform and intends on using it starting in 2019.

b) What Exists Today

SCE relies on a manual process and its staff's professional judgment to estimate fire potential risk, taking into account a number of variables such as wind, temperature, humidity, and vegetation properties. SCE's staff includes a team of meteorologists who are members of the American Meteorological Society and who hold specialized education in Atmospheric Sciences.

c) Effectiveness

Commission Resolution ESRB-8 recognized that proactively de-energizing electrical facilities is a complex decision, depending on many factors including fuel moisture and local metrological conditions of humidity and winds.[140] The high-performance computer platform helps address this complexity, by providing the ability to consider and analyze large amounts of data, consisting of many factors to provide for objective forecasting of wildfire indices.

d) Forecast

Table IV-17 below summarizes the forecast incremental costs in SCE's request for Advanced Modeling Computer Hardware.

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[140] Resolution ESRB-8, p. 8, *available at* http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M218/K186/218186823.PDF.

Table IV-17
2018-2020 Advanced Modeling Computer Hardware Costs[141]

Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Advanced Modeling Computer Hardware	2,943	3,722	1,330	$ 7,995
Grand Total	**$ 2,943**	**$ 3,722**	**$ 1,330**	**$ 7,995**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Advanced Modeling Computer Hardware Maintenance	50	120	120	$ 290
Grand Total	**$ 50**	**$ 120**	**$ 120**	**$ 290**

e) Detailed Program Description

In considering whether to de-energize power lines, SCE considers a wide variety of factors which may include, but are not limited to, the following:

- The National Weather Service issuing Red Flag Warnings for counties that contain SCE circuits in HFRA
- Ongoing assessments from SCE meteorologists regarding local conditions related to wind speed, humidity, and temperature
- Real-time situational awareness information from personnel positioned in HFRA identifying extreme weather conditions
- Input from its Fire Management experts regarding any ongoing firefighting efforts
- Specific concerns from local and state fire authorities regarding the $potential consequences of wildfires in select locations
- Awareness of mandatory or voluntary evacuation orders in place
- Expected impact of de-energizing circuits on essential services such as public safety agencies, water pumps, traffic controls, etc.
- Other operational considerations to minimize potential wildfire ignitions

141 Refer to Work Paper Vol. 2 (Forecast - Advanced Modeling Computer Hardware; Forecast - Advanced Modeling Computer Hardware Maintenance)

SCE plans to further refine its fire risk mitigation decision-making by utilizing risk-modeling to create a Fire Potential Index. To do so, SCE must purchase hardware and software capable of statistically-analyzing mass quantities of information real time, such as historic weather information and fuel moisture. This technology will do the following:

- Compute high-quality granular weather forecast data that allows for enhanced weather prediction capabilities supporting PSPS planning and implementation
- Compute wind speed forecasts, fuel moisture statistics and humidity levels to create a wildfire threat index which rates the potential for wildfires fueled by strong seasonal winds to assist with development of understanding of fire threats in areas where observations of fuel moisture are not readily available. Development of a wildfire index can assist with SCE crew deployment based on the rating scale
- Improve Load modeling with the additional granular temperature, humidity, wind and solar related data inputs

SCE is engaging qualified vendors to assess cost and scope for this technology and plans to designate an appropriate data center and sufficient circuit and network capabilities to properly house and support the equipment.

SCE expects that the final configuration and project scope will likely include the following elements:

- Order hardware, coordinate with SCE data center personnel to prepare data center with appropriate circuit and network connection
- Install and optimize the Weather Research and Forecasting (WRF) Model[142] on both computer systems

[142] The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. It features two dynamical cores, a data assimilation system, and a software architecture supporting parallel computation and system extensibility.

- Use SCE observation network to validate optimal WRF configuration.
- Operationalize WRF configuration(s)
- Run WRF over historical period (30 years) on backup computer systems. Implement nudging scheme and initialize soil moisture/temperature properly. Provide analytics including fire potential index, fuels, high-impact weather variables
- Gather and parse load data from SCE. Match to historical weather data to train load model (aggregate spatially)
- Implement fuel moisture model on the WRF grid. Spin-up dead fuel moisture
- Implement live fuel moisture model on the WRF grid;
- Implement fire potential index on WRF grid. Create analytics and data feeds to appropriate users
- Install existing SCE models (Damage Model, etc.) and build web-based interface for on demand model initialization.

f) <u>Alternatives Considered</u>

SCE is not aware of equivalent alternatives. The ability to timely process countless weather-related data points to create forecast models that allow for creation of wildfire threat index ratings and supporting PSPS initiation is not available by manual means.

5. Asset Reliability and Risk Analytics

a) <u>Program Overview</u>

As part of the Asset Reliability and Risk Analytics program, SCE seeks to: (1) develop capabilities in predicting an asset's overall wildfire-related risk; and (2) given an asset's risk, prioritize work, repairs, and/or replacement(s) to minimize potential wildfire ignitions. SCE will utilize its existing analytics platform to develop composite risk models that can be leveraged to predict risk as it relates to distribution assets, vegetation health, and extreme weather events that could impact public safety, including wildfire ignitions. These risk models will be used to enhance existing processes, including the following:

- Identifying which assets should be prioritized for replacement or upgrade based on the environment they operate in and their asset characteristics (i.e., number of splices, conductor type; fusing, etc.);
- Analyzing forecasted and historical weather conditions;
- Conducting and prioritizing maintenance;
- Analyzing asset types; and
- Analyzing operational data (such as load, duty cycle, etc.).

Using these analytics to prioritize mitigation efforts on the highest risk assets in the high fire risk areas will help optimize SCE's actions to help overall ignition risk.

This program also proposes advanced analytic capabilities for streaming grid data (smart meter, supervisory control and acquisition data (SCADA), etc.) to improve advanced fault detection. This capability will allow SCE to use artificial intelligence, machine learning, and predictive modeling on streaming data to identify early warning signs of potential faults and to immediately identify a fault that has occurred, to more quickly respond to remediate a public safety risk. Quickly detecting downed energized conductors and predicting faults that could cause increase ignition risk would reduce fire risk and maintenance costs, making the system safer and more cost effective.

b) <u>What Exists Today</u>

SCE collects a large amount of data on asset operations, maintenance, and other asset characteristics, using manual analysis and human judgment for asset classes individually and relying primarily on scheduled maintenance or the Commission's prescribed issue remediation timeframes to address and prioritize asset reliability risk.

c) <u>Effectiveness</u>

SCE is pursuing this initiative to help support risk-informed decision making to address increasing fire risk, including potential PSPS deployment. This program also focuses on upgrading and replacing SCE's infrastructure to mitigate potential ignition risks. By developing models that predict which assets are more likely to experience faults that could increase ignition risks, SCE can prioritize where, and what, assets need remediation to optimize system investments as efficiently as possible.

While focusing on asset health to meet system reliability goals has historically been a primary driver of SCE's asset management approach, SCE needs additional tools and data to inform prioritization of asset and circuit upgrades to mitigate ignition risk in HFRA. In order to understand the ignition risk of particular assets and their circuits, and prioritize remediation across SCE's system accordingly, SCE needs to gather relevant data together in a central analytics platform to develop models that allow SCE to make risk-informed investment and operational decisions that reduce wildfire risks.

SCE also plans to accelerate and improve its current manual asset analysis approach to rapidly adapt to new information and methods to continuously improve how SCE manages asset reliability and public safety risks across SCE's system. This platform is designed to assimilate more data in the future as it becomes available (such as supercomputer fire simulation data, new weather station data, etc.) and train composite risk models using analytics and machine learning to improve the accuracy and usefulness of the models in mitigating wildfire risk over time.

This initiative will also use advanced analytics to improve operations by using streaming data from the electric grid to augment analysis for PSPS decision-making by using real-time fire simulation data from the advanced computer models and predictive fault analytics together to get a full picture of the state of SCE's assets in HFRA.[143] For example, today, SCE's first indication of an energized downed conductor may be from a phone call from a first responder or customer. In the future, using outage event data from SCE's smart meter system, SCADA data, and fire simulation data, SCE will be able to locate downed conductors

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[143] *See* Chapter IV, Section C.5, *supra,* for a discussion of SCE's advanced computer program.

faster and with greater location specificity and, using the advanced computing platform, quickly understand the impact of a potential ignition event. This will significantly decrease the risks associated with downed conductors, including wildfire ignitions and help SCE work more effectively with first responders when wildfire events do occur.

d) Forecast

Table IV-18 below summarizes the forecast incremental costs in SCE's request for Asset Reliability and Risk Analytics.

Table IV-18
2018-2020 Asset Reliability and Risk Analysis Tool Costs[144]

Capital (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Asset Risk Modeling	2,141	505	-	$ 2,646
Operational Analytics	1,239	-	-	$ 1,239
Grand Total	**$ 3,380**	**$ 505**	**$ -**	**$ 3,885**

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Operational Analytics Development/Delivery	7	9	-	$ 16
Grand Total	**$ 7**	**$ 9**	**$ -**	**$ 16**

e) Detailed Program Description

The Asset Reliability and Risk Analytics program is composed of two major work tracks.

(1) Asset Risk Modelling

The first work track is focused on developing risk models that create composite risk scores based on asset, environmental and operational data. This will provide guidance on ignition risks so that SCE can prioritize asset maintenance, upgrades and replacement work to decrease the risk of wildfires. As such, the key objectives and elements of Asset Risk Modelling are as follows:

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[144] Refer to Work Paper Vol. 2 (Forecast - Asset Risk Modeling; Forecast - Operational Analytics; Development and Delivery - Operational Analytics)

- Enhance public safety by identifying and prioritizing assets for ignition risk mitigation in HFRA by creating composite risk indexes for those assets based on their characteristics (splices, fusing, conductor type, fault risk, maintenance and operational data, and fire simulation data from the "super computer" platform)
- Integrate relevant SCE and public domain data to enable risk modelling
- Develop and implement risk models associated with SCE Assets, surrounding vegetation, weather and operational data that then result in a consolidated Risk Score
- Integrate risk model events, data and scores for ingestion into the machine learning and analytics environment to operationalize the asset risk modelling capability
- Display geospatial visualization of the risk model events and scores along with appropriate notifications and alerts to the situational awareness center, distribution planning, engineering, and SCE work and asset management teams
- Conduct exploratory analysis using machine learning techniques to gain greater insights into the data and improve model accuracy by searching for anomalies or extremes and improving spatial and temporal fidelity of major data sources as new sensors and simulation data becomes available

(2) Operational Analytics

The second work track is focused on using analytics to develop advanced fault detection. Specifically, the program is designed to develop and improve energized wire down detection algorithms using streaming data from meters, SCADA, remote fault indicators and other sensors to shorten the duration of Energized Downed Conductor (EDC) events and reduce ignition risks. Key elements and objectives of operational analytics for energized downed conductor detection are as follows:

- Identify many EDC events within approximately fifteen minutes and to be able to mitigate public danger as fast as possible;
- Determine the confidence, location, and risk factor of an EDC and respond appropriately;
- Provide first responder notification of an EDC in faulted conditions that pose a public safety risk;
- Use the information from events to tune continue to fast curve settings on RARs (where available) to further diminish risks to public safety from EDCs; and
- Use data analytics tools to create a platform capable of improving existing operational analytics and algorithms to detect infrastructure in faulted conditions and predict assets more prone to faults.

SCE intends on developing its Asset Reliability and Risk Analytics program in several phases with initial capabilities in November of 2018 and program completion in 2019.

f) Alternatives Considered

SCE considered using generic reliability-centered maintenance software and algorithms. SCE rejected this alternative because the level of integration work, customization of commercial off-the-shelf software to do risk analytics, and the individual asset lifecycle focus would be more costly, take longer, and be less flexible to accommodate future requirements than using SCE's existing platform.

6. Additional Required Staffing

As discussed in this testimony, the state's substantially increasing fire risk means that SCE must respond to more frequent and prolonged fire threats throughout its service area. SCE is planning to enhance its staffing expertise in early fourth quarter 2018 to be more fully prepared to address any fire conditions emerging later this year. SCE anticipates filling four new full-time positions in the fourth quarter of 2018:

One Fire Management Officer – SCE currently has two Fire Management Officers, responsible for coordinating with first responders and enhancing first responder safety, and reporting and informing operational decisions. Increasing fire risk is placing a significant strain on SCE's Fire Management Officers, who also support system planning efforts related to grid resiliency. This additional resource will help SCE continue to timely respond to fire incidents and coordinate with first responders.[145]

Two Additional Meteorologists – SCE currently staffs three meteorologists who have historically been responsible for forecasting related to energy procurement. These meteorologists now also support SCE's Business Resiliency department, performing several additional tasks including: coordinating the installation of weather stations; contracting with vendors to deploy high resolution weather models; developing new tools and products to support the situational awareness center; exploring new models to predict fire potential; and supporting incidents and pre-incidents by providing meteorological expertise (including on a twenty-four-hour, seven-day-a-week schedule at SCE's Situational Awareness Center during activated incident management conditions). The proposed two additional positions will support these added functions, along with staffing the situational awareness center staffing twenty-hour staffing during activation events.

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[145] In support of the Fire Management Officer responsibilities, SCE has included within the forecast staffing one vehicle that is furnished with additional radios for SCE communication (Edison 900mH, Fire Radios along with scanner function).

