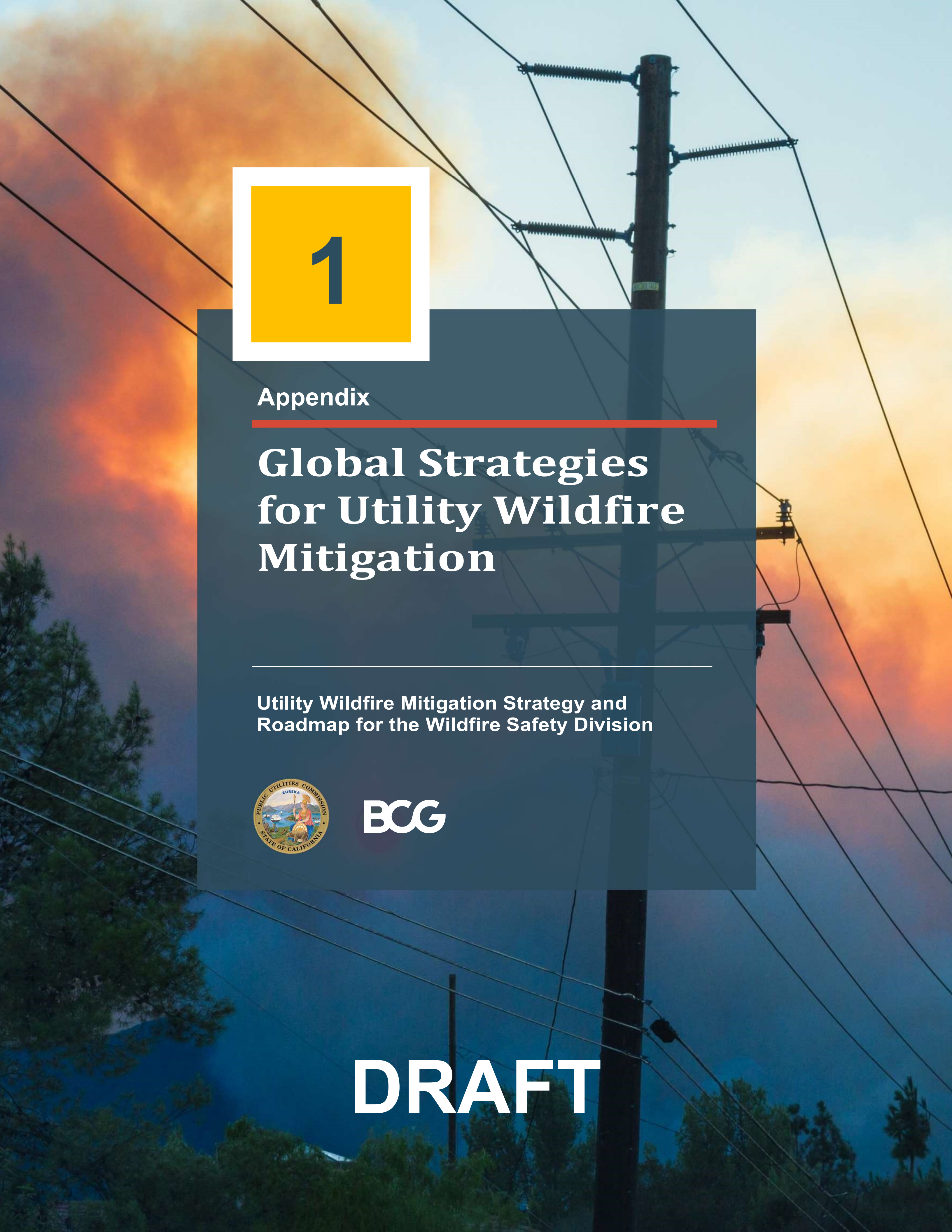

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Appendix

Global Strategies for Utility Wildfire Mitigation

Utility Wildfire Mitigation Strategy and Roadmap for the Wildfire Safety Division

DRAFT

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1 Introduction

Electric utilities, regulators, and other public and private sector stakeholders across California are focused on reducing the growing risk of utility-related wildfires; yet California is not alone in facing increased wildfire risk. Other geographies are experiencing comparable trends influenced by similar macro factors: climate change, drought, invasive insects that affect native vegetation, and, in many cases, population growth in the wildland-urban interface (WUI). In 2019, catastrophic wildfires in Brazil destroyed over 2 million acres of the Amazon rainforest,[1] while the EU experienced three times more wildfires than historic norms.[2] A significant number of wildfires also damaged over 25 million acres in Australia in late 2019 and early 2020. [3] Wildfires are recognized as a global challenge, and the risks are evolving as the climate and other factors continue to change the wildfire landscape.

No geography yet has developed a comprehensive solution to ignited wildfire risk stemming from utility infrastructure. While one geography may be a leader in certain aspects, it may lag in others. ~~It is important to acknowledge that f~~For solutions to be effective, they have to consider local factors such as geography, existing grid topology, governance structures, and local culture. A solution that has been effective in one geography cannot be directly applied to another without taking these factors into account. For example, in terms of situational awareness, California has a vast network of wildfire detection cameras available in public, online forums it is able to ~~leverage~~ use that does not exist elsewhere.[4] As another example, Victoria, Australia led the way in using innovative techniques to facilitate culture change, establishing financial incentives specifically for wildfire mitigation to encourage utility wildfire risk reduction initiatives, but utilities operate at a different scale and are subject to different liabilities than those in California.

This report lays out the current landscape in California and overlays global practices that can serve as a starting point for recommendations aimed at reducing utility-related wildfire risk. While California utilities are already incorporating some of these learnings, continued effort is needed to ensure that they are adapted quickly and cost effectively, and that they lead to a significant and measurable reduction in wildfire risk for Californians. To identify these global practices, wildfire-related conditions and mitigation practices of other wildfire-prone geographies were surveyed to understand the initiatives underway and their effectiveness in reducing wildfire risk. In addition, experts on risk management, disaster planning and recovery, and safety culture, from the utility industry as well as others, were interviewed to learn what other approaches might be applicable. Insights from this work can support sharing successful or innovative practices and be used to improve utility operations in wildfire-prone geographies.

1.1 Summary of main observations

Current California utility wildfire mitigation regulatory environment

Today, California utilities primarily contribute to wildfire mitigation by reducing the risk of ignition related to utility infrastructure, particularly under conditions when and where such ignition would

[1] CBS News. *"Brazil's Bolsonaro says he will accept aid to fight Amazon fires."* August 27, 2019. https://www.cbsnews.com/news/amazon-wildfires-brazil-spurns-20-million-aid-offer-from-g-7-nations-today-2019-08-27/.

[2] Tidey, A. *"There have been three times more wildfires in the EU so far this year."* Euronews. https://www.euronews.com/2019/08/15/there-have-been-three-times-more-wildfires-in-the-eu-so-far-this-year

[3] Reuters. *"Australian Authorities Warn Bushfire Reprieve Will Be Over Soon."* The New York Times. https://www.nytimes.com/reuters/2020/01/07/world/europe/07reuters-australia-bushfires.html

[4] Nevada Seismological Laboratory. http://www.alertwildfire.org/.

lead to catastrophic wildfire. As utility wildfire mitigation has increasingly become an urgent priority for the state, the legislature has passed a number of bills related to utility wildfire prevention and oversight.