One Fire Scientist – This new position will build and mature complex fire models designed to predict wildfire ignition and propagation by considering multiple variables such as weather, fuel, and asset conditions. Once developed, these models will inform SCE's IMT of severe fire conditions which may require deployment of PSPS in HFRA.

The proposed four full time positions are expected to remain on staff within SCE's Business Resiliency department to support projects, programs, and work streams focused on preparing and responding to potential fire conditions.

a) Forecast

Table IV-19 below summarizes the forecast incremental costs in SCE's request for Additional Required Staffing.

Table IV-19
2018-2020 Staffing Costs [146]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Additional Required Staffing	115	460	460	$ 1,035
Vehicle for Fire Manager	-	20	20	$ 39
Grand Total	**$ 115**	**$ 480**	**$ 480**	**$ 1,074**

D. Enhanced Operational Practices

1. Vegetation Management

a) Overview of Expanded Vegetation Management Activities

Vegetation management is a longstanding component of SCE's efforts to minimize ignitions associated with electrical facilities. SCE has an inventory of approximately 900,000 trees near its electrical facilities (system wide) inspected annually and pruned[147] as needed to maintain mandated clearances. Due to the longstanding drought and bark beetle infestation, SCE also removes approximately 40,000 trees per year that are dead, dying, or diseased and could fall into its electrical facilities. SCE is also inspecting and pruning trees in

[146] Refer to Work Paper Vol. 2 (Forecast - Additional Required Staffing; Forecast - Vehicle for Fire Manager)

[147] SCE uses "pruning" and "trimming" interchangeably.

areas recently added to the Commission's designated Tier 2 and Tier 3 High Fire Threat Areas to meet new mandated clearances[148] and expanding time-of-trim clearances throughout these areas to factor in the new recommended distances.[149]

As part of its GS&RP, SCE plans to expand its vegetation management activities to assess the structural condition of trees in HFRA that are not dead or dying, but could fall into or otherwise impact electrical facilities and potentially lead to ignitions and outages. These trees may be as far as 200 feet away from SCE's electrical facilities. Trees posing a potential risk to electrical facilities due to their structural or site condition will be removed or otherwise mitigated.[150] For example, a 75-foot tall palm tree, 50 feet from electrical facilities not only has the potential to fall into these facilities, but its palm fronds can dislodge and blow into electrical facilities igniting a fire. While this palm tree meets all mandated compliance clearances and is not dead or dying, under this new effort, SCE may still identify it as a potential risk to be mitigated by either removing dead fronds or removing the tree altogether. SCE views this as an important effort in light of increasing winds that have the potential to blow palm fronds and other debris into utility lines from even greater distances.

Another example is a tree near electrical facilities that has heavy woody stems that are exempt from mandatory clearances. While this tree meets all the mandatory clearance requirements, through the threat assessment, SCE may conclude that it is expected to pose a risk and remove the tree.

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[148] In those areas that were recently added, the required clearances went from 18 inches to 48 inches.

[149] In the Commission's designated Tier 2 and Tier 3 High Fire Threat Areas the recommended time-of-trim clearances went from 6.5 feet to 12 feet for lines operating between 2,400 volts and 72,000 volts. Recommended time-of-trim clearances for lines operating at higher voltages were also increased. (*See* D.17-12-024, pp. 100-102.)

[150] Many trees that may pose an expected risk to SCE's electrical facilities are on private or public property and SCE may not have rights to access the property to conduct assessments and perform mitigation tasks. Thus, SCE may be prevented from reducing potential tree risks by property owner opposition and/or restricted access to private property.

b) What Exists Today: SCE's Vegetation Management-Related Activities and Associated Rate Recovery Mechanisms

As noted above, SCE currently has a number of vegetation management programs in place to comply with current state and federal regulations. As shown in Table IV-20, SCE recovers existing vegetation management program costs through one of three CPUC ratemaking mechanisms: (1) the GRC; (2) the Drought Catastrophic Event Memorandum Account (Drought CEMA); or (3) the Fire Hazard Prevention Memorandum Account (FHPMA).[151] As also shown in the below table, in this Application SCE proposes recording costs for its expanded vegetation management activities in the GS&RPMA. Alternatively, SCE believes the Commission could confirm these costs are now eligible for recording in the Drought CEMA under the "new normal" environment of year-round fire risk.[152]

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[151] In addition, SCE recovers through its FERC Formula Rate, FERC jurisdictional vegetation management related costs.

[152] Ordering Paragraph (OP) 2 of Resolution ESRB-4 states "Investor Owned Electric Utilities must take practicable measures necessary to reduce the likelihood of fires associated with their facilities. These measures include: increasing vegetation inspections and removing hazardous, dead and sick trees and *other vegetation* near the IOUs' electric power lines and poles; …" (Emphasis added). SCE is proposing to remove trees that, based upon tree-specific assessments, create a potential threat to its facilities and could, under the "new normal" environment, be appropriately considered as "other vegetation" within the scope of the Resolution.

Table IV-20
Vegetation Management CPUC Cost Recovery Summary

Vegetation Management Activity	GRC	Drought CEMA	FHPMA	GS&RP BA
Vegetation management compliance inspections, pruning & opportunity removals and non-drought-related dead, dying and diseased tree removal	✓			
Transmission ROW and road maintenance	✓			
Removal of dead, dying & diseased trees in bark beetle infestation zones		✓		
Resolution ESRB-4 related activities including removal of hazardous, dead and sick trees in HFRA		✓		
D.17-12-024 changes: • New compliance clearance in expanded Tier 2 and Tier 3 areas (change from 18 inches to 48 inches) • Incorporation of new recommended time-of-trim clearance in Tier 2 and Tier 3 areas			✓	
Planned expanded vegetation management activities (removal/partial removal of trees that pose a risk to electrical facilities)				✓

(1) <u>2018 GRC</u>

SCE included in its 2018 GRC revenue requirement forecast $63.8 million and $10.4 million (2015 constant $) for distribution-related and transmission-related vegetation management expenses, respectively.[153] This includes "all of the expenses associated with tree trimming and tree removal in proximity to transmission and distribution high voltage lines and weed abatement around overhead structures in high fire designated areas. It also includes costs to plant different species of trees as replacements and in handling preventative soil treatment" for adherence to the regulations in place at the time of filing.

SCE's vegetation management activities included in its 2018 GRC filing are designed to maintain compliance clearances for the approximately 900,000 trees that exist in proximity to electrical facilities throughout SCE's service area. SCE must comply with

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[153] *See* A.16-09-001, Exhibit SCE-02, Vol. 4, pp.16 – 18 and Exhibit SCE-02, Vol. 7, pp. 24-25.

many vegetation regulations, including GO 95 Rule 35, Public Resources Code Sections 4292 and 4293, and FERC FAC-003.

SCE's rights-of-way are inspected annually for compliance with state requirements. During these inspections, trees or vegetation that require pruning to maintain required clearances (both vertical and horizontal) from high voltage lines are scheduled for pruning or removal. The pruning takes into consideration a tree's anticipated growth over twelve-months.[154] Fast-growing species, or trees in areas designated as high risk for wildfire, may need more frequent pruning to maintain required compliance clearances. SCE engages contractor resources to prune and remove trees and weeds, and other activities, to comply with these requirements.

During these annual line clearance inspections, inspectors also may identify trees that must be removed per existing regulations (e.g., dead, dying and diseased trees,[155] overhangs in HFRA, and opportunity removals (e.g., healthy trees requiring pruning multiple times a year due to their growth rate). Because opportunity removals require owner consent, SCE attempts to contact owners for approval to remove the tree, and leaves contact information if the owner is unavailable.[156] In addition to the approximately 40,000 trees removed due to drought and bark beetle infestation, SCE removes on average approximately 12,500 trees per year under its normal vegetation management program.

SCE also included in its 2018 GRC revenue requirement $3.6 million (2015 constant $) for transmission-related road and rights-of-way maintenance activities

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[154] For example, if the required clearance is 48 inches in CPUC Tier 2 and Tier 3 Areas and the anticipated annual growth for that species of tree is 24 inches, the tree would be pruned to a distance of at least 72 inches. Based on the recommended time-of-trim clearances in D.17-12-024, SCE has started to expand the trimming distances in CPUC Tier 2 and Tier 3 Areas to reflect at a minimum the new recommended time-of-trim distances.

[155] As discussed below, the costs of removing dead, dying, and diseased trees in HFRA and bark beetle infested zones are recorded in SCE's Drought CEMA. Dead, dying and diseased trees removed under SCE's normal vegetation management program are in non-HFRA and non-bark beetle infested zones.

[156] SCE continues to maintain compliance clearances by pruning when property owner approval to remove the tree is not obtained.

including annual grading, repairs of damaged storm drains, repairs of access roads, annual brush clearing along access roads and weed abatement on parcels of property owned by SCE along transmission rights-of-ways, as required by city or county fire codes.[157]

(2) Drought CEMA

Because of unprecedented levels of tree mortality caused by the multi-year drought and bark beetle infestation, SCE records in its Drought CEMA costs associated with removing dead, dying, or diseased trees that can fall into SCE's facilities in HFRA and bark beetle infestation zones. Unlike trees near power lines that must be trimmed to prevent encroachment into the mandated clearances, large dead or dying trees can be located outside of SCE's rights-of-way and fall into electrical facilities. Given that tree mortality is ongoing, SCE inspects for newly dead, dying, and diseased trees every 90 – 120 days in HFRA. Because these inspections are limited in scope, they can be performed fairly quickly via ground and aerial inspections. SCE is removing approximately 3,000 – 4,000 trees per year because of bark beetles and approximately 35,000 trees per year because of the drought.

(3) Fire Hazard Prevention Memorandum Account

Decision 17-12-024 adopted new regulations to enhance the fire safety of overhead electric power lines and communication lines in high fire-threat areas. The Decision allowed SCE and other electric IOUs to track and record their costs to implement these new regulations in the FHPMAs established pursuant Commission decisions issued in R.08-11-005. As stated previously, SCE is inspecting and pruning trees to meet the Commission's new 48-inch clearance requirement in the expanded Tier 2 and Tier 3 areas, and increasing the trimming distance to reflect the Commission's new recommended time-of-trim clearances. The incremental costs of both activities are being recorded in its FHPMA.

Recovery of the costs recorded in the FHPMA may be through one or more applications where the Commission will verify and assess the reasonableness of

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157 *See* A.16-09-001, Exhibit SCE-02, Vol. 7, pp. 23-24.

recorded costs. Only those costs not already being recovered in rates (e.g., costs previously booked to the FHPMA and subsequently recovered in rates in a previous GRC proceeding) may be recorded in the FHPMA. Because SCE submitted its 2018 GRC prior to the issuance of D.17-12-024, it will record incremental costs associated with that Decision in its FHPMA until its 2021 GRC.

c) Forecast

Table IV-21 provides SCE's forecasted costs SCE for this effort. These costs are above and beyond what SCE incurs today and have not been included in SCE's 2018 GRC and are not recorded in its FHPMA or Drought CEMA. While this expanded effort may include inspections of FERC jurisdictional assets, only those costs associated with CPUC jurisdictional assets will be recorded in the GS&RPMA. As operational details are further developed, the types of, and forecast of, incremental costs may change. As explained later in this section, SCE's forecast is based on its aspirational targets for 2019 and 2020, or mitigating up to 15,000 and 30,000 trees in those years, respectively.[158]

[158] Refer to Work Paper Vol. 2 (Unit Cost and Scope - Removal)

Table IV-21
2018-2020 Vegetation Management Costs[159]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Tree Inspection	-	1,226	1,226	$ 2,452
Program Management	-	4,692	8,235	$ 12,927
Removal	-	30,218	60,435	$ 90,653
Mitigation	-	3,608	7,217	$ 10,825
Property Owner Incentives	-	404	808	$ 1,211
Grand Total	**$ -**	**$ 40,148**	**$ 77,921**	**$ 118,069**

d) Detailed Program Description: Expanded Vegetation Management Activity

As part of the GS&RP, SCE intends to go beyond its existing vegetation management and tree removal activities by focusing on trees in HFRA that are not dead or dying but potentially pose a risk to electrical facilities.[160] More specifically, SCE intends to focus on trees in its HFRA far enough away from electrical facilities that are not covered by existing mandated clearance requirements,[161] but close enough to potentially fall into or otherwise impact these facilities. SCE will use a risk-based approach to identify, assess, and mitigate the expected threat level posed by these trees. The key components of this expanded activity covering trees outside of existing clearance requirements include:

- A dedicated tree inspection process;
- A tree-specific threat assessment;
- Risk-based tree removal or mitigation; and
- Enhanced efforts to obtain property owner approval to remove trees.

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159 Refer to Work Paper Vol. 2 (Forecast - Tree Inspection; Forecast - Program Management; Forecast - Removal; Forecast – Mitigation; Forecast - Property Owner Incentives; Unit Cost and Scope – Mitigation; Unit Cost - Program Management; Scope - Program Management; Unit Cost and Scope - Removal)

160 These expanded efforts will look at SCE's transmission, distribution, and generating facilities, including secondary distribution, substations, and communication facilities.

161 This also includes exemptions from the clearance requirements for woody stems.

Below is an overview of program operations. SCE anticipates finalizing and implementing the operational details of this effort during the first quarter of 2019, and refining its operational approach on an ongoing basis, as the program matures.

(1) Dedicated Tree Inspection Process

SCE is developing a detailed inspection process to identify subject trees that could potentially fall into or otherwise impact electrical facilities in HFRA, separate from its existing inspection processes.[162] These inspections will look at areas on either side of SCE's electrical facilities called the "utility strike zone" from which a tree or a portion of a tree could directly strike or impact electric facilities. The areas inspected on either side of SCE's electrical facilities can vary significantly (up to 200 feet) based on the height of the trees. SCE anticipates that most inspections will be performed by inspectors on the ground.

SCE is developing an inspection prioritization methodology that will include factors such as, fire threat area tier, fuel loading surrounding SCE's facilities, permit and environmental considerations, tree density, and population density. This prioritization methodology will help SCE focus on areas posing the highest risk to public safety and property damage. For example, removing a tree in a sparsely populated area with minimal fuel around SCE's facilities does not mitigate as much risk as removing a tree in a densely populated area where there is fuel near the facilities that can ignite if an energized line was to provide the ignition source. In addition, there are areas in HFRA where obtaining permits to remove trees may take up to a year or more, thus these areas may be prioritized differently from areas where permits are not required or are typically granted. Finally, this program will focus on trees that are outside of SCE's ROW and for which SCE may not have easement rights to disturb, so trees where SCE can obtain owners' permission for removal will be prioritized over trees where owners refuse.

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[162] If during these inspections, a dead, dying, or diseased tree in HFRA is identified, it will be inventoried and removed with the associated removal costs recorded in the Drought CEMA.

(2) Tree-specific Threat Assessment and Inventory

Once a subject tree is identified, an assessment will be performed using a Level 1 assessment approach.[163] When specific tree characteristics are identified during the Level 1 assessment, a Level 2 assessment[164] of the tree will be conducted. These assessments will be conducted by certified arborists trained to conduct such assessments. The assessment will evaluate the condition of the tree and the expected threat it poses to electrical facilities. For example, if the tree is leaning away from SCE's facilities and does not pose other risks, a Level 1 assessment may determine the tree poses no significant risk. The assessment will include tree characteristics such as those shown in Table IV-22 and site conditions such as those shown in Table IV-23. Moreover, although this program seeks to make strides in removing trees that pose such threat, the limitations of SCE's access rights, permissions and sheer volume of non-SCE trees located near SCE's facilities make it impossible to entirely eliminate all risk from such trees.

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163 These are industry standard assessments typically conducted by arborists for many purposes. A Level 1 assessment is a limited visual assessment that is generally performed from one side of the tree while the inspector is located within or adjacent to the utility easement. This inspection can be ground-based, vehicle-based, or aerial-based (i.e., fixed-wing, helicopter, drone, LiDAR) as appropriate for the site conditions, type of facilities, and tree population being considered. A Level 1 assessment focuses on identifying obvious tree defects (e.g., dead branches, leaning) observable from the side of the tree nearest electrical facilities.

164 A Level 2 assessment is a more detailed, ground-based visual assessment of an individual tree and its surrounding site. A Level 2 assessment may include walking around the tree – looking at the site, buttress roots, trunk, and branches. Access restrictions, severe terrain or other obstacles may prevent access or otherwise limit ingress to do a 360-degree assessment of an individual tree.

Table IV-22
Tree Characteristics

Basal wound	Bleeding and/or resinosus
Bulges and/or swellings	Cankers, including bleeding & gall rust
Cavities	Embedded wires or cables
Codominant or multiple stems from base or higher on trunk	Conks indicating heart rot, root rot, sap rot or canker rot
Cracks including shear	Dead branches and/or top
Dieback of twigs and/or branches	Excessive lean or bow
Fire damage	Seam
Foliage – off-color, flagging or loss	Hazard beam
History of limb failure(s) on tree	Included bark
Large branches overhanging powerline	Lightning damage
Live crown ratio below 30 percent	Mistletoe – dwarf or broad-leaf
Nesting holes – birds, mammals, insects	Past poor pruning practices
Species failure patterns	Weak, unsound branch attachments
Unnatural or structurally unsound canopy weight distribution	Insect activity such as frass from termites, bark beetles or carpenter ants
Roots injured, exposed, undermined or uplifted	Dead palm fronds that can dislodge during high winds

Table IV-23
Site Conditions

Areas known to be affected by introduced tree pathogens	Construction – including trenching, paving or road construction
Areas of recent clearing/new edge	History of failure(s) at site
Change in drainage	Change in grade
Cultural disturbance to landscape - natural or unnatural	Diseased center – dead tree in middle and dying trees around it
High stand density with single species composition	Specific conditions like high winds
History of repeated outages on circuit	Fire damage
Raptor nests above lines	Recent thinning or logging
Soils prone to slides	Wet sites
Storm damage	

The tree-specific risk assessment will identify if the tree should be mitigated to remove an expected risk. Trees assessed to potentially threaten electrical facilities and require mitigation will be included in SCE's tree inventory for tracking purposes. This allows SCE to prioritize the removal or mitigation of trees that create an expected risk to electrical facilities, without removing every tree that could potentially strike electrical facilities. Table IV-24 illustrates what this risk-based mitigation approach may look like.

Table IV-24
Sample Risk Based Mitigation Approach

Recommended Mitigation	Recommended Mitigation Activities
Total Tree Removal	Criteria: Tree is expected to pose a risk to electrical facilities and shows characteristics that make the tree or parts thereof, unstable Additional Activities: • Add to inventory • Enhanced efforts to identify property owner (e.g., research public records) • Enhanced efforts to contact and negotiate with property owner, including, but not limited to, providing replacement tree and/or engaging local fire agencies, as needed
Partial Tree Removal or Trimming	Criteria: Partial removal or trimming can mitigate the expected risk and does not remove more than 30 percent of the crown. In addition, the condition is not caused by or exacerbated by site conditions. Additional Activities: • Add to inventory • Enhanced effort to identify property owner • Enhanced effort to contact property owner • Remove tree if property owner willingly approves • Monitor if not removed. Re-inspect/assess based on frequency proposed by inspector
Monitor Only	Criteria: Tree considered stable and not expected to pose a risk in the foreseeable future, but shows signs of an emerging threat characteristic or changing site condition (e.g., erosion) Additional Activities: • Add to inventory • Re-inspect/assess based on frequency proposed by inspector • No need to contact property owner
No Mitigation Required	Criteria: Tree considered stable and not expected to pose a risk in foreseeable future Additional Activities: • Do not add to inventory • Re-assess during next annual inspection

(3) Enhanced Efforts to Obtain Property Owner Approval

Since most trees to be mitigated through this effort reside on private or public property, property owner approval is required to remove the trees. SCE plans to take additional measures to contact property owners when tree removal is recommended. At times, the property owner differs from the occupants of the property, meaning that SCE may need to research public property records to identify property owners and obtain contact information; make multiple efforts to contact the property owner; and negotiate with the property owner to overcome their opposition to removing the tree. Depending upon location, additional approvals may be required from homeowner associations or governmental agencies.

SCE anticipates that some property owners will oppose removing trees that are not dead or dying, for reasons such as perceived value, visual appearance, sentimental value (e.g., grandfather planted the tree), shade, and environmental value. SCE will try to negotiate with property owners and may need to provide replacement trees or other inducements on a case-by-case basis. In certain situations, SCE may engage local fire agencies to help persuade property owners of the criticality of removing the tree. Until SCE gains experience in the field, it is difficult to determine the level of property owner opposition and how best to overcome it.

(4) Risk-Based Tree Mitigation

While many of the trees that pose an expected threat to electrical facilities may be mitigated through removal, other mitigation options include partial tree removal where major branches are removed; palm frond removal; and monitoring where the tree does not need removal or partial removal yet, but may in the future. It is anticipated that the mitigation will be conducted by third-party contractors. Tree removal will be performed using a combination of industry-standard methods such as: (1) directional felling, (2) climb and sectionalize, (3) crane, and (4) high hazard.[165] Once the trees are felled, they are bucked and slashed, and the logs and debris are removed from the site.

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[165] The directional felling method is used when a tree can be brought safely to the ground by an experienced feller, typically without rigging, climbing, or vehicles (e.g., cranes, tractors). This is typically the least expensive method. The climb, sectionalize method is used for trees that, due to their size, condition and/or location, cannot be free-felled or worked with a crane. Under this method, an experienced feller climbs the tree and sections of the tree are brought to the ground by placing rigging in the tree. The crane method is used for trees that, due to their size, condition and/or location, require the use of overhead crane(s) and/or heavy equipment to safely bring the tree to the

Given this work is all being done in HFRA, SCE will remove all debris over 18 inches in length and greater than one inch in diameter. Unlike bark beetle infested trees that have limited secondary uses, the logs from these trees may be suitable as lumber or other purposes. SCE will explore potential uses for the logs and vegetation materials it removes.

(5) Program Management, Environmental Compliance and Quality Assurance

SCE will establish a program management function for these expanded activities. Among other things, it will:

- Prioritize work (e.g., where inspections should be performed);
- Plan and schedule contractor work;
- Research property ownership and contact information;
- Manage property owner approval escalation process and negotiate with property owners, as needed;
- Interface with property owners and federal, state and local agencies and fire agencies;
- Perform community outreach;
- Provide accounting, invoicing, reporting, and project management support;
- Plan the inspection and tree removal work;
- Obtain required permits;
- Oversee the contractors who inspect, inventory, assess and remove trees; and
- Input tree inventory data.

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ground. The High Hazard method is used for trees that, due to their hazardous condition, cannot be removed utilizing any of the other felling methods. The High Hazard method requires workers that are highly skilled and experienced in rigging from multiple locations, and using multiple cranes, or specialized equipment, to bring the tree safely to the ground.

As needed, SCE will also retain biological and archaeological consulting firms to assess possible impacts to sensitive biological and cultural resources, as required, in areas where SCE will be removing trees. These consultants will monitor and guide work in potentially sensitive environmental areas; conduct field surveys; develop special training for tree removal crews; and prepare documentation and reports.

In addition, there will be a Quality Assurance function independent from the program management function that will confirm that contractors perform the required work in accordance with their contract and SCE internal standards; verify that the inspectors correctly identified subject trees and performed threat assessments; and verify the accuracy of the inventory of mitigated trees.

e) Deployment Schedule

SCE is developing its operating plans for this effort with an anticipated deployment in the first quarter of 2019. SCE estimates that it will target removing approximately 7,500 trees in 2019, and 15,000 trees in 2020, with aspirational targets of up to 15,000 trees in 2019 and 30,000 trees in 2020.[166] Additional trees will be mitigated through partial removal.

2. Infrared Inspection Program

a) Program Overview

SCE is developing a bi-annual Infrared (IR) Inspection Program for overhead distribution lines within HFRA. Inspection findings will be prioritized per SCE's Distribution Inspection Maintenance Program (DIMP) manual and given appropriate system remediation timeframes. IR inspections will help increase safety by enhancing critical circuit inspections and reducing fire safety hazards caused by potential equipment failures. These IR inspections will also improve reliability.

[166] SCE's cost forecast assumes the high end, or aspirational, targets for 2019 and 2020.

b) What Exists Today

SCE visually inspects overhead facilities under General Orders 95 and 165. Visual inspections, while valuable, only detect issues visible to the naked eye, and cannot reveal potential issues inside of sealed components or covered objects that may lead to component failures posing a fire risk.

c) Effectiveness

SCE has evaluated the need for IR inspections on its distribution circuit. The engineering review concluded these inspections offer a substantial benefit above standard visual inspections by adding a layer of visibility into potential failures.

In 2017, SCE conducted an IR inspection program study involving a statistically random sample of its overhead distribution system. This program study identified "Hot Spots," i.e., areas where there is a temperature difference between either two phases, or two pieces of metal on one phase. These Hot Spots are not visible to the naked eye and can only be detected by a trained thermographer using an IR camera. SCE removed and analyzed these Hot Spots and determined they are reliable predictors of future component failures that, if unaddressed, could potentially result in faults and customer outages.

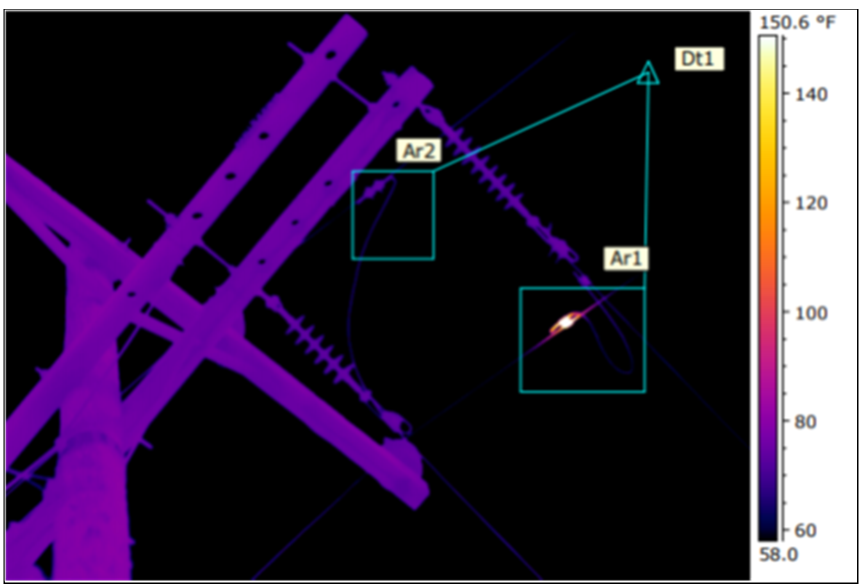
Later, in 2018, SCE conducted an IR inspection of all remaining high fire circuits and identified another 192 findings on these circuits. These 192 findings are potential failures that were not visible during a visual inspection or other testing.