The main regulatory vehicle for the Wildfire Safety Division (WSD) to evaluate utilities' plans to reduce utility wildfire risk is the Wildfire Mitigation Plan (WMP), which was introduced in Senate Bill 1028 (Hill, 2016) and further defined in SB 901 (Dodd, 2018), Assembly Bill 1054 (Holden, 2019),[5] and AB 111 (Committee on Budget, 2019).[6] The WMP process requires plans to be submitted for wildfire risk reduction, the first round of which was evaluated by the California Public Utilities Commission (CPUC) in 2019. In order to administer the WMP process, AB 111 established the WSD within the CPUC as of January 1, 2020.[7] The WSD is also responsible for assessing compliance to these plans. Future refinement of the WMP process and guidelines will also be led by the WSD, and will incorporate any new legislative requirements that are passed in relation to the WMPs.

The statutes establish a 90-day period during which the WSD reviews the WMPs for compliance and effectiveness, accepts public comments, and ultimately issues a decision -to approve or deny the plans for implementation for:

a) three investor-owned utilities (IOUs) – Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E);
b) three small-and-multi jurisdictional utilities (SMJUs) – Liberty Utilities, Bear Valley Electric Service, Inc., and PacifiCorp; and,
c) two independent transmission operators (ITOs) – Horizon West and Trans Bay Cable.

The WMPs contain details of utility plans to manage wildfire risk stemming from utility infrastructure, including key activities like grid hardening, approaches to vegetation management and inspection, plans for disabling reclosers under high risk conditions, protocols for proactive de-energization, and infrastructure inspection plans with proposed work completion timelines and estimated costs. The WMPs also consider the current state and future scale and scope of utility Public Safety Power Shutoffs (PSPS), complementing CPUC activity related to utility PSPS decisions.

Actions for the WSD and utilities to consider

As the WSD and the utilities learn from the implementation of the initial WMPs, they can also look to utility wildfire mitigation practices from other geographies. While no one method, tool, or innovation is a 'silver bullet', five areas have interesting or differing practices to consider:

1. Technology, including situational awareness and forecasting: Using satellites with greater detection capabilities and faster refresh rates to more rapidly characterize wildfires.

[5] Assembly Bill 1054 (Holden, Chapter 79, Statutes of 2019), (AB 1054).
[6] Assembly Bill 111 (Committee on Budget, Chapter 81, Statutes of 2019), (AB 111).
[7] AB 111 shifts long-term responsibility for utility-related wildfire safety to the California Natural Resources Agency (CNRA) by July 1, 2021 and moves WMP submissions to a three-year cycle with annual updates starting with 2020 submissions. Additionally, the CPUC will need to coordinate and collaborate with an appointed Wildfire Safety Advisory Board, whose role is to advise the CPUC on IOU and publicly-owned utility (POU) WMPs.

2. Risk assessment and mapping: Using artificial intelligence and machine learning to monitor situational awareness (e.g. using tools like cameras) and implementing refined risk mapping using sophisticated modeling, incorporating the latest insights from fire science to develop a single source of truth for wildfire risk.

3. Public Safety Power Shutoff usage: Limiting power shutoff events. No other geography implements PSPS as a regular part of operations to address severe weather. Some de-energize lines if customer service is not affected or in the presence of suppression personnel, when a safety issue exists.

4. Grid design and system hardening: Investing in differing grid designs and conducting independent, in-depth explorations of the efficacy and cost-effectiveness of advanced hardening measures, such as Rapid Earth Fault Current Limiters (REFCLs).

5. Vegetation management: Adopting advanced and partially automated technologies, such as LiDAR, drones, databases of individual trees with strike potential, workforce planning software, and others to conduct vegetation management.

Collaboration Areas for the WSD and Utilities

In addition to the WMPs, and corresponding activities, utility actions within California take place in the context of a broader environment. Because of this, utilities must collaborate and coordinate with many other stakeholders at the federal, state, and local levels. Specifically, there are four collaboration areas where California's electric utilities can take a leading role in coordinating with others in order improve not just the effectiveness of today's mitigation initiatives, but ensure longer-term resilience in the state. These four areas include (1) governance and coordination; (2) culture and behavior; (3) applied science, technology, and data; (4) workforce development. The following sections outline the existing state of collaboration within each area of utility wildfire mitigation, and specific ideas from other geographies to inform future recommendations:

1. Governance and coordination: Increasing coordination between utilities, and various prevention, suppression, and local agencies. Additionally, supporting local structures like the Bushfire Committees in Australia, which identify local values-at-risk, communicate risk levels, and decide on mitigation measures through popular consensus.

2. Culture and behavior: Improving safety culture, such as an example from Victoria, Australia with a financial incentive program specifically for wildfire mitigation efforts called the "F-Factor scheme" to support utilities in reducing wildfire risk, however, no other geography had a similar financial incentive system.

3. Applied science, technology, and data: Pursuing more advanced data and analytics, investing in new technology developments, and leveraging third-party, independent verification to improve overall system hardening efforts.

4. Workforce development: Improving workforce development by addressing workforce constraints, and considering practices such as training personnel working in high fire threat areas (including those of its utility) on ignition detection and fire suppression techniques.

In addition to the actions the WSD and utilities should take to collaborate with others, the WSD is also responsible for implementing existing and future legislative priorities. This includes the evolution of the WMPs, and a continued focus on proactively reducing utility-related wildfire risk. Changes to other legislation and regulation governing utility wildfire mitigation, as well as funding available for prevention and mitigation initiatives, will also direct WSD efforts.

1.2 Approach to global practices

Lessons learned from mitigation practices adopted in other wildfire-prone geographies were used to inform recommendations for the WSD and for utilities. These mitigation practices were broken into the areas outlined above in Section 1.1. The activities discussed in this appendix were informed from a deeper assessment that was conducted for five areas: Portugal, Spain, British Columbia, Canada, Victoria, Australia, and Washington State. Practices from other geographies that experience significant wildfire risk in North America and abroad were also evaluated. Information was collected from a range of relevant parties, including operations managers, regulatory affairs, and wildfire program professionals at utilities, as well as natural resources professionals and emergency management professionals familiar with wildfire prevention.

Interviews were also conducted to identify practices from other industries that have faced difficult-to-quantify risks, the need for multi-party cooperation, and the challenge of regulating practices across a wide range of stakeholders, situations, and constraints. In particular, risk management approaches and data strategies from mining, asset management, insurance, healthcare, and crisis response were reviewed. Experts with experience regulating the aviation and securities industries, as well as those responsible for budgeting, disease monitoring, and national intelligence were interviewed. Figure 1, below, outlines key statistics for each of the most relevant geographies analyzed.

Figure 1: Key wildfire statistics for most relevant geographies

	California	US (Overall)[3]	BC, Canada	Portugal	Spain	Victoria, AU
Est. total forested area (millions of acres)	33	820	150	8	45	20
Est. area burned annually by wildfire (million acres)[2]	1.1	8.8	3.3	0.25	0.20	0.30
Est. percent of wildfires ignited by power lines	8-13%	1-2%	N/A	N/A	1-2%	1-2%
Relative focus on prevention vs. suppression	Most focused on suppression	Spend weighted to suppression	Spend weighted to suppression	Spend weighted to suppression	Spend weighted to suppression	Highest spend on prevention
Direct utility incentives to reduce wildfire risk	No	No	No	No	No	Yes, F-Factor
Use of PSPS at scale	Yes	Generally no	No	No	No	No
Adoption of single wildfire risk model	Static wildfire risk map	No single simulation-driven map	Static wildfire risk map	No single simulation-driven map	No single simulation-driven map	Single risk map via Phoenix RapidFire

In particular, the experience of the Australian ~~province~~ state of Victoria offers many lessons. Following the 2009 Black Saturday Bushfires, which killed 173 people, the state took a number of actions to prevent such severe consequences from wildfire from reoccurring, including a mandated network performance standard formalized in regulations with annual compliance tests prior to each fire season, known as REFCLs . While the 2019/2020 wildfire season had a devastating impact on people's lives and caused serious damage to the natural resources and biodiversity of Australia, focused most significantly in New South Wales where more than 3,000 homes were destroyed, the number of deaths remained far below that of the 2009 bushfires, at 25 people.[8,9] As such, this report chose to highlight the observations from research and interviews with participants in Victoria, which are explored in case studies throughout this appendix and summarized in Section 4.

2 Priority actions for the WSD and utilities

Utilities and regulators around the world have begun to take action in order to reduce utility-related wildfire risk. While no holistic, complete solution has been found in any single geography, lessons learned from around the globe can be used to inform priority actions that utilities should be taking, and that the WSD should encourage via the Wildfire Mitigation Plans, or otherwise.

2.1 Technology, including situational awareness and forecasting

California is often viewed as having made recent advancements in situational awareness for early detection of wildfires, with significant deployments of wildfire detection cameras in high wildfire risk areas, particularly in the southern portion of the state. The Alert Wildfire Spotting System extensively covers a large geographic area and enables the public to stream the camera feed in real time.[10] This enables the public, utilities, and emergency responders to identify the location of wildfires and track their progression by triangulating multiple cameras on the same fire front. Utilities are already taking steps toward developing technologies to assist in automated wildfire spotting to more quickly and consistently detect wildfires.

California has also joined geographies such as Australia in monitoring wildfires using satellites. Increasingly high resolution images that are refreshed more frequently are becoming available to monitor vegetation density and dead vegetation fuel levels. Technology originally developed for missile launch detection is now being deployed to track live wildfires. Some geographies are making progress piloting or deploying satellite technology, including BC, Canada, which is piloting a service, Tanka, to parse real-time satellite imagery. Tanka's service detects wildfires, and monitors their size and propagation. Tanka reports results to the Canadian authorities in real time, and the authorities are then able to deploy resources quickly to suppress fires before they become uncontrollable.[11]

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[8] Yeung, Jessie. *"Australia's deadly wildfires are showing no signs of stopping. Here's what you need to know."* CNN, January 13, 2020. https://www.cnn.com/2020/01/01/australia/australia-fires-explainer-intl-hnk-scli/index.html
[9] Chappell, Bill. *"Australia Wildfires Have Claimed 25 Lives And Will Burn For Months, Officials Say."* NPR, January 6, 2020. https://www.npr.org/2020/01/06/793931658/australia-wildfires-have-claimed-25-lives-and-will-burn-for-months-officials-say.
[10] Nevada Seismological Laboratory. "Alert Wildfire". 2019. http://www.alertwildfire.org/.
[11] Molteni, Megan. "The science of fighting wildfires gets a satellite boost." *Wired*, September 11, 2017. https://www.wired.com/story/the-science-of-fighting-wildfires-gets-a-satellite-boost/.

2.2 Risk assessment and mapping

Innovative systems that offer the potential for generating intelligence more accurately and quickly, strengthening both planning and operational efforts is also an area for further investment. For example, image analysis can now be streamlined through artificial intelligence (AI) and machine learning (ML). Historically, wildfires were only detected when emergency authorities were notified by members of the public, limiting the scope of early detection to only populated areas or areas which planes happened to be flying. Today, these new techniques allow authorities to simultaneously monitor a large portfolio of cameras, receive early indication of a fire's propagation, and compare imagery to monitor changes in vegetation density and fuel moisture content.

While no geography yet had a highly advanced statewide wildfire-oriented data and analytics architecture, a modeling tool developed in Australia, Phoenix RapidFire,[12] is used to assess impacts given an ignition. The Phoenix RapidFire system (developed by the University of Melbourne) can anticipate how fire will eject embers that may ignite vegetation beyond the primary fire perimeter. Such ejections are particularly common with eucalyptus trees, which are native to Australia, have been introduced in California, and can dramatically expand fire risk by threatening secondary ignitions beyond a containment perimeter. Such improved 'match drop' modeling improves propagation and consequence forecasting[13] and can provide far more accurate risk assessments than was previously possible. In 2014 and 2015, a simulation run using Phoenix RapidFire used the most extreme observed fire weather, simulated ignitions at nearly 28,000 points, estimated how a wildfire would propagate, and mapped values-at-risk to determine the overall impact. An example of this output is shown in Figure 2 below. The Victorian government used these estimates to assign each geographic region a risk score for its utility wildfire regulatory program.[14] Such accurate estimation leads to more informed incident leadership,[15] which has been shown to be more effective in containing large wildfires than the marshalling of additional suppression resources. Utilities in California are also investing in advanced fire propagation and simulation modeling to conduct more sophisticated risk assessment and mapping.

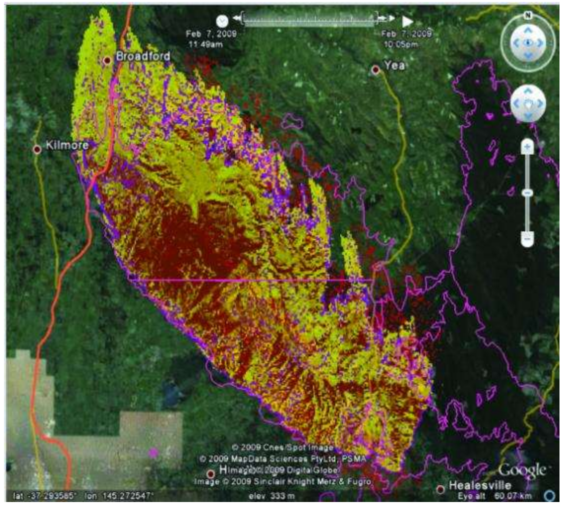
Figure 2: Example Phoenix RapidFire map showing highest risk areas of ignition

[12] Thwaites, T. "The computer program that saved a town." *Pursuit*, September 24, 2015. https://pursuit.unimelb.edu.au/articles/the-computer-program-that-saved-a-town.

[13] Section 3.3, Page 44 of [2011 Powerline Bushfire Safety Taskforce] states... "The Taskforce has identified Phoenix as the best available tool to assess fire loss consequence at this time..." Source: TasNetworks. *Management Plan: Bushfire Mitigation*, October 2015. https://www.aer.gov.au/system/files/TasNetworks%20-%20TN029%20-%20Bushfire%20Mitigation%20-%20January%202016.pdf.

[14] Victorian Department of Environment Land Water and Planning: Powerline Bushfire Safety Program. *F-factor Incentive Scheme: Regulatory Impact Statement*. October 2016. https://www.energy.vic.gov.au/__data/assets/pdf_file/0022/44419/f-factor_-_Regulatory_Impact_Statment_Oct16.pdf.

[15] The individual responsible for all operational decision, in response to an event that requires an emergency response. Source: National Parks Service. *Fires and fuels management: Definitions, ambiguous terminology and references*. https://www.nps.gov/olym/learn/management/upload/fire-wildfire-definitions-2.pdf.



2.3 Public Safety Power Shutoff usage

The costs of wildfire mitigation initiatives and the risk of wildfire, coupled with its costs and the liability of its significant negative impact, create a strong incentive for utilities in California to utilize PSPS as a wildfire mitigation tool. Utilities have statutory authority to preventatively shut off power using PSPS as a measure of last resort to assure public safety. Yet, PSPS occurs far more often today than what may be expected for a measure of last resort, as the condition of utility assets and the surrounding vegetation is not sufficiently prepared to face high wildfire risk conditions. Misalignment of incentives, whereby utilities do not pay for the community impact and economic damage of PSPS events but do assume all liability for wildfire ignitions, exacerbates the tendency for utilities to utilize PSPS. However, utilities are not held accountable for the safety and economic impacts a community may face without power. For example, it is acknowledged that individual homes and businesses purchased hundreds, if not thousands, of generators during the widespread 2019 PSPS outages. Anecdotes reference unlit traffic signals, hospitals with limited power, and wasted frozen food at restaurants and grocery stores. All of these impact local economies, while also negatively impacting statewide climate change goals with the use of diesel-fueled generators.