Figure IV-21 shows a connector in its normal state, which an inspector would see during a General Order 165 inspection. Figure IV-22 shows the same connector as seen during an infrared inspection and identified as a potential Hot Spot.

Figure IV-21
Visual Inspection View

Figure IV-22 below shows that the connector identified as Ar1, when compared to the connector identified as Ar2, exhibits a temperature difference (Dt1) over 180 degrees Fahrenheit.

Figure IV-22
Infrared Inspection[167]



d) Forecast

[167] DIMP utilizes a three priority rating system, designed to identify issues, and set appropriate timeframes for repair. Priority "1" conditions require immediate action, Priority "2" conditions are assigned a due date between zero to 12 months, based on the risk when located within High Fire Areas, and Priority "3" conditions are General Order 95/128 issues that are not an imminent safety and/or reliability risk.

Table IV-25
2018-2020 Infrared Inspection Program Costs [168]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Infrared Inspection Program	-	459	459	$ 918
Grand Total	**$ -**	**$ 459**	**$ 459**	**$ 918**

e) Detailed Program Description

SCE is proposing a bi-annual IR inspection program, conducted at the distribution circuit level and including circuits entirely, or partially, located in SCE's HFRA. SCE would conduct the majority of inspections by truck; however, a small percentage of the system requires hiking or scanning from a helicopter. Truck inspections would use a two-person crew, with the passenger aiming an infrared camera at overhead facilities as the driver drove the area.[169] When the crew discovers a potential issue, they will stop and determine if it is a Hot Spot. If confirmed, SCE will record relevant data (location, equipment, temperature reading, and pictures (infrared and optical)) and schedule the equipment for remediation. Inspection findings would be prioritized per SCE's DIMP and given appropriate remediation timeframes.

SCE proposes to deploy IR Program inspections starting in 2019, with half of the system circuits in HFRA inspected in 2019 and the remaining portions inspected in 2020. SCE will use the results of the 2017 effort, and 2018-2020 data to determine the appropriate inspection cycles for IR inspections going forward after 2020.

f) Alternatives Considered

IR inspections offer a substantial benefit above standard visual inspections by adding a layer of visibility into potential equipment failures. As information gained from the IR inspections is not available to the human eye, SCE at this time is not proposing a formal alternative but expects to continue for review of IR cycles based upon additional data gained through 2020.

[168] Refer to Work Paper Vol. 2 (Forecast - Infrared Inspection Program)

[169] Hiked inspections would use a two-person crew for safety and other reasons. Helicopter inspections would be done using a mounted camera with at least a two-person crew.

3. PSPS Protocol Support Functions: Customer Communications and Line Patrols

a) Overview

As discussed in Section II.B.5, SCE's PSPS protocol involves proactively de-energizing portions of SCE's system under extreme fire conditions. Per Resolution ESRB-8, SCE is developing a customer awareness and communication strategy to inform stakeholders about the program, obtain feedback, and provide notice of de-energization events. This includes the town hall meetings SCE is conducting within areas potentially impacted by PSPS events and direct customer mailings providing information about SCE's PSPS protocol. To date, SCE has already conducted town hall meetings in Santa Barbara, Camarillo, and elsewhere, with more planned for the near future. SCE also is meeting with large business customers, telecommunication providers, and water companies.

In addition, operationally, SCE will deploy line patrol crews to assess circuit conditions prior to de-energization and also before restoring service to confirm it is safe to re-energize.[170]

b) What Exists Today

SCE has a communication framework in place to support emergency outages. SCE's existing notification capabilities must be enhanced to support the PSPS protocol due to their lack of functionality and bandwidth. SCE requires a notification system that will permit SCE to send out mass notifications in a timely manner. Moreover, SCE's current notification capabilities do not permit customized messages, including language preferences.

c) Effectiveness

(1) Customer Outreach Activities

SCE agrees with Resolution ESRB-8 that public outreach is an important component of a utility's pre-emptive power shutoff protocol. The Resolution requires

[170] Subject to fire or other public agency approval it is safe to enter impacted area.

SCE and other utilities to complete outreach efforts with state agencies, tribal governments, local agencies, and representative from local communities within 90 days of the Resolution's effective date, July 12, 2018. SCE is also required to submit a report to the Commission outlining its public outreach efforts, and notification and mitigation plan. The plan must include communication methods for informational workshops along with notification plans for when protocols are engaged.

To meet this expectation, SCE is planning and conducting customer outreach activities to increase stakeholders' awareness and understanding of SCE's PSPS protocol. SCE's messaging emphasizes that this is a measure of "last resort" for the utility but is nonetheless very important to have as an option in order to address and mitigate potential fire threats and protect the overall safety of the communities in and around SCE's service area.

Just prior to, during, and following PSPS events, SCE expects customers to contact SCE when they receive emergency outage notifications or otherwise experience impacts associated with PSPS events.

The proposed customer notifications, dedicated customer website, and town hall meetings, along with the Emergency Outage Notification System (EONS) system, all support SCE's public outreach efforts on its PSPS protocol.

(2) Line Patrols

In addition to the customer outreach efforts discussed above, a critical component of SCE's PSPS protocols is to assess potential extreme fire risk conditions with the help of line patrols and monitoring functions (including troublemen and supporting crews) in the field prior to making the decision to de-energize. In addition, SCE will utilize line patrols to assess the condition of each circuit prior to re-energizing after the extreme conditions have subsided as well in order to assist with assessing ignition risks and ensuring public safety prior to re-energizing.

The line patrol activities described above in support of PSPS protocols was not accounted for in SCE's GRC as budgeting was based upon line patrols focused upon a specific circuit with a detected system issue (for example, circuit fault) as compared to a circuit group based upon the PSPS protocols.

d) Forecast

Table IV-26 below summarizes the forecast incremental costs in SCE's request for PSPS Protocol Support Costs.

Table IV-26
2018-2020 PSPS Protocol Support Costs[171]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Direct Customer Mailings	978	990	990	$ 2,958
Town Hall Community Meetings	40	15	15	$ 71
Emergency Outage Notification System	660	1,004	1,004	$ 2,667
Customer Contact Center Support	440	440	440	$ 1,319
Line Patrols	1,048	1,048	1,048	$ 3,144
Grand Total	**$ 3,165**	**$ 3,497**	**$ 3,497**	**$ 10,159**

e) Detailed Program Description

(1) Customer Outreach Activities

Direct Customer Mailings: SCE, as part of its communication strategy supporting PSPS and promoting general wildfire threat awareness, has developed and is sending mailings to customers located within the HFRA. These mailings provide information on SCE's PSPS protocol and invite customers to in-person community meetings for further discussion. SCE expects to continue the yearly mailings for at least the next three years to increase customer knowledge regarding PSPS and provide additional information regarding wildfire mitigation and general outage preparedness.

Town Hall Community Meetings: In further support of SCE's customer engagement efforts, SCE is proactively sponsoring community "Town Hall" meetings that commenced in May 2018 and will continue through October 2018. These sessions are

[171] Refer to Work Paper Vol. 2 (Forecast - Direct Customer Mailings; Forecast – Town Hall Community Meetings; Forecast - Emergency Outage Notification System; Forecast - Customer Contact Center Support; Forecast - Line Patrols)

intended to inform and assist in potential outage preparation and to offer a venue to answer customer questions regarding PSPS. Beyond 2018, SCE primarily expects to hold community meetings based on need or customer request throughout the service area.

Emergency Outage Notification System (EONS): In response to urgent customer information needs during PSPS events and related outages, SCE has procured a software solution provided by Message Broadcast that provides numerous benefits including:

- Ability to quickly and easily create and deliver customized outage communications in the customers' digital channel(s) of preference (Smartphone, SMS text, Email, TTY and Social Media);
- Bandwidth to deliver up to 1.5 million digital outage communications within one hour; and
- Ability to provide near real-time and historic reporting on notifications sent to customers including the ability to see actual customer messages for each communication.

In selecting Message Broadcast, SCE considered various criteria including the ability to distribute high volumes of personalized communications in a short period of time. EONS is expected to be fully deployed as of December 2018 and utilized going forward in support of PSPS outage events. SCE selected Message Broadcast in support of the expected need to send up to 1.5 million customer communications within 60 minutes that is not available through SCE's existing systems. SCE's Automated Outage Communications (AOC) system was originally built as a digital communications platform for contacting Medical Baseline and Critical Care customers regarding Maintenance and Repair Outages. It has since been expanded to include all SCE customer types and is at the peak of its potential capabilities. It does not have the bandwidth to process and distribute Emergency Outage Notifications to customers in a short period of time.

Customer Contact Center Support: In conjunction with the increased PSPS patrols, SCE intends to provide support for customers during PSPS events via its Customer Contact Center, but anticipates additional resources to support the incremental increase call volumes associated with PSPS events.

(2) Line Patrols

SCE intends to deploy crews upon alert of a potential PSPS event to assess extreme fire conditions as part of factors to be considered in making the decision to de-energize. In addition, these additional crews will be needed to visually inspect primary conductors and associated assets to determine that circuits have not sustained damage and are safe to re-energize.

4. Mobile Generator Deployment

a) Program Overview

Because PSPS may disrupt electric services to critical electrical loads and essential customers, SCE plans to contract the deployment of temporary mobile generators for Essential Use[172] customers to assist maintaining electric service for essential life, safety, and public services on a case-by-case basis. These case-by-case decisions will be made by SCE's IMT, based on the unique circumstances associated with each event. SCE's supply chain organization performed a competitive solicitation for generator regional vendors who could support mobile generator deployment, and will keep a list of generator vendors assigned to different regions.

b) What Exists Today

Today, SCE does not have a specific program to provide mobile generators for PSPS events. In support of Essential Use customers, SCE may elect to provide temporary mobile generators to preserve critical public functions.

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[172] Essential Use customers are defined by the Commission as those that provide essential public health, safety, and security services. *See* General Order 166. Examples include agencies providing essential fire or police services, hospitals and skilled nursing facilities, communications utilities, facilities supporting fuel and transportation services, water and sewage treatment utilities, and others.

c) Effectiveness

In situations where SCE is preparing to initiate PSPS, the deployment of mobile generators will support maintaining service to Essential Customer needs.

d) Forecast

Table IV-27 below summarizes the forecast incremental costs in SCE's request for Mobile Generator Deployment.

Table IV-27
2018-2020 Mobile Generator Deployment Costs[173]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Mobile Generator Deployment	137	137	137	$ 411
Grand Total	**$ 137**	**$ 137**	**$ 137**	**$ 411**

e) Detailed Program Description

Under the plan, SCE would begin to assess emergency generator deployment once SCE's Business Resiliency weather staff forecasts or identifies extreme fire conditions. Once these conditions become a credible threat, the Business Resiliency organization will hold a situational awareness call with internal stakeholders (SCE Organizations including: Transmission and Distribution, Customer Service, Public Affairs, etc.) to determine if PSPS monitoring activities (in-field weather measurements coupled with microclimatic and environmental assessments at the circuit level) should move forward. This decision will be primarily based on a combination of weather forecasts (National Weather Service, SCE weather stations, external weather data, etc.) and various environmental factors (fuel volume, fuel moisture content, vegetation health/density, etc.) that are predicted or exist near the affected circuits.

If the decision is made to move forward with PSPS monitoring, the Electrical Services Incident Management Team (ESIMT) will be activated (if not already deployed). The Operations Section Chief will work with the IMT Logistics Section to determine

[173] Refer to Work Paper Vol. 2 (Forecast - Mobile Generation Deployment)

availability and begin sourcing of generators for areas that may be affected by a PSPS event, while the PSPS Task Force (special team tasked with assessing the impacts of executing a PSPS event) begins to coordinate the need and sizing of generators to be deployed.

SCE's Supply Chain Organization performed a competitive solicitation for generator regional vendors who could support mobile generator deployment to which a mobile generator selection vendor list was created. SCE's Logistics Section will have a list of generator vendors assigned to different regions. The Logistics Section is in charge of identifying generator source(s) and provide preliminary estimates of when the generators will become available. For generators 500 kW and below, the expected turnaround time is between two to three hours from initial call until the generator is delivered on-site. Generators greater than 500 kW typically can be delivered within 24 hours.

f) Alternatives Considered

SCE considered two other mobile generator alternatives, listed below in Table IV-28. The first alternative involves providing mobile generation solely to Critical Care customers (138 customers assumed for purposes of alternative deployment). This results in a projected increase of $939,315 annually. However, this alternative would require a significant amount of Qualified Electrical Workers to install and disconnect the generators, thus precluding them from providing their critical functions and support to SCE's service area during a PSPS event (monitoring, patrolling, troubleshooting, repairs, etc.).