State leadership and residents across California view the magnitude of previous PSPS events as unacceptable. In the fall of 2019, PG&E implemented multiple wide-ranging PSPS events – one of which shut off power to 700,000 PG&E customers between October 9-12, 2019 (areas of which are highlighted in Figure 3 below), directly impacting an estimated 2 million Californians for up to 48 hours.[16,17]

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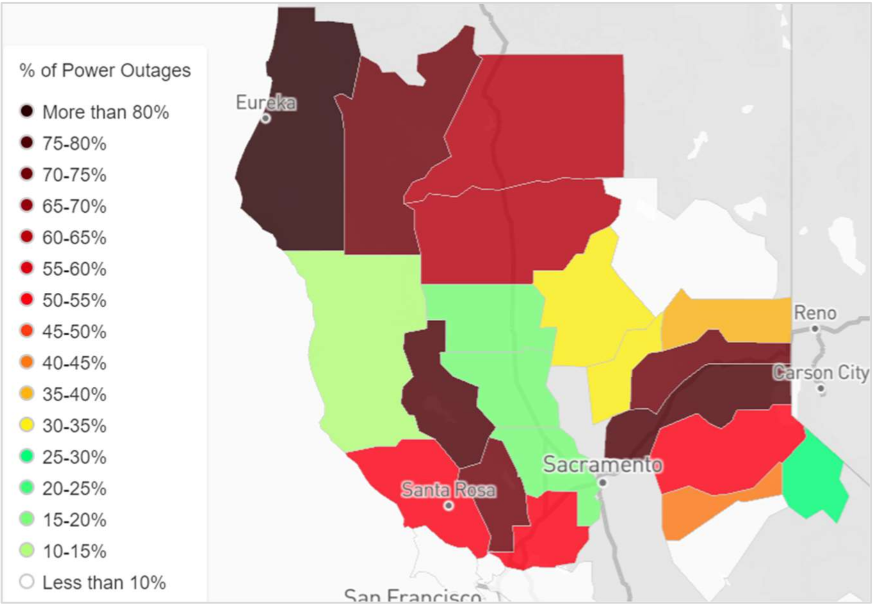
[16] Batjer, M., *Letter to Mr. William Johnson*, October 14, 2019. https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/PGE%20Letter%20-%20PSPS%2010-14-19.pdf.

[17] Note: a vast majority of customers were restored power within 48 hours, however some outages may have lasted longer. PG&E External Communications. *15 Things You Need to Know About PG&E's Oct. 9-12 Public Safety Power Shutoff.* October 14, 2019. https://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20191014_15_things_you_need_to_know_about_pges_oct_9-12_public_safety_power_shutoff

Figure 3: California power outages for PG&E customers by county at 10AM on October 9, 2019



Source*:* Record Searchlight. "California Power Shutoff (October 9, 2019)." October 14, 2019. https://data.redding.com/ca-power-shutdown-2019-oct-power-outages/.

There are also numerous direct and indirect impacts of PSPS on safety and the economy. In Sonoma County alone, the county economic development board estimated $50-70 million in economic losses for the single county during the one PSPS event on October 9-12, 2019.[18] Communities across the state also continue to raise concerns about the impact PSPS has on their residents from unreliable access to food, phones, transportation, and even water in some cases. These negative impacts disproportionately affect low-income Californians and are particularly acute for populations with Access and Functional Needs and Limited English Proficiency, where communication about PSPS has been inadequate in the past.

Following the frequent use of PSPS during the 2019 wildfire season, the CPUC took multiple actions. It launched a formal investigation of the implementation and effectiveness of recent PSPS events. A letter from CPUC President Marybel Batjer on October 14, 2019, instructed utilities to expand their upcoming 2020 Wildfire Mitigation Plans to focus on increasing the safe performance of utilities, reducing the need for PSPS events, creating more resilient communities, and producing results before the next year's wildfire season.[19] However, many of the investments needed to reduce the use of PSPS require longer-term planning and investments, but may not deliver immediate near-term benefit. The tradeoffs between competing initiatives and the desire for near-term improvements in wildfire risk reduction must be balanced and aligned with long-term plans and objectives.

Relative to other geographies with substantial wildfire risk, California is an outlier in its use of proactive de-energization of electric service ahead of anticipated fire weather (e.g., dry conditions, high winds). Typically, utilities in other locations will only de-energize areas under evacuation order or where firefighters are actively applying suppression measures, to ensure their safety.

[18] Committee on Energy, Utilities and Communications, *Oversight Hearing*, November 28, 2019.
[19] Batjer, M., *Letter to Mr. William Johnson*, October 14, 2019.

The consequences of PSPS can be managed through a combination of improved customer outreach and coordination with local authorities. Disasters with similar timing and consequence as wildfire, such as hurricanes, are met with a coordinated response, in which residents are given substantial information about the level of danger, and resources are coordinated and deployed at scale. In contrast, California's utilities in 2019 had significant communication challenges with inaccessible web sites and limited community resource centers availability.

2.4 Grid design and system hardening

Another tool to mitigate utility wildfire risk and limit the need to utilize PSPS is through grid design choices, as seen in other geographies which have sought to limit the frequency and extent of de-energization. Most notably, many of the geographies examined, particularly in Europe and Australia, have more redundancy than the grid in California. While adding redundancy is a long-term project that incurs significant cost, it can also add value in terms of reliability of electric supply and providing grid operators with more options during fire weather conditions.

In California, many utilities today have a radial grid topology, where branches of distribution lines are not interconnected, and so the impact of cascading a power shutoff (e.g., from a 'trunk' to a subsequent 'branch') are high. Whereas iIn a looped topology (where lines are interconnected) utilities have the needed redundancy to ensure continued power supply. In Australia, for example, the extensive use of such a looped grid topology has meant that utilities are able to de-energize lines, even at the transmission level, without jeopardizing reliable service to their customers. This means that if portions of the grid are de-energized from time to time, these are typically in situations where there is sufficient redundancy to prevent a significant disruption in supply to customers. ~~As such, while Australian utilities may de-energize lines, their communities are not subject to the large-scale type PSPS events that have become a feature of recent fire seasons.~~

Another alternative to limit the need for PSPS is to proactively change the configuration of assets to limit utility-related ignition risk. For example, utilities today use reclosers to ensure the consistent flow of electricity (in service of reliability goals); however vegetation contact can disconnect reclosers, cutting off the flow of electricity. In their default setting these reclosers are set to automatically reconnect, potentially sending electricity down a damaged line with vegetation in contact. In fact, the 2007 Witch Fire in San Diego County and one of Australia's 2009 Black Saturday wildfires were caused by reclosers that repeatedly re-connected the electric current, despite damage to the connected power line.[20] California utilities have begun to limit the automatic engagement of reclosers during periods of high wildfire risk, preventing electric current from flowing along lines that might have been damaged and could precipitate a wildfire. One system hardening initiative observed to address this in other geographies includes ~~Rapid Earth Fault Current Limiters (~~REFCLs~~)~~, which is a new technology being deployed in some areas to limit the amount of energy that is transferred into vegetation in the event of a system fault. Based on research and validation conducted in Victoria, limiting the amount of energy that is released can have a significant effect in reducing wildfire risk in higher wildfire risk scenarios.

[20] Baker, David. "Power-line restart device implicated in past wildfires." *San Francisco Chronicle*, November 2, 2017. https://www.sfchronicle.com/bayarea/article/Power-line-restart-device-implicated-in-past-12324764.php.

2.5 Vegetation management

A significant part of each utility's strategy in California to mitigate utility-related wildfire risk is to increase vegetation management activity. However, the state's shortage of qualified arborists today has challenged utilities to manage these experts efficiently. Emerging technology to support vegetation management offers opportunities to efficiently collect and organize the data they need to diagnose the health of potential hazard trees and other vegetation and prescribe risk-appropriate treatment cycles more accurately. Using these technologies, some companies have reduced vegetation management costs by up to 20%, largely through a combination of forecasting methods, satellite and aerial imaging, LiDAR, and algorithms that can impact the growth rate of vegetation near power lines[21]. Examples of advanced vegetation management practices being implemented by utilities as reported in a global BCG survey on Vegetation Management Practices are outlined below across four key categories.

First, many examples highlight the ability to capture data using multiple sources:

- LiDAR used as primary remote data capture technology for vegetation along distribution line identification, since it can be used in aerial inspections, including from drones, as well as from walking and vehicles[22]
- Technological advances enable more granular data over a wider area (50 points per square foot) at increased speeds and reduced cost
- 3D images used beyond vegetation management such as managing utility assets and other potentially hazardous infrastructure (e.g., telecommunications lines & structures)
- High-resolution aerial, thermal, and satellite imagery can also be used
- Each of the above can be augmented by manual inputs by vegetation management inspectors and other personnel

Second, advanced practices are emerging related to predicting vegetation growth:

- Historical data, including LiDAR, can be used to forecast expected tree growth, to determine optimal time for treatment
- Meteorological, species, and thermal information can be used to enhance prediction model and assess tree health
- Growth models can be validated through observation by trained arborists, either directly or reviewing photographs taken by on-site crews

Further, opportunity exists to optimize treatment temporally and geographically:

- Multi-variable algorithms can be used to optimise treatment and sequence by geographical regions and time to maximize risk spend efficiencies
- Algorithms take into account treatment type, seasonal constraints, and available capacity to maximise compliance at minimum cost
- Considers impact of combining the cutting and pruning with growth retardants and tree replacement or removal

Finally, practices are looking to define target clearances based on value at risk metrics:

- Risk and consequence of vegetation contacting the line used to define target clearances, for example, informed by computer simulations to ensure areas prone to causing significant damage from wildfire are most carefully treated

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[21] Yanez, Magin. "The Power Grid of the Future." *BCG*, 2018. http://image-src.bcg.com/Images/BCG-The-Power-Grid-of-the-Future-July-2018_tcm9-196899.pdf.

[22] Amadori, Jason. "Utility Infrastructure Vegetation Management Using LiDAR, Imagery and GIS." *LiDAR Magazine,* 2012. http://lidarmag.com/wp-content/uploads/PDF/LiDARMagazine_Amadori-UtilityVegetationManagement_Vol2No5.pdf.

- Applied when regulations do not prescribe clearances, or compliance alone is not a satisfactory measure of risk to network
- System implications beyond vegetation taken into account, for example, to local communities, probability of fire propagation, probability of suppression, and other factors

Overall, while no single action or innovative practices encountered in other geographies eliminates the risk of an ignition related to utility infrastructure, from grid hardening to vegetation management, improving utility wildfire mitigation activities to ensure the most cost effective, highest risk reduction actions are taken is critical to have meaningful impact on California's wildfire and PSPS risk.

3 Collaboration Areas for the WSD and Utilities

In order for the WSD and utilities to continue paving the way globally in wildfire mitigation, they must not only pursue the individual activities, but also support the broader enabling environment surrounding utility wildfire mitigation, in collaboration with others. This includes building critical processes, developing new tools, and improving capabilities related to utility wildfire mitigation. Four collaboration areas where the WSD and utilities can directly work with others have been identified below. These are areas that could make a difference in helping California reach the kind of sustained change required to achieve long-term resilience, versus one-off efforts that result in short term impact. These four areas build on one another, with successful coordination providing the potential to move California more quickly to prevent future utility-related wildfires.

These areas include: (1) governance and coordination; (2) culture and behavior; (3) applied science, technology, and data; and (4) workforce development.

In addition to building on the four enablers, the WSD and utilities must also continue to implement legislation and regulation related to utility wildfire mitigation and ensure adequate resources to complete their responsibilities.

3.1 Governance and coordination

California today is a leader in multi-stakeholder, coordinated wildfire response capabilities. Organizations such as FIRESCOPE, a cross-agency body that has continuously coordinated fire agencies in the state since the 1980s, have enabled California to pave the way in efforts to respond rapidly to wildfires in the state. Through the State of California Hazard Mitigation Plan, California Governor's Office of Emergency Services (Cal OES) provides a baseline understanding of fire hazards, risks, and population vulnerability that others can build on. While California has set a strong example globally for wildfire response coordination and overall emergency response, utility efforts to better coordinate their wildfire mitigation efforts could be further improved.

Utility prevention efforts in California ~~today are~~have been, and to a large extent still are, ~~largely~~ planned and executed in silos, with a lack of coordination with 1) the multiple stakeholders that work on the same utility wildfire mitigation activity (e.g., fuel management) and 2) the stakeholders whose work on related aspects of utility wildfire mitigation has ramifications for other areas of wildfire management (e.g., the relationship between recovery and investing in preventative community measures such as home hardening). Utility coordination of these activities, and with local communities in particular, can drive more efficient use of resources and better utility wildfire mitigation outcomes.

One example of the siloed utility approach to coordination is in their vegetation management plans. Today, utilities are focused on executing the vegetation management adjacent to their infrastructure to maintain compliance with clearance requirements in GO 95 and to address grow-in or fall-in risk to utility equipment. However, utility vegetation management programs are not often coordinated with overall fuel management efforts led by local land managers like the California Department of Forestry and Fire Protection (CAL FIRE), the United States Forest Service (USFS), and/or local communities. While CAL FIRE and USFS coordinate projects that border each other, in certain situations, lack of utility collaboration can result in missed opportunities for these stakeholders to leverage vegetation management efforts to support creation of fire breaks and other fuel treatments for at-risk communities. Land managers also highlighted the absence of a combined record of utility, CAL FIRE, USFS, and other fuel management activity as a knowledge gap that enables fragmented and uncoordinated activity.

Beyond utility activities outlined in the most recent WMPs, many examples of one-off or targeted cooperation highlight the opportunity to further improve coordination of prevention activities. Previous instances of coordination can be found for targeted mitigation activities:

- For example, the creation of the Santa Ana Wildfire Threat Index (SAWTI) was an effort assisted by SDG&E in collaboration with the Department of Oceanic and Atmospheric Sciences at UCLA, the U.S. Forest Service (USFS) Predictive Services, and Vertum Partners, and resulted in new and valuable information being shared with emergency response agencies.[23] The index is now leveraged during prevention activities to ensure everyone is prepared during times of high threat and has resulted in improved risk assessments for the state overall.

- Another example of improved coordination at the local level is SCE's work with the California Fire Safe Council (CFSC) to award grants to eight projects in 2019 and $200,000 in grants in 2018 to thirteen local Fire Safe Council projects.[24] SCE is also on the board of the CFSC, providing a means to engage local communities on utility wildfire mitigation efforts. These programs, executed in collaboration with the CFSC, are illustrative of the type of collaboration that needs to continue to build in coming years. However, significant efforts are needed to make this type of engagement sustainable, scalable, and integrated with other related efforts.

Examples from other geographies also highlight the ability to collect insights, develop tools, and engage local stakeholders. Although research showed that community empowerment is a critical tool for wildfire mitigation and emergency preparedness, California does not yet have a risk-informed process to coordinate utility investment in local communities' wildfire mitigation activities. Rather, utilities engage the many actors in an ad hoc way.