The second alternative includes providing mobile generation for all Medical Baseline and Essential Use customers (853 customers assumed for purposes of alternative development). This results in a projected increase of $6,820,515 annually and would also stretch existing resources similar to alternative one. SCE is, however, proactively addressing these segments of Medical Baseline customers through education/outreach materials and workshops, urging these customers to plan ahead for outages—regardless of cause—and to have adequate backup generation or uninterruptible power supplies to power critically important medical devices.

Table IV-28
Mobile Generator Deployment Alternatives

Alternatives	Estimated Number of Circuits Proactively De-energized Annually	Essential Customers Proactively De-energized Annually	Critical Care Customers Proactively De-energized Annually	Medical Baseline Customers Proactively De-energized Annually	Total Mobile Generators Needed	Total Annual Cost	Difference from Proposal
Alt 1	60	n/a	138	n/a	138	$ 1,076,400	$ 939,315
Alt 2	60	39	138	715	892	$ 6,957,600	$ 6,820,515

5. Portable Community Power Trailers

a) Program Overview

SCE's customers may be without power for extended periods due to wildfire mitigation efforts, including PSPS activation and/or more planned outages associated with hardening the grid and installing technologies that reduce wildfire risk. Although SCE has developed a public outreach plan in support of PSPS, including overall wildfire awareness and preparation, SCE expects that some customers will need some assistance in receiving critical messages from SCE, public agencies, first responders, news agencies, social media, etc. SCE's proposed Portable Community Power Trailers (PCPTs)—towable trailers equipped with a clean, hybrid renewable generation system and energy storage—can be deployed within three to four hours to any HFRA community to provide outreach and support to affected customers.

b) What Exists Today

SCE's current customer outreach efforts consist mainly of sending a team of SCE employees to incident centers to interact with customers, answer questions, share helpful information, and, at times, pass out LED flashlights, water, etc. This typically involves setting up portable, temporary shade structures, tables, and chairs and staffing the event with various employees from across the utility.

However, while this solution may be acceptable when responding to incidents after they have occurred or after inclement weather has passed, it is not suitable to have temporary shade structures, tables, chairs, and other miscellaneous items staged outside during high fire conditions, (e.g., when there are 50+ mile an hour winds). A robust, stable, and strong platform solution provides a safe and resilient platform to connect with the communities SCE serves in order to provide needed amenities during PSPS events and extended repair or maintenance outages.

c) Effectiveness

As referenced in Resolution ESRB-8: "Increased coordination, communication and public education can be effective measures to increase public safety and minimize adverse impact from de-energization." SCE agrees, and considers in-situ outreach an important component of event coordination, communication, and outreach. Moreover, these Portable Community Power Trailers will have a reliable and clean source of back-up power so that customers can plug in and charge their personal devices (mobile phones, tablets, laptops, etc.) so that they can continue to receive information/updates from SCE about their outage, listen for relevant public safety broadcasts, and/or connect with friends and family concerned with their well-being.

d) Forecast

Table IV-29 below summarizes the forecast incremental costs in SCE's request for PCPTs.

Table IV-29
2018-2020 Portable Community Power Trailer Unit Costs [174]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Portable Community Power Trailers	1,102	9	9	$ 1,120
Grand Total	**$ 1,102**	**$ 9**	**$ 9**	**$ 1,120**

e) Detailed Program Description

SCE forecasts the need for eight PCPTs to enable rapid response (approximately three to four hours) to community needs across its service area. The PCPTs

[174] Refer to Work Paper Vol. 2 (Forecast - Portable Community Power Trailers)

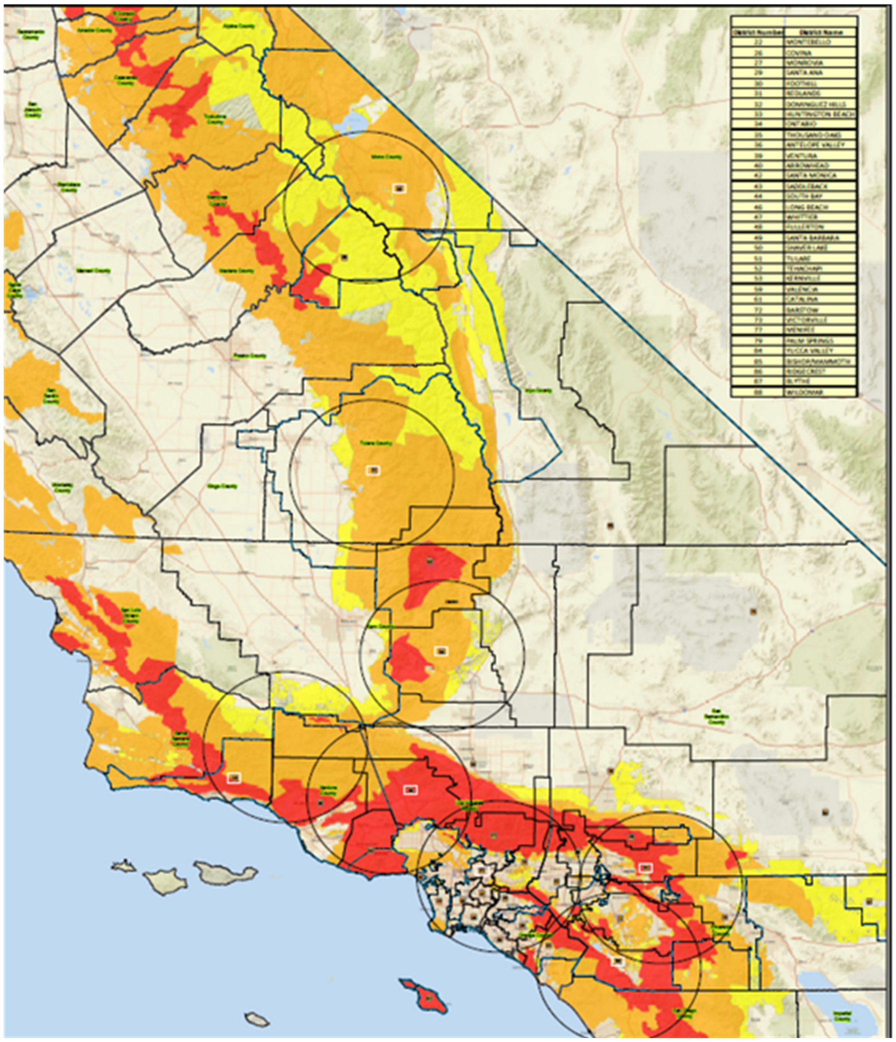
would be located at strategic locations throughout SCE's 50,000 square mile service area, with a particular focus on deployment in HFRA.

The two-axle, 10-foot industrial trailers would be equipped with a clean hybrid generation and energy storage system, consisting of a deployable 2.25 kW photovoltaic (PV) array, 6.5 kW liquid propane generator, 130 lbs. of propane fuel, 6 kW 120/240 VAC utility interactive inverter/charger, and 10.7 kWh AGM battery storage system. With the PV array deployed and outriggers extended, the PCPT can be deployed in winds in excess of 100 mph. Moreover, depending on electrical demand, the unit can easily run on battery energy storage alone, reducing the need to run the fossil fueled backup generators for much of the day while in service.

The primary goal of the PCPTs is to provide charging stations for mobile phones, laptops, and tablets—personal devices that customers rely upon for important notifications and updates from SCE about their outage, relevant public safety broadcasts, and to stay in contact with family and friends. A mobile hot spot may be provided for those without mobile broadband connections, and a large TV screen will stream local news channels via local online TV streaming. The PCPTs will also be outfitted with a fire extinguisher, first aid kit, and informational brochures and resources. Depending on the type of event supported and weather conditions, water and/or snacks may be provided on a case-by-case basis.

The PCPTs would be deployed based on direction from the IMT Incident Commander (IC) when SCE's Weather Services team forecasts extreme fire conditions and monitoring of impacted areas begins. PCPTs would ideally be onsite at least 12-24 hours before power is shutoff, and stay deployed until after the event ends and the IMT determines there is no need for further outreach. If there is significant damage to SCE assets as a result of the storm and it is safe to stay operational, the PCPT team may elect to stay in the community to communicate about repair efforts and continue supporting the community until repairs can be effected. Figure IV-23 shows the proposed deployment of the PCPTs.

Figure IV-23
Portable Community Power Trailer Unit Deployment



1. (85) Bishop/Mammoth Service Center
2. (51) Tulare Service Center
3. (52) Tehachapi Service Center
4. (49) Santa Barbara Service Center
5. (59) Valencia Service Center
6. (22) Montebello Service Center
7. (31) Redlands Service Center
8. (88) Wildomar Service Center

f) <u>Alternatives Considered</u>

SCE considered two lower cost alternatives. Alternative one consisted of a much smaller, single axle trailer, but this option provided minimal storage space for ancillary equipment and outreach materials and little to no space for staff to take a break from the elements, and for these reasons was deemed inadequate.

Alternative two consisted of the hybrid renewable generation system with backup generator and battery storage capability, but on a flatbed trailer with no enclosed storage space to hold and protect outreach materials/equipment or allow staff to take a break from the elements. For these reasons, Alternative two was also deemed inadequate.

E. Wildfire Mitigation Program Study Costs

Table IV-30 below summarizes the forecast incremental costs in SCE's request for Wildfire Mitigation Program Studies.

Table IV-30
2018-2020 Studies Costs[175]

O&M (2018 Constant $000)				
Deliverable	**2018**	**2019**	**2020**	**Total**
Distribution Fault Anticipation Technology Study	198	68	40	$ 306
Advanced Unmanned Aerial Systems Study	113	453	340	$ 907
High Resolution Weather Related Study	200	-	-	$ 200
Grand Total	**$ 512**	**$ 521**	**$ 380**	**$ 1,413**

1. Distribution Fault Anticipation Technology Program Study

SCE plans to deploy and perform a program study on Distribution Fault Anticipation (DFA) technology for ten distribution circuits located in HFRA.[176] This technology was developed collaboratively by Texas A&M Engineering and the Electric Power Research Institute, Inc. (EPRI). SCE currently receives line circuit data from monitoring and protection systems and performs utility preventive maintenance accordingly. Data gained from the DFA deployment could be used to further assist with the diagnosis of potential system failures in support of equipment repair/replacement and reduction of potential fire ignition risks and reliability impacts.

DFA allows for continuously monitoring circuit current and voltage waveforms, from utility substation current and potential transformers (CT's and PT's, respectively) and

[175] Refer to Work Paper Vol. 2 (Forecast - High Resolution Weather Related Study; Forecast - Distribution Fault Anticipation Technology Program Study; Forecast - Advanced Unmanned Aerial Systems Study)

[176] The program study will be performed on a twelve month period.

applying digital signal processing, pattern matching, along with other software techniques to report ongoing and developing circuit events and conditions that could be used in support of maintenance decisions as appropriate.

The DFA module will be located within the substation and monitoring circuits impacts as the circuits leave the station. SCE intends to study the information received from the DFA program study in determining future deployment decisions to further assist in support of equipment maintenance reviews. The DFA module will be located within the substation and will monitor circuits impacts as the circuits leave the station. SCE intends to study the information received from the DFA program study in determination of future deployment decisions to further assist in support of equipment reviews.

2. Advanced Unmanned Aerial Systems Study

The Advanced Unmanned Aerial Systems (UAS) study project will inform and advance SCE's existing UAS program by exploring the capabilities of Beyond Visual Line of Sight (BVLOS) flight. SCE's UAS program is developing the capability to expedite patrolling utility lines following a PSPS event or other extended outage, to more quickly and safely restore power to its customers.[177] SCE plans to contract with an approved UAS vendor with significant experience in BVLOS flight in order to explore these capabilities, better understand how to successfully navigate the restrictive Federal Aviation Administration (FAA) regulations governing BVLOS flight, and lay the foundation to establish an internal BVLOS UAS program.

Today, SCE's Aircraft Operations department currently owns and operates three UAVs, in addition to a small fleet of helicopters, for conducting a wide variety of operations (e.g., pole sets, inspections, line patrols, etc.) across the utility. Aircraft Operations is routinely called upon to conduct circuit patrols of utility lines that are particularly long, traverse mountainous or heavily vegetated terrain, and/or traverse terrain that is difficult to access via the ground. SCE currently utilizes helicopters to conduct select circuit patrols following extreme

[177] Outages following extreme wind or weather events require a patrol of SCE's lines before they can be re-energized.

weather conditions when called upon by SCE's Grid Operations department, who may have difficulty accessing these lines for a visual inspection or may otherwise be resource constrained. It is particularly important to patrol lines prior to re-energization following an extreme wind or weather event in case foreign objects have come into contact with electrical lines (which could ignite fires upon re-energization) or lines have been knocked to the ground due to extreme weather. UAVs are currently not used for circuit patrols due to FAA regulations that generally require the UAV to be within line of sight of the operator or pilot.

As described earlier in this testimony, SCE may need to leverage the PSPS protocol to address increasing wildfire risk. In some cases, SCE estimates that PSPS outages could last up to 72 hours. Therefore, it is important to restore power to customers quickly and safely following extreme fire and weather conditions. The ability to conduct circuit patrols via UAV operating BVLOS is expected to be a more efficient and cost-effective means to inspect electrical assets, especially for large-scale outages when resources may already be constrained. Moreover, the lessons learned from the pilot project can be applied in the future for developing an in-house BVLOS program to conduct other important utility work (e.g., equipment inspections, asset mapping, etc.).