Effective planning needs to balance utility-led activities with local communities' understanding of local resources, their ability to draw on a wider range of resources, and to connect with key partners (e.g., planning agencies, landowners). A leading example of this coordination is in

[23] Rolinski, T. et al. "The Santa Ana Wildfire Threat Index: Methodology and Operational Implementation." *American Meteorological Society* 31 (2016): 1881-1897. https://journals.ametsoc.org/doi/pdf/10.1175/WAF-D-15-0141.1.
[24] California Fire Safe Council. *"Edison International Fire-Safe Community Grant Program."* 2019. https://cafiresafecouncil.org/grants-and-funding/grants-clearinghouse/edison-international-fire-safe-community-grants/.

Australia, which established Bushfire Committees. These committees have two important features:

- Committees are organized using a clear, detailed, and comprehensive handbook, designed to be understood by non-experts. The committees use this handbook to write a charter, which provides a single source of reference for values-at-risk,[25] roles and responsibilities, and risk management plans.
- These committees are organized by state fire officials but consist of local government, police, utility representatives, business people, and other landowners, often by appointment due to expertise or relationships with the community. They are given detailed planning templates, mapping software, and risk calculators to determine prioritization themselves. As a result, responsibilities are well-documented and receive community buy-in. Local planning and involvement also helped overcome resistance to fuel and vegetation management on private land.

Utilities participate in these committees to ensure consistency and coordination of their activities, like fuel management. Their role on the committees is as a stakeholder and asset owner; and their assets are included as economic priorities. Utilities are held accountable for their part of mitigation plans (e.g., vegetation management), as well as in incident response.

A primary role of the committee is developing a Bushfire Risk Management Plan, which is similar to California's Community Wildfire Prevention Plans, but contains additional detail. In developing these plans, committees pursue six objectives:[26]

1. Develop fire risk management program;
2. Document the methods and assumptions behind risk assessments, prioritization of values-at-risk, and plans for risk mitigation methods and assumptions used;
3. Identify and deploy resources efficiently towards prioritized risk management activities;
4. Integrate risk management into the decision-making process used by all stakeholders, public and private;
5. Ensure close coordination between landowners, risk management, and fire authorities; and,
6. Monitor and review the implementation plans to ensure these plans' feasibility, efficacy and effectiveness.

Overall, increased coordination can also further avoid conflicting prevention, response, and recovery activity that the WSD and utilities are leading. Figure 4 below outlines the many stakeholders involved in the utility wildfire mitigation landscape today. The WSD has now begun to lead coordination efforts by engaging many of the stakeholders below in a Utility Wildfire Mitigation Steering Committee that focuses on operational and policy issues related to utility wildfire mitigation efforts.

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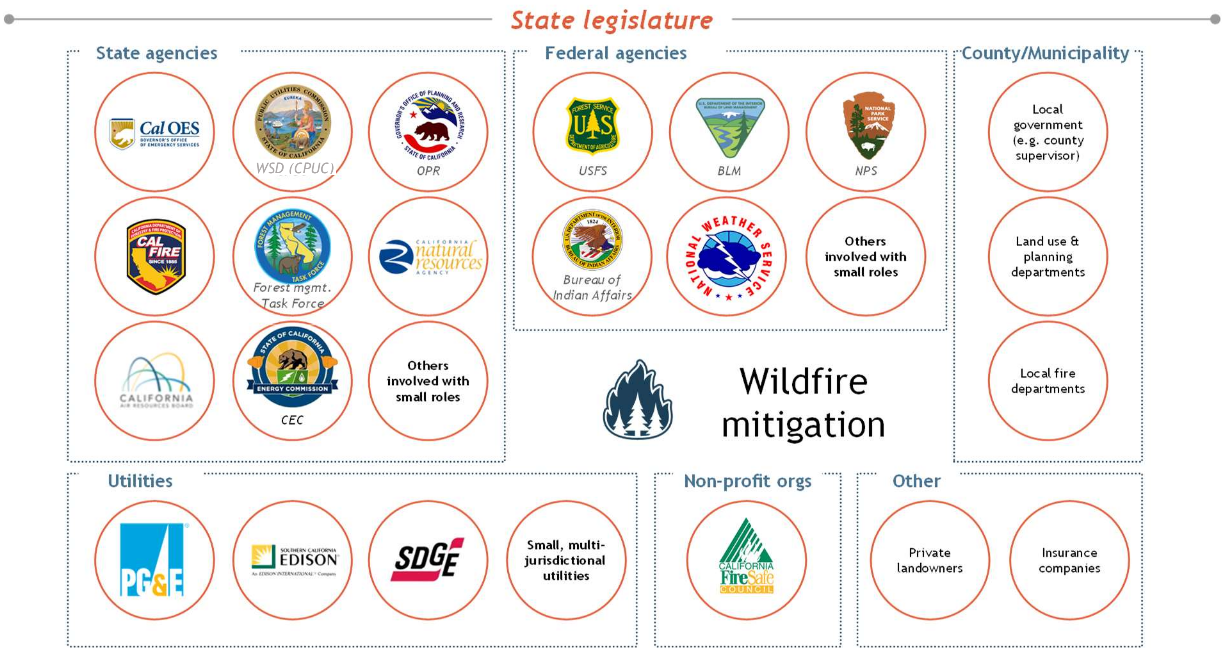
[25] Values-at-risk is a relative estimate, or known measure of worth of resources and property exposed to a chance of loss or damage from wildland fire; those resources or property specified. Source: National Parks Service. *Fires and fuels management: Definitions, ambiguous terminology and references*. https://www.nps.gov/olym/learn/management/upload/fire-wildfire-definitions-2.pdf.

[26] Department of Fire and Emergency Services of Western Australia. *Bushfire Risk Management Plan*. https://www.dfes.wa.gov.au/waemergencyandriskmanagement/obrm/Documents/Template%20-%20Bushfire%20Risk%20Management%20Plan.docx.

Figure 4: Stakeholders involved in wildfire mitigation



3.2 Culture and behavior

One of the WSD's responsibilities includes oversight of utilities' safety and public safety culture, with the mission of improving the culture and behavior around public safety within the utilities it regulates. As referenced in AB 1054 (Holden, 2019), safety culture of utilities is a key component in mitigation efforts and is insufficient today. Therefore, the WSD must continue to work with utilities to advocate for safety management improvements to mitigate wildfire and other risks caused by electric infrastructure. Additionally, the CPUC's Office of the Safety Advocate (OSA), the duties of which are now under other CPUC divisions, has recommended improvements to oversight, which the WSD needs to adopt, and to utilities' safety management, safety culture and utility infrastructure. The task of regulating safety culture continues to be a challenge for the WSD and will require further efforts to create a utility environment where public safety is truly reflected in the operating model of all organizations.