Since the areas or circuits SCE wishes to patrol are already difficult to access, this currently precludes the use of drones as an efficient means of conducting a circuit patrol. Additionally, while traditional aircraft can be an efficient means of inspecting assets, it is relatively expensive (compared to a UAV) and helicopters are much better suited to fully utilize their additional payload capability for more heavy-duty restoration efforts. UAVs take advantage of the efficiency of traditional manned aircraft inspections but at a much lower cost due to the lower cost of the resources required to operate and maintain them. Exploring, and ultimately achieving, the ability to perform BVLOS flights via UAS would be a more efficient and affordable way to conduct circuit patrols following a PSPS event or extended outage in an effort to safely expedite the restoration of power to SCE customers. The ability to perform

BVLOS UAV flights could provide a valuable new tool given the diverse geography of SCE's service area.

3. High Resolution Weather Forecast Study

From September 2018 through September 2019, SCE will perform a program study in support of a high-resolution weather forecast tool providing near-real time, high-resolution operational weather forecasts for weather parameters such as precipitation, wind speed and direction, wind gust, temperature, and humidity. This study will gather weather information and map it against SCE infrastructure, via an interactive web application. Furthermore, it is expected to notify SCE personnel about potential weather hazards.

The high resolution forecast tool is expected to incorporate a combination of traditional weather models and proprietary technology to increase forecast accuracy, confidence, and resolution. More specifically, it utilizes information gained from cellular phone towers, along with other inputs, to provide enhanced weather forecasting that is more accurate than existing forecast capabilities. Forecast resolution and temporal granularity is expected to provide unique information that existing forecast products do not currently offer. These data give the user the ability to drill down to specific locations with high confidence and accuracy.

Forecasts produced under this program study are also expected to be easily incorporated into and enhance many of SCE's system situational awareness reports utilized to support emergency response and related planning efforts. This includes pre-staging response personnel and/or taking preemptive action to provide for the safe operation of SCE's system by cancelling planned outages or executing PSPS during dangerous or extreme weather. SCE's main focus will be using the data to make wildfire mitigation-related operational decisions, such as cancelling planned maintenance during high fire weather conditions (e.g., high winds coupled with high temperatures and low humidity). The high-resolution data will also help SCE evaluate new models, reports, and indices used to communicate risks around severe weather events.

SCE will track the accuracy of forecasts produced under this program study against forecasts received from traditional weather models and vendors. These accuracy reports will inform future decisions about forecast modeling use and supporting companies, and SCE's long-term use of this product.

V.

COST RECOVERY

A. Summary of SCE's Ratemaking Proposal

This Chapter presents SCE's ratemaking proposal for the GS&RP. SCE proposes to establish: (1) an initial GS&RPMA to be effective on September 10, 2018,[178] the date of this Application, and (2) the GS&RPBA, effective upon a final Commission decision. Both accounts will record the GS&RP incremental actual O&M expenses and capital-related revenue requirements (e.g., depreciation, return on rate base, property taxes, and income taxes) to provide for the recovery of all recorded GS&RP-related costs. Amounts recorded in the GS&RPMA would be transferred to the GS&RPBA upon a final Commission decision. Beginning in 2019, SCE requests to include in distribution rates a forecast GS&RP revenue requirement for each year up until the time these revenue requirements are included in SCE's 2021 GRC.

SCE respectfully requests the Commission authorize the GS&RPMA immediately, so the utility can begin recording expenses associated with implementing critical program activities, including deploying covered conductor throughout circuits in HFRA. However, SCE will not recover in rates amounts recorded in the GS&RPMA until approved by the Commission in this proceeding.

Because the Commission will perform a full reasonableness review of the scope of the GS&RP activities and forecast costs in this proceeding, SCE requests the Commission establish a "reasonableness threshold" be set at 115% of the total GS&RP capital and O&M forecast of $582 million (2018 $) over the 2018 – 2020 time period, or $670 million (2018 $). SCE proposes that the total recorded spend up to the $670 million (2018 $) be deemed reasonable and any amount of total spend recorded in excess of these amounts will be subject to a traditional reasonableness review in a future application. To further support a "reasonableness threshold," SCE proposes that no further reasonableness of the GS&RP is required if: (1) SCE GS&RP

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[178] SCE's forecast costs are as of September 10, 2018 filing date.

spending is less than or equal to the reasonableness threshold and (2) SCE manages the cost per circuit mile for the covered conductor program to up to 115% of the estimated amount supported in Chapter IV, Section B, or $428k/mile in 2018. If the cost for the covered conductor program exceeds $493k/mile, escalated appropriately, then SCE will file an application to support why the cost to install covered conductors were greater than that threshold.

In addition to a detailed description of the entries and operation of the GS&RPMA and the GS&RPBA and proposed reasonableness standards, this chapter also presents an overview of currently authorized or pending wildfire risk reduction ratemaking mechanisms.

B. <u>Overview of SCE's Currently Authorized or Pending Ratemaking Mechanisms Associated with Wildfire Risk Reduction Cost Recovery</u>

To date, SCE has requested incremental costs as the result of wildfires (e.g., SCE's March 14, 2018 "Z-Factor" advice letter for incremental wildfire insurance cost), and the Commission has previously authorized ratemaking accounts associated with the recovery of certain costs associated with mitigating fire risk (e.g., Fire Hazard Prevention Memorandum Account (FHPMA)). This Chapter addresses where those costs, which do not include the costs requested in this Application that are associated with the GS&RP, are being addressed.

1. <u>Z-Factor</u>

SCE's authorized Z-Factor mechanism is a post-test year ratemaking mechanism for significant events outside of SCE's control and the normal course of business. Preliminary Statement Part AAA provides for Z-Factor recovery through a Tier 3 advice filing with the burden of proof on SCE to prove that its request satisfies stated Z-Factor criteria. Cost recovery is first subject to a $10 million deductible and costs must: be related to exogenous event; be beyond management's control; not be a normal part of business; disproportionately impact the company; be reasonable; and satisfy other, similar criteria.

On December 29, 2017, SCE sent a notification letter to the Commission's Executive Director explaining the urgent need to replenish its wildfire insurance in 2017 and provided notice of SCE's intent to establish a Z-factor for costs associated with incremental wildfire-related liability insurance related to the December 2017 California wildfires. On March 14, 2018, SCE filed a Tier 3 Advice Letter 3768-E requesting Z-Factor recovery of $107 million of net premium costs incurred to obtain a 12-month, $300 million wildfire insurance policy for 2018. SCE obtained the insurance policy from the only insurer in the global market willing to provide this much capacity of sufficiently broad insurance coverage this low in the insurance "tower" for a California private electric utility. Per SCE's advice letter, this mechanism would currently only cover SCE's purchase of additional wildfire insurance in December 2017. Advice Letter 3768-E remains pending before the Commission for approval.

2. Wildfire Expense Memorandum Account (WEMA)

On April 3, 2018, SCE filed an application to seek authority to establish the WEMA. If approved by the Commission, this account will be used to track incremental unreimbursed wildfire liability-related costs. Specifically, in its application, SCE proposed to create a WEMA to track all amounts paid by SCE that are the result of a wildfire, and that were not previously authorized in SCE's GRC, including: (1) payments to satisfy wildfire claims, including any co-insurance, deductibles, and other insurance expense paid by SCE; (2) outside legal expenses incurred in the defense of wildfire claims; (3) payments made for wildfire insurance and related risk-transfer mechanisms; and (4) the cost of financing these amounts.[179]

The costs that will record to this account are inherently different from the costs included in this application. Moreover, the Commission has not yet approved SCE's WEMA application. As such, no costs have been recorded to SCE's proposed WEMA.

3. Catastrophic Event Memorandum Account (CEMA) – 2015 – 2016 Drought and 2016 Fires

Commission Resolution ESRB-4 directed the IOUs to reduce the likelihood of fires caused by their facilities by increasing vegetation inspections and removing hazardous, dead and sick trees and other vegetation near power lines and poles. In addition the IOUs were

[179] A.18-04-001, p. 3.

directed to share resources with CalFire to staff lookouts near IOU property and to clear access roads under power lines for fire truck access.

On March 1, 2018, SCE filed its CEMA Application (A.)18-03-004 requesting that the Commission authorize SCE to recover costs recorded in SCE's CEMA associated with the 2015-2016 drought, the 2016 Erskine Firestorm, the 2016 Sand Firestorm, and the 2016 Blue Cut Firestorm. The Governor issued a State of Emergency Proclamation for each of these events making them eligible for incremental cost recovery. Pursuant to California Public Utilities Code Section 454.9, SCE only requested to recover the costs it incurred to: (1) restore service to customers, (2) repair, replace, or restore damaged facilities, and (3) comply with governmental agency orders in connection with events declared disasters by competent state or federal authorities.[180]

In its testimony, SCE (1) described the CEMA Drought and the efforts SCE took to mitigate the effect of the Drought on SCE's systems; (2) described each of the CEMA Firestorm Events referenced above and the extensive damage to SCE's infrastructure caused by these severe storms; (3) described the actions SCE took to respond to these catastrophes, including restoring service to its affected customers; (4) documented the incremental capital-related costs SCE incurred in restoring service and repairing, replacing, or restoring its infrastructure after each CEMA Firestorm Event; and (5) requested authority from the Commission to recover in rates the incremental Drought O&M and Firestorm-related capital revenue requirement recorded in its CEMA subaccounts.

The vegetation management activities as described in Section IV.D.1 of this testimony are above and beyond the activities described in Resolution ESRB-4 and therefore SCE is seeking recovery of these incremental vegetation management costs in the GS&RPBA (or, as noted earlier, SCE believes that alternatively these costs could be recorded in the Drought CEMA).

[180] State of Emergency Proclamations were issued by the Governor's Office for each of the CEMA events.

4. **Fire Hazard Prevention Memorandum Account (FHPMA)**

On October 1, 2009, SCE filed Advice Letter 2387-E to establish the FHPMA in compliance with D.09-08-029.[181] The original purpose of this account was to track the difference between all fire hazard prevention costs that related to activities necessary to implement the requirements of D.09-08-029, and the amounts previously authorized in SCE's 2009 GRC. Specifically, D.09-08-029 authorized SCE to track: (1) expenses associated with vegetation management; (2) increased expenses related to the maintenance program, inspection program and patrolling requirements; (3) expenses incurred in designing, constructing, and maintaining facilities to mitigate fire hazards in high speed wind areas; and (4) other expenses incurred in implementing D.09-08-029.

In SCE's 2012 GRC, SCE included a forecast for these activities. As such, after the 2012 GRC Decision was issued, the FHPMA was no longer used to track the costs for these activities. In January 2012, the Commission issued D.12-01-032 in Phase 2 of OIR 08-11-005. Utilities were required to prepare and issue a fire prevention plan. In 2015, the Commission issued R.15-05-006 to develop and adopt fire threat maps and fire safety regulations. This rulemaking significantly lessened the scope of activities that SCE was authorized to track in the FHPMA.

The Commission adopted D.17-12-024 on December 21, 2017 adopting new regulations to enhance the fire safety of overhead electric power lines in high fire-threat areas. Specifically, this decision added a new high fire-threat district to General Order (GO) 95. In addition, it amends various GO 95 rules to increase line clearance and inspection cycles. It also required each electric IOU to prepare a fire-prevention plan. This decision authorizes electric IOUs to track the costs in the FHPMA incurred to implement the regulations adopted by D.17-12-024.[182] The FHPMA will remain open for R.15-05-006 costs until the first GRC after the

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[181] The Commission issued D.09-08-029, Measures to Reduce Fire Hazards in California before the 2009 Fall Fire Season, in Phase 1 of Order Instituting Rulemaking (OIR) 08-11-005.

[182] *See* D.17-12-024 p. 4.

rulemaking proceeding is closed. Recovery of the FHPMA ending balance may be sought by application.

The Commission closed R.15-05-006 in January 2018 and therefore SCE currently anticipates it will seek recovery of amounts recorded in its FHPMA in the 2021 GRC.

5. <u>Wildfires Customer Protections Memorandum Account (WCPMA)</u>

On November 27, 2017, SCE filed Advice Letter 3707-E pursuant to Resolution M-4833 to implement emergency residential protections for affected SCE residential customers in Orange County affected by the two Canyon fires. In compliance with Ordering Paragraph 4 of the Resolution, SCE established the Wildfires Customer Protections Memorandum Account (WCPMA) to record costs associated with customer protections pursuant to Resolution M-4833. These protections will be in effect for one year until November 9, 2018. Specifically, the Resolution orders the implementation of the following emergency residential protections for one year:

1. Waive Service Disconnection, Security Deposit, and Late Fees for affected wildfire residents;
2. Expedite move-in and move-out service requests;
3. Stop estimated energy usage for billing attributed to the time when the home/unit was unoccupied because of the wildfires;
4. Implement payment plan options; and
5. Support low-income customers affected by the December 2017 wildfires.

On January 26, 2018, the Commission's Executive Director issued a letter to the energy utilities directing the utilities to propose similar relief as adopted by Resolution M-4833 for their non-residential customers as well. As such, SCE filed Advice Letter 3707-E-A to provide protection measures for both residential and non-residential customers affected by the wildfires in Orange County. Advice Letter 3707-E-A was approved by Energy Division on January 2, 2018.