Specific safety culture improvements and recommendations were also outlined in legislation. AB 1054 charged the Wildfire Safety Advisory Board (WSAB) with making recommendations to the Wildfire Safety Division on the "appropriate scope and process for assessing the safety culture of an electrical corporation" by June 30, 2020. AB 1054 then requires the WSD to consult with the CPUC to adopt a process to conduct annual safety culture assessments for each utility, by December 1, 2020, and annually thereafter. While existing safety proceedings are underway for PG&E, under the PG&E Safety Culture Investigation,[27], additional efforts are also beginning to focus on connecting compliance to public safety culture. Already, IOUs must demonstrate a link between executive compensation and safety performance to receive a safety certification that

[27] California Public Utilities Commission. *PG&E Safety Culture Investigation*. April 2019. https://www.cpuc.ca.gov/PGEsafetyculture/

~~grants access to the Wildfire Fund~~ established in AB 1054[28] and AB 111 (Committee on Budget, 2019).[29]

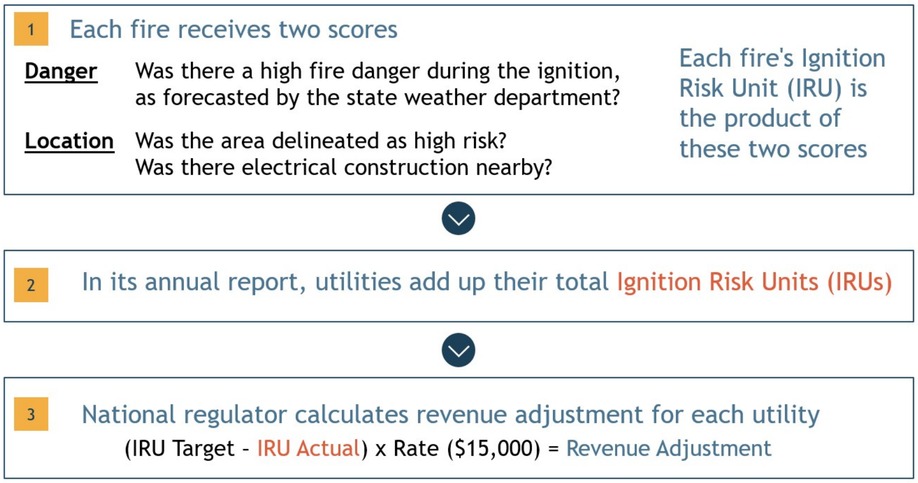
The WSD is especially focused on shifting utilities from a compliance-focused culture towards a culture centered on public safety. This a long-term focus on building proactive safety cultures within the utility space is essential in ensuring long-term resilience. Establishing a durable safety culture also requires a collective commitment to continuous improvement, and is an effort that the WSD, utilities, and others in the space continue to work towards. Specifically, the 2020 WMP guideline updates introduced a new tool, the Utility Maturity Model, to gain insight into utilities plans to continue to improve their utility-related wildfire mitigation efforts over time.

Another example of ways to shift utility public safety culture is through the use of financial incentives. One example comes from Victoria, Australia, in the form of the F-Factor Scheme, outlined in Figure 5 below. In Victoria, the F-Factor Scheme makes an adjustment to the return that the utility receives by directly incentivizing reduction in ignitions, focusing on those most likely to lead to catastrophic wildfire. Each ignition related to utility infrastructure recorded during the year is weighted by two factors: the location of the ignition and the degree of weather danger present at the time of ignition (as announced by the state weather agency). The ignitions are weighted from 0.02 for the least risky ignitions up to 99 for wildfires caused by construction activities during the highest possible fire risk conditions (Code Red). Locational risk weighting takes into account estimates of fire loss,[30] drawn from the Phoenix RapidFire model (as well as historical fire ignitions and other inputs). Weather risk weighting is comprised of the Fire Danger rating as declared on the day of ignition by the state government.

Under the F-Factor Scheme, utilities are given a target (as weighted by the same locational and weather factors) for ignitions stemming from their infrastructure. Should the utilities cause more ignitions than the target, the state reduces the rate they can charge customers in the coming year. Should the utilities cause fewer ignitions than their target, they would be able to collect a corresponding bonus. As a result of the F-Factor Scheme, utilities have implemented more cost-effective ignition reduction policies, such as minimizing changes in power flow, which may cause sparks, during high-risk conditions.

[28] Assembly Bill 1054 (Holden, Chapter 79, Statutes of 2019), (AB 1054).
[29] Assembly Bill 111 (Committee on Budget, Chapter 81, Statutes of 2019), (AB 111).
[30] Using number of houses lost as a proxy for the consequence of a fire for communities. Source: Victorian Department of Environment Land Water and Planning: Powerline Bushfire Safety Program. *F-factor Incentive Scheme: Regulatory Impact Statement*. October 2016. https://www.energy.vic.gov.au/__data/assets/pdf_file/0022/44419/f-factor_-_Regulatory_Impact_Statment_Oct16.pdf.

Figure 5: Outline of Victoria's F-Factor Scheme to incentivize utilities to reduce ignitions



Given these financial incentives, the ignitions weighted as 0.02 would carry a penalty of just $300, whereas the riskiest ignitions weighted at 99 for wildfires caused by construction activities during the highest possible fire risk conditions (Code Red) would carry a penalty of almost $1.5 million (AUD) in the F-Factor Scheme, regardless of the eventual wildfire consequences. [31] The CPUC has previously leveraged a variety of performance based ratemaking mechanisms in the past, with varying levels of success. If the WSD were to consider incentives specifically for wildfire mitigation, it could be a novel application of such mechanisms within California. However, any such effort would first require WSD effort to better understand critical success factors based on previous CPUC experience.

Beyond examining wildfire-specific incentive schemes, there are lessons to be learned from other industries related to risk management. Examples from financial institutions and the energy sector highlight opportunities to improve the risk-maturity of wildfire mitigation approaches. Each industry highlights the need to begin with a detailed understanding of the risk today, before pursuing mitigation activities. In banking, risk management techniques to measure 'long-tail' risk emphasize the importance of advanced analytics to inform mitigation activities. Data collection, pooling, and analysis are the underlying common factors that actors must contribute in order to effectively work together. Increasing risk maturity over time, as leveraged in the energy sector, is about how to move from risk-naïve or risk-aware, towards risk-based decisions. An outline of one approach is in Figure 6 below.

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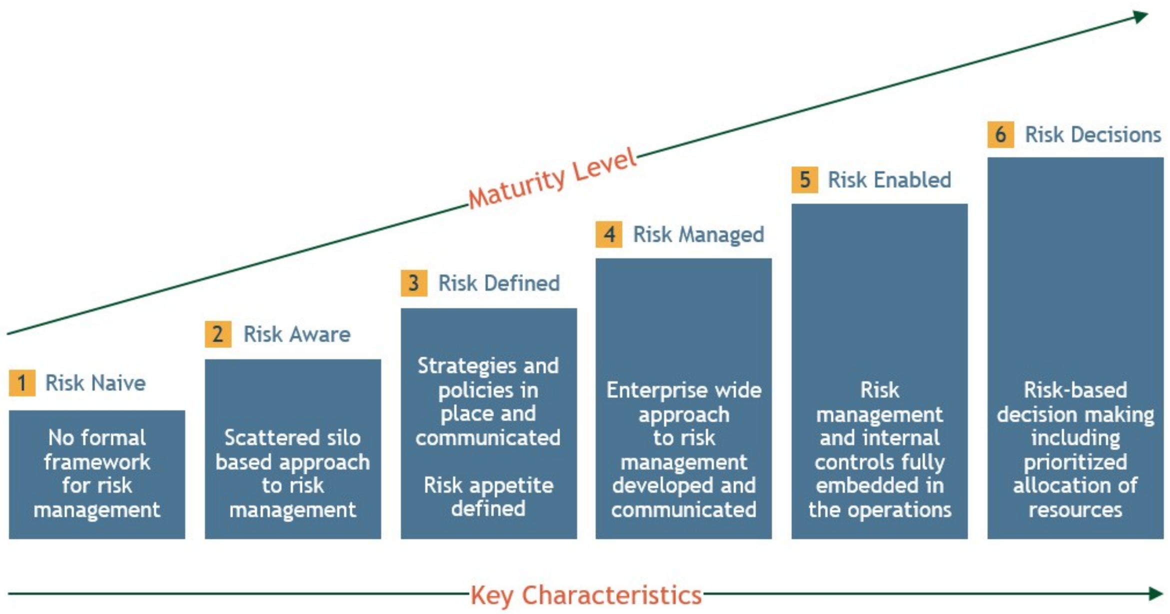
[31] Australian Energy Regulator. *AER releases F-factor scheme results for Victorian electricity distributors for 2017-18*. June 28, 2019. https://www.aer.gov.au/communication/aer-releases-f-factor-scheme-results-for-victorian-electricity-distributors-for-2017-18.