On January 26, 2018, SCE filed Advice Letter 3733-E to implement emergency customer protections for residential and non-residential customers affected by the December 2017 wildfires and January 2018 mudslides pursuant to Resolution M-4835. As such, SCE revised the WCPMA to include residential and non-residential customers affected by the Thomas Fire, Montecito mudslides, Creek and Rye fires, and the Liberty fire. The WCPMA will remain in effect for one year until January 11, 2019, unless otherwise specified or extended by order of the Commission per Resolution M-4835. Advice Letter 3733-E was approved by the Energy Division on March 7, 2018.

6. 2018 GRC

SCE did not include any GS&RP-related costs in its 2018 GRC revenue requirement, therefore SCE will record GS&RP costs in the GS&RPBA over the 2018 GRC period. In the 2021 GRC, SCE anticipates it will then include on-going GS&RP-related costs in the test year revenue requirement, which will also include the on-going capital-related revenue requirement for the capital expenditures incurred prior to 2021.

C. Description of Grid Resiliency Program Memorandum Account

To enable recovery of SCE's actual incremental revenue requirements, SCE seeks to establish the GS&RPMA to be effective on the date SCE files its Application. The initial revenue requirements associated with incremental costs incurred for the GS&RP will be recorded in the GS&RPMA. Similar to all Commission-approved memorandum accounts, the GS&RPMA will protect against retroactive ratemaking concerns yet will not guarantee recovery in rates of any of the recorded costs prior to Commission review and approval in this application. SCE proposes to only use this interim ratemaking (i.e., the GS&RPMA) to record incremental costs prior to a Commission decision in the proceeding. Recovery of the balance in the GS&RPMA will be through the GS&RPBA as discussed in the following section.

SCE requests that the GS&RPMA be made effective as of the date of this filing so that SCE may expeditiously track costs in the account that it anticipates incurring during the pendency of the Commission's disposition of this application.

D. Description of Grid Resiliency Program Balancing Account

The two-way GS&RPBA will record the actual O&M, payroll taxes, and capital-related revenue requirement (e.g., depreciation, return on rate base, property taxes, and income taxes) on a monthly basis. The GS&RPBA will be effective upon the Commission's final decision in this proceeding.

Each month, SCE will record in the GS&RPBA:

- An initial transfer of the recorded activity in the GS&RPMA (debit);
- Capital-related revenue requirements (debit), including depreciation, return on rate base, property taxes, and income taxes based on recorded capital additions and rate base; and
- Recorded incremental O&M costs (debit)

All recorded incremental costs will include provisions for overhead loadings on direct labor dollars, to account for items such as benefits and payroll taxes.[183] In addition, interest expense will accrue each month in the GS&RPBA at the three-month commercial paper rate until the year-end transfer of the GS&RPBA balance to the BRRBA.

E. Proposed Reasonableness Review of GS&RP Expenditures Forecast

1. Proposed Reasonableness Threshold

Because the Commission will perform a full reasonableness review of the scope of the GS&RP activities and forecast costs in this proceeding, SCE requests the Commission establish a "reasonableness threshold" for all recorded amounts. In this Application, SCE proposes a GS&RP reasonableness threshold be set at 115% of the total GS&RP capital and O&M forecast of $582 million (2018 $) over the 2018 – 2020 time period, or $670 million (2018 $). SCE proposes that the total recorded spend up to the $670 million (2018 constant $) be

[183] Overhead loading factors will be based on authorized rates. The revenue requirements presented herein reflect all SCE labor loadings. However, to the extent a particular labor loading is currently accounted for in another balancing account (e.g., Pensions, Post-Employment Benefits Other Than Pensions (PBOPS), Medical, Dental and Vision), SCE will not include these labor loadings in the recorded operation of the GS&RPBA.

deemed reasonable and any amount of total spend recorded in excess of these amounts will be subject to a traditional reasonableness review in a future application. To further support a "reasonableness threshold," SCE proposes that no further reasonableness of the GS&RP is required if: (1) SCE GS&RP spending is less than or equal to the reasonableness threshold and (2) SCE manages the cost per circuit mile for the covered conductor program to up to 115% of the estimated amount supported in Chapter IV, Section B, or $428k/circuit mile[184]. If the cost for the covered conductor program exceeds $493k/mile, then SCE will file an application to support why the cost to install covered conductors were greater than that threshold. The threshold defined is supported by generally accepted cost engineering practices and considers the level of scope definition, detailed engineering, detail of unit costs, and potential accuracy ranges.

2. Proposed Review Process

The Commission's review of GS&RP program costs spent up to the reasonableness threshold will occur in the annual ERRA Review proceedings to ensure account entries are stated correctly and associated with GS&RP activities as defined and approved by the Commission.

F. Rate Recovery of Recorded GS&RP Revenue Requirements

To help ensure that customers only pay the actual GS&RP revenue requirements, SCE proposes to transfer the revenue requirement recorded in the GS&RPBA to the distribution sub-account of the Base Revenue Requirement Balancing Account (BRRBA) on an annual basis. Using this approach, any difference between the forecast GS&RP revenue requirements included in rate levels and the actual recorded GS&RP revenue requirements will be trued up in the BRRBA. This proposed ratemaking provides that no more and no less than the reasonable revenue requirements associated with the GS&RP activities will ultimately be collected from customers. Any over-collection recorded in the BRRBA at the end of each year will be refunded

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[184] Based on 592 circuit miles.

to customers in the subsequent year. Similarly, any undercollection recorded in the BRRBA at the end of each year will be recovered from customers in the subsequent year.

G. Forecast GS&RP Revenue Requirements

Table V-31 below presents SCE's forecast 2018-2020 revenue requirements for the GS&RP:

Table V-31
Forecast 2018-2020 GS&RP Programs Revenue Requirements
(in Millions of Nominal Dollars)[185]

Total Grid Resiliency | Thousands of Nominal Dollars					
Line	**Description**	**2018**	**2019**	**2020**	**Total**
1	O&M	8,138	54,643	118,314	$181,094
2	Franchise Fees & Uncollectibles	120	773	1,735	$2,629
3	Depreciation	1,551	5,904	14,162	$21,616
4	Taxes	(1,298)	(1,991)	(4,048)	($7,337)
5	Return	1,979	8,022	21,070	$31,071
6	**Total Revenue Requirement**	**$10,490**	**$67,349**	**$151,233**	**$229,072**

Beginning in 2019, SCE requests to include in distribution rates a forecast GS&RP revenue requirement for each year up until the time these revenue requirements are included in SCE's 2021 GRC. SCE proposes to include the GS&RP forecast revenue requirement in an advice letter to be filed in November of each year beginning in November 2018. In the annual advice letters, SCE will update the GS&RP revenue requirements to reflect the prior year recorded capital expenditures, any forecast capital expenditure changes in the following year, and also the most recently adopted rate of return on rate base, franchise fees and uncollectible rates, and tax rates. SCE will then consolidate the changes in its distribution rates to reflect these updated GS&RP revenue requirements in conjunction with other authorized rate level changes in its January 1 consolidated revenue requirement and rate change advice letter.

1. Capital Expenditures and Additions

SCE's forecasted revenue requirement as shown in Table V-31 above were derived based on estimated direct capital expenditures of $407 million (2018 constant $), as

[185] Refer to Work Paper Vol. 2 (Revenue Requirement)

supported in Section IV of this testimony and shows estimated direct capital expenditures escalated for each calendar year. The total estimated expenditures of $407 million are forecast to close to plant-in-service as the assets are placed in service.

Table V-32
Forecast 2018-2020 GS&RP Capital Expenditures

Capital (2018 Constant $000)					
Line	**Description**	**2018**	**2019**	**2020**	**Total**
1	**Grid Hardening**				
2	Wildfire Covered Conductor	33,936	45,979	204,927	$284,842
3	Remote-Control Automatic Reclosers	-	8,789	18,076	$ 26,864
4	Fusing Mitigation	11,923	44,949	9,362	$ 66,235
5	**Total Grid Hardening**	**$45,859**	**$ 99,716**	**$232,365**	**$377,941**
6	**Enhanced Situational Awareness**				
7	HD Camera	1,123	2,272	741	$ 4,136
8	Weather Station	1,066	5,922	6,345	$ 13,334
9	Advanced Modeling Computer Hardware	2,943	3,722	1,330	$ 7,995
10	Asset Reliability and Risk Analytics	3,380	505	-	$ 3,885
11	**Total Enhanced Situational Awareness**	**$ 8,512**	**$ 12,421**	**$ 8,416**	**$ 29,349**
12	**Capital Total**	**$54,371**	**$112,137**	**$240,781**	**$407,290**

a) Capital Additions and Plant-In-Service

Capital expenditures are not included in rate base until the assets are ready for service. The accounting for this is prescribed by the Federal Energy Regulatory Commission ("FERC") Uniform System of Accounts ("USoA"). When incurred, capital expenditures record to FERC Account 107, Construction Work In Progress ("CWIP"). While in CWIP, costs typically accrue capitalized financing costs (known as Allowance for Funds Used During Construction ("AFUDC") at rates based on a prescribed formula in the FERC USoA. Once ready for service, cumulative costs, including AFUDC, are transferred from CWIP to Plant-In-Service[186] as Capital Additions. At this same time, AFUDC accruals are stopped, the cumulative balance is included in rate base, and depreciation expense begins.

[186] Plant-In-Service includes FERC Accounts 106 (Completed Construction Not Classified) and 101 (Electric Plant-In-Service).

For purposes of forecasting capital for the GS&RP, SCE has assumed that AFUDC accruals will be zero. However, on a recorded basis, the GS&RPBA will reflect actual recorded revenue requirements, including all applicable overheads and AFUDC to the extent that they are incurred.

b) Depreciation Expense and Accumulated Depreciation

Line 3 of 6 in Table V-32 above shows forecast total annual depreciation expense of $21.6 million over the 2018 – 2020 period. Annual depreciation expense in this application are based on the authorized depreciation rates in SCE's 2015 GRC.[187] On a recorded basis, SCE will utilize its 2015 GRC authorized depreciation rates. When a Final 2018 GRC Decision is available, SCE will true-up the recorded depreciation expenses in the GS&RPBA to reflect its then authorized depreciation rates.

2. Rate of Return

SCE calculated the return on rate base using SCE's current authorized rate of return of 7.61 percent established in D.17-07-005 and subsequently approved in Advice Letter 3665-E. On a recorded basis, SCE will update its rate of return on rate base to be consistent with the then-currently authorized rate of return.

3. O&M Expenses

SCE's forecasted revenue requirements as shown in Table V-31 were derived based on estimated O&M expenses of $175 million (2018 constant $) supported in Section IV and summarized in Table V-33 below. O&M labor expenses include all applicable overheads.

[187] D.15-11-021.

Table V-33
Forecast 2018-2020 GS&RP O&M Expenses

O&M (2018 Constant $000)					
Line	**Description**	**2018**	**2019**	**2020**	**Total**
1	**Grid Hardening**				
2	Wildfire Covered Conductor Program	747	951	4,201	$ 5,899
3	Remote-Control Automatic Reclosers	845	457	371	$ 1,673
4	Fusing Mitigation	271	2,640	21,138	$ 24,049
5	**Total Grid Hardening**	**$ 1,862**	**$ 4,049**	**$ 25,710**	**$ 31,621**
6	**Enhanced Situational Awareness**				
7	HD Camera	618	2,572	3,197	$ 6,387
8	Weather Station	142	631	1,200	$ 1,973
9	Advanced Weather Modeling Tool	384	604	604	$ 1,592
10	Advanced Modeling Computer Hardware	50	120	120	$ 290
11	Asset Reliability and Risk Analytics	7	9	-	$ 16
12	Additional Staffing Required	115	480	480	$ 1,074
13	**Total Enhanced Situational Awareness**	**$ 1,317**	**$ 4,416**	**$ 5,600**	**$ 11,333**
14	**Enhanced Operational Practices**				
15	Vegetation Management	-	40,148	77,921	$118,069
16	Infrared Inspection Program	-	459	459	$ 918
17	PSPS Protocal Support Functions	3,165	3,497	3,497	$ 10,159
18	Mobile Generator Deployment	137	137	137	$ 411
19	Portable Community Power Trailers	1,102	9	9	$ 1,120
20	**Total Enhanced Operational Practices**	**$ 4,404**	**$ 44,249**	**$ 82,023**	**$130,676**
21	**Wildfire Mitigation Program Study**	**$ 512**	**$ 521**	**$ 380**	**$ 1,413**
22	**O&M Total**	**$ 8,095**	**$ 53,235**	**$113,712**	**$175,042**

4. Income Taxes

SCE estimates income taxes by following the rules and methods adopted in the Company's GRCs. SCE will use flow-through tax rate making as required by this Commission, unless normalization treatment is required by the Internal Revenue Service or previously allowed by this Commission. This rate proceeding includes the following tax adjustments.[188] Based on the nature of the GS&RP costs, SCE has assumed that the additions are not eligible for tax repair

[188] 2018 GRC (A.16-09-001), SCE-09, Vol. 2, at pp. 22-28.

deductions. To the extent SCE finds that certain additions are eligible for tax repair deductions, the revenue requirement impact will be accounted for in the operation of the GS&RPBA:

a) Tax Depreciation

b) Ad Valorem Lien Date Adjustment

c) Removal Costs

d) Synchronized Interest

e) Capitalized Software

f) Deduction of State Income Taxes

SCE computes tax expense using the applicable federal corporate tax rate of 21 percent and the state corporate tax rate of 8.84 percent.

Appendix A

Acronym List

Acronym List

A.	Application
AB	Assembly Bill
ABC	Aerial Bundled Cable
AFUDC	Allowance for Funds Used During Construction
AL	Advice Letter
AOC	Automated Outage Communications
ACSR	Aluminum Conductor Steel Reinforced
AGM	Absorbent Glass Mat (Battery)
BLF	Branch Line Fuse
BLR	Branch Line Recloser
BRRBA	Base Revenue Requirement Balancing Account
BVLOS	Beyond Visual Line of Sight
Cal Fire	California Department of Forestry and Fire Protection
CBs	Circuit Brakers
CEMA	Catastrophic Event Memorandum Account
CEOPBA	CEOP Balancing Account
CFO	Contact from Object
CLFs	Current Limiting Fuse
CWIP	Construction Work in Progress
D.	Decision
DACs	Disadvantaged Communities
DEER	Database for Energy Efficiency Resources
DERs	Distributed Energy Resources
DFA	Distribution Fault Anticipation
DIMP	Distribution Inspection Maintenance Program
DSM	Demand Side Management
ED	Energy Division
EDC	Energized Downed Conductor
EOC	Emergency Operations Center
EONS	Emergency Outage Notification System
ERRA	Energy Resource Recovery Account
ESIMT	Electrical Services Incident Management Team
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHPMA	Fire Hazard Prevention Memorandum Account
FRP	Fiber Reinforced Polymer
GO	General Order

GOV.	Governor
GRC	General Rate Case
GS&RP	Grid Safety and Resiliency Program
GS&RPBA	Grid Safety and Resiliency Program Balancing Account
GS&RPMA	Grid Safety and Resiliency Program Memorandum Account
HD	High Definition
HFRA	High Fire Risk Areas
ICS	Incident Command System
IOUs	Investor Owned Utilities
IPIP	Intrusive Pole Inspection Program
IR	Infrared Inspection
kW	Kilowatt
kWh	Kilowatt hour
mA	Milliamps
MW	Megawatts
NEETRAC	National Electric Energy Testing Research and Applications Center
NIFC	National Interagency Fire Center
OCP	Overhead Conductor Program
OIR	Order Instituting Rulemaking
ODIP	Overhead Detailed Inspection Program
ODRM	Outage Database and Reliability Metrics System
O&M	Operation and Maintenance
ORA	Office of Ratepayer Advocates
PCPTs	Portable Community Power Trailers
PLP	Pole Loading Program
PMO	Program Management Office
PSPS	Public Safety Power Shutoff
PPA	Power Purchase Agreement
PTZ	Pan Tilt Zoom
PUC	California Public Utilities Code
PV	Photovoltaic
R.	Rulemaking
RAMP	Risk Assessment and Mitigation Phase
RARs	Remote Controlled Automatic Reclosers
RCS	Remote Controlled Switches
SB	Senate Bill
SCADA	Smart meter, supervisory control and acquisition data
SCD	Short Circuit Duty
SCE	Southern California Edison
XL-HDPE	Crosslinked low density polyethylene

TURN	The Utility Reform Network
UAV	The Advanced Unmanned Aerial Systems
USoA	Uniform System of Accounts
WCCP	Wildfire Covered Conductor Program
WCPMA	Wildfires Customer Protection Memorandum
WEMA	Wildfire Expense Memorandum Account
WRF	Weather Research and Forecasting
WWG	Western Weather Group

Appendix B

Witness Qualifications

SOUTHERN CALIFORNIA EDISON COMPANY
QUALIFICATIONS AND PREPARED TESTIMONY
OF BILL CHIU

Q. Please state your name and business address for the record.

A. My name is Bill Chiu, and my business address is One Innovation Way, Pomona, California, 91768.

Q. Briefly describe your present responsibilities at the Southern California Edison Company.

A. I am the Director of Grid Resiliency & Public Safety Program Management Office (PMO) within Southern California Edison Company's Transmission and Distribution operating unit. In this capacity, I oversee the enterprise-wide operational mitigation to address the wildfire and public safety risk.

Q. Briefly describe your educational and professional background.

A. I have a Master's degree in business administration and a Master of Science in Electrical Engineering from University of Southern California, and a Bachelor of Science degree in Electrical Engineering from Cal Poly Pomona. I am a licensed Professional Engineer in the State of California and Texas. I joined Southern California Edison in 1998 and have held various engineering and management positions, including the Director of Engineering, prior to my current role as the Director of PMO. Prior to joining SCE in 1998, I held various roles in planning, engineering, project management, and technical supervisory capacities for Bechtel Power Corporation, Los Angeles Department of Water & Power, and Austin Energy. I am a senior member of IEEE Power & Energy Society (IEEE PES) and have served as executive officers for the IEEE PES Transformers Committee from 2004 to 2015.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.

SOUTHERN CALIFORNIA EDISON COMPANY
QUALIFICATIONS AND PREPARED TESTIMONY
OF DON DAIGLER

Q. Please state your name and business address for the record.

A. My name is Don Daigler, and my business address is 8631 Rush Street, Rosemead, CA 91770.

Q. Briefly describe your present responsibilities at the Southern California Edison Company.

A. I am the Director of Business Resiliency under the Operational Services Organizational Unit (OU). I am responsible for Southern California Edison's overall Business Resiliency activities. I also manage the company's emergency management functions for all hazards facing the company's business lines, facilities, and people and lead the development and implementation of corporate Business Continuity Plans and Disaster Recovery Plans.

Q. Briefly describe your educational and professional background.

A. I have a Bachelor of Science in Liberal Studies with an educational focus on Health Physics and have more than 30 years of experience in the areas of national security and emergency management. My career includes 26 years of service in the federal government, where I have held several senior leadership positions, both in the field and at the policy level in Washington, D.C. Immediately prior to joining SCE, I was the Response Planning Director for the Federal Emergency Management Agency (FEMA), where I led all national and regional response planning activities and was the planning lead during several large scale disasters, such as hurricanes Sandy, Isaac, and Irene. In that capacity, I was also responsible for leading the agency's chemical, biological, radiological, nuclear, and explosives programs as well as the National Hurricane Program and Remote Sensing Program. Previously, I ran the Technology Integration Program for the Department of Energy's National Nuclear Security Administration, which developed specialized emergency response equipment. Before moving to Washington, D.C., I held leadership roles for the Department of Energy's Nevada Site Office, including the position of Director of the Homeland Security and Defense Division. My federal government experience also includes experience with the Environmental Protection Agency and the Department of Defense.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.

SOUTHERN CALIFORNIA EDISON COMPANY

QUALIFICATIONS AND PREPARED TESTIMONY

OF PHILIP R. HERRINGTON

Q. Please state your name and business address for the record.

A. My name is Philip R. Herrington, and my business address is 8631 Rush Street, Rosemead, California 91770.

Q. Briefly describe your present responsibilities at the Southern California Edison Company.

A. I am Senior Vice President of Transmission and Distribution responsible for the operation, maintenance and modernization of SCE's electrical grid that covers a 50,000 square-mile service area.

Q. Briefly describe your educational and professional background.

A. I have a Bachelor of Science degree in chemical engineering from the University of California, Santa Barbara, and a Master's degree in business administration from the University of Southern California's Marshall School of Business.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.

SOUTHERN CALIFORNIA EDISON COMPANY

QUALIFICATIONS AND PREPARED TESTIMONY

OF MELANIE JOCELYN

Q. Please state your name and business address for the record.

A. My name is Melanie Jocelyn, and my business address is 1 Innovation Way, Pomona, CA 91768.

Q. Briefly describe your present responsibilities at the Southern California Edison Company.

A. I am a Vegetation Management Principal Manager in SCE's Distribution & Maintenance group. I oversee the prevention of vegetation from coming into contact with SCE's electrical facilities by scheduling the trimming and removal of trees in proximity to transmission and distribution rights-of-way.

Q. Briefly describe your educational and professional background.

A. I have a Bachelor of Science in Environmental Policy Analysis and Planning from the University of California Davis. I have been employed by Southern California Edison since 2009.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.

SOUTHERN CALIFORNIA EDISON COMPANY
QUALIFICATIONS AND PREPARED TESTIMONY
OF LINDA R. LETIZIA

Q. Please state your name and business address for the record.

A. My name is Linda R. Letizia, and my business address is 8631 Rush Street, Rosemead, California 91770.

Q. Briefly describe your present responsibilities at the Southern California Edison Company ("SCE").

A. I am the Principal Manager of the CPUC Revenue Requirements and Tariffs group in the State Regulatory Operations Department, and have overall responsibility for the management, development, and presentation of revenue requirements and ratemaking showings before the California Public Utilities Commission.

Q. Briefly describe your educational and professional background.

A. I graduated from the University of California at Davis in 1980 with a Bachelor of Science degree in Mathematics. I have been employed by Southern California Edison Company since 1984. Since joining Edison, I have held various positions in the Regulatory Policy and Affairs and Regulatory Operations departments. My responsibilities have included revenue allocation and rate design, the preparation of pricing studies and analyses, and the development of revenue requirements and ratemaking proposals for numerous regulatory proceedings before the California Public Utilities Commission. I have also been employed in the Capital Recovery Section and Corporate Budgets Section of the Controller's Department. I have previously testified before the California Public Utilities Commission.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.

SOUTHERN CALIFORNIA EDISON COMPANY

QUALIFICATIONS AND PREPARED TESTIMONY

OF DOUGLAS A. TESSLER

Q. Please state your name and business address for the record.

A. My name is Douglas A. Tessler, and my business address is 8631 Rush Street, Rosemead, California 91770.

Q. Briefly describe your present responsibilities at the Southern California Edison Company.

A. I am the Senior Manager of CPUC Revenue Requirements in the Financial Planning & Analysis section of the Treasurer's Department. I am primary responsible for development of the Standardized Operations and Maintenance (O&M) and Capital Expenditure workpapers for all GRC and non-GRC CPUC Revenue Requirements. I am also responsible for maintaining the Results of Operations (RO) model used to calculate the CPUC revenue requirement.

Q. Briefly describe your educational and professional background.

A. I received a Bachelor of Science Degree in Accounting from California State Polytechnic University, Pomona in 1999 and Master of Science Degree in Business Administration from California State University, Fullerton in 2006. I am also a Certified Public Accountant (inactive). I began my career at Southern California Edison in 1997 as an Accounting Assistant in the Property Accounting area of the Controller's Department. From 1999 to 2005, I worked in various accounting positions within the Controller's Department. In 2005, I moved to the Audit Services Department where I worked as a Corporate Auditor. In 2008, I transferred to the Investor Relations Department at Edison International (the parent and holding company of Southern California Edison) where I worked as a Senior Financial Analyst. In 2010, I began working in the Revenue Requirements & Forecasting group in State Regulatory Operations as a project manager where I assumed my current position in 2015. In early 2018, the CPUC Revenue Requirements function was transferred from State Regulatory Operations to Treasurers.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.

SOUTHERN CALIFORNIA EDISON COMPANY
QUALIFICATIONS AND PREPARED TESTIMONY
OF THUAN Q. TRAN

Q. Please state your name and business address for the record.

A. My name is Thuan Q. Tran, and my business address is 1 Innovation Way, Pomona, CA 91768.

Q. Briefly describe your present responsibilities at the Southern California Edison Company.

A. I am a Principal Manager of T&D Apparatus and Standards Engineering. I help to develop engineering talents, lead many new developments in substation, automation and apparatus engineering projects, and manage the T&D Apparatus & Standards Engineer group of nine managers and approximately 80 engineers, project managers, technical advisers. The group is responsible for performing technical studies, testing, qualifying, specifying new electrical equipment, such as transformer, cable, wire, capacitors, etc. for Transmission, substation and distribution. The group prepares and facilitate approvals of design, construction standards and operations and maintenance manuals. In addition, the group also has the responsibility of performing root cause analysis of equipment failures and making mitigation recommendation.

Q. Briefly describe your educational and professional background.

A. I joined Southern California Edison in 1989 after graduating from the University of California at Irvine with a Bachelor of Science degree in Electrical Engineering. I also received a Master of Engineering in Electrical Engineering with an emphasis in Power Systems at University of Idaho, Moscow in 2004 and Master of Business Administration (MBA), University of La Verne, La Verne in 1992. I am also a certified Professional Engineer (PE) in Electrical Engineering in California. Since joining the company in 1989 and through 2003, I worked as a distribution engineer, automation engineer and substation apparatus engineer. I led a number of projects from distribution automation development to commissioning transmission voltage-level static VAR systems. I moved to a leadership capacity as a supervising engineer in Distribution Apparatus Engineering, Senior Manager of Substation Engineering, Senior Manager of Protection and Automation.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Exhibit SCE-01, entitled *Prepared Testimony in Support of Southern California Edison Company's Application for Approval of Its Grid Safety and Resiliency Program* as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.