Figure 6: Risk management maturity model



Source: MacWilliams, John. *Enterprise Risk Management*. CPUC Implementing Utility Wildfire Mitigations Plans Workshop, September 18, 2019.https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/External%20Expert%20Panel%20Slides.pdf#page=5.

3.3 Applied science, technology, and data

Data and analytics to support risk-informed decision-making

A key focus of the WSD is on incorporating data and analytics into their risk management approaches. The CPUC laid the foundation for this work with the development of the CPUC Fire Threat Map~~, adopted in January 2018~~.[32] Following that, the CPUC and utilities continued to invest in more advanced analytics. For example, in 2019, SDG&E developed a proprietary tool to quantify the risk of vegetation contact for each of its circuits, based on such data inputs as the counts of trees adjacent to the circuit's right-of-way by species and height, as well as a historical correlation with outages.[33] Additionally, as part of their preparation for the 2020 WMPs, some utilities utilized wildfire propagation modeling to identify areas of high risk at a more granular and operational scale than the CPUC's High Fire Threat District maps. However, these efforts have taken place in silos, with each major utility developing unique analytical and decision-making processes.[34] These examples highlight some of the issues, further detailed in Figure 7 below, that the WSD and utilities still face related to use of data and analytics. These pain points hamper rigorous wildfire risk calculations based on standardized data and methodologies, thereby precluding a shared understanding of wildfire risk and a synchronized response to the threat of wildfires.

[32] ~~Malashenko, E., *Advice Letter 5211-E / 3172-E*~~Decision Adopting Regulations to Enhance Fire Safety in High Fire-Threat District, Decision 17-12-024. ~~January 19, 2018.~~Approved December 14, 2017.
[33] San Diego Gas and Electric. *Wildfire Mitigation Plan Update*. September 17, 2019. https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/SDGE%20Wildfire%20Plan%20Update%20at%20the%20CPUC%209.17.19%20R1.pdf.
[34] BCG interviews with IOU representatives, 2019.

Figure 7: Current data-related pain points in today's WSD utility-related wildfire oversight process

1 Limited data quality

Data are not collected in the same manner, available with the same timeliness, or presented in a consistent manner, limiting their usefulness

2 Lack of standardization

Utilities use different diagnostic and prioritization approached as well as different data taxonomies for many variables, making it difficult to share and align on best practice

3 Decisions require manual intervention

Many of the decisions are ultimately made by subject matter experts, and do not follow objective criteria

4 Lack of transparency

WSD has little visibility into the diagnostics and decision-making carried out by IOUs, as well as the data they utilize, as they prioritize their efforts

5 Limited stakeholder participation

Utilities develop their plans mostly in isolation, with limited collaboration within IOUs and with other stakeholders

SB 209 (Dodd, 2019) begins to address these issues by mandating that Cal OES and CAL FIRE establish the Wildfire Forecast and Threat Intelligence Integration Center, charged with supporting data-driven wildfire risk management. The particular responsibilities of the Wildfire Forecast and Threat Intelligence Integration Center include gathering data about drivers of wildfire risk, developing specific intelligence products related to fire weather, and coordinating statewide forecasting and data-sharing.[35] The WSD is also developing more advanced data aggregation and data analytical tools and should coordinate with efforts related to the Wildfire Forecast and Threat Intelligence Integration Center, further detailed in *Appendix 3: Utility Wildfire Mitigation Data Strategy.*

Innovation in system hardening and equipment and wildfire mitigation tools

Continued development and testing of new technology and tools is also a priority. The U.S. Department of Homeland Security's Science and Technology Directorate used table-top exercises, simulating wildfires and working with participants drawn from law enforcement, fire, and emergency medical services to identify priority issues, information requirements, and capability gaps. The exercises found that situational awareness, fire modeling, and public outreach were among the most significant technology gaps.[36] In California today many institutions are leading the way in closing these gaps through organizations such as the WIFIRE lab at UCSD, the Fire Weather Research Laboratory at San Jose State University, the EPIC program within the CPUC, and a Proof of Concept/Wildfire Innovation Sprint led by CAL FIRE. [37] The CPUC and CAL OES also convened a Wildfire Technology Innovation Summit in March 2019 to enable learning across organizations and to connect individuals in the field.[38]

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[35] Senate Bill 209, (Dodd, Chapter 405, Statutes of 2019), (SB 209).
[36] United States Department of Homeland Security. *Wildland Urban Interface Fire Operational Requirements and Capability Analysis*. May 31, 2019. https://www.dhs.gov/sites/default/files/publications/wui_fire_report_of_findings_july_24_2019v2_508.pdf.
[37] Office of Governor Gavin Newsom. *Governor Newsom Announces Two Innovative Contracts for Wildfire Prevention and Response*. September 18, 2019. https://www.gov.ca.gov/2019/09/18/governor-newsom-announces-two-innovative-contracts-for-wildfire-prevention-and-response/.
[38] See *Wildfire Technology Innovation Summit*, https://firetechsummit.cpuc.ca.gov/

Overall, California utilities can continue to employ new technologies to more efficiently and effectively reduce their wildfire risk. Examples of innovative technologies include new imaging technology that supports greater precision and reduced time to issue detection. Weather stations now employ cameras that can be remotely operated, using infrared to detect smoke plumes with 360° of range. The number of California wildfire cameras available online grew nearly tenfold in the past year.[39] LiDAR can be used to more rapidly gather data about the condition of utility assets and vegetation along rights-of-way in a single scan. Additional details are provided earlier in this report about LiDAR use in vegetation management in particular; however, an example of using LiDAR for both vegetation and asset inspections concurrently is at Manitoba Hydro in Canada, which mapped its heavily forested corridors with LiDAR, prioritizing points by risk of failure and impact of failure, creating a 3-dimensional profile of utility corridors, and facilitating simulations of expected tree growth.[40] Drones can be used to quickly collect high-quality imaging in difficult-to-access areas, such as wilderness areas inaccessible by road or areas with smoke from existing fires which would be dangerous for crewed vehicles or airplanes to enter.[41]

Additional examples focus on new tools to reduce risk. Before the wildfire season, for example, BC Hydro (the utility of British Columbia) applies chemical retardants that reduce the combustibility of fuels along their rights-of-way. In addition, Texas A&M University has developed and tested automatic detection of voltage fluctuations that may precipitate failures, faults, and outage – which, in turn, may result in a wildfire ignition, given the right circumstances. With this technology, utilities gain a leading indicator that can enhance both their maintenance planning and operations during high fire threat conditions.[42]

Utilities also have opportunity to continue supporting R&D efforts, in coordination with CAL FIRE, the WSD, and the CEC, as they support technology innovation related to mitigation measures (e.g. vegetation management, response tools, grid modernization, and system hardening tools).

Evaluating the efficacy and efficiency of emerging technologies

At this time, many widely-discussed methods of reducing utility-related wildfire risk, such as undergrounding utility lines or installing covered conductors, are extremely capital-intensive relative to their ability to reduce statewide wildfire risk. New technologies promise more effective and cost-effective risk reduction, but utilities will need to validate their safety and effect on reliability.

Fire authorities and utilities are also employing a range of technologies to more precisely gauge risks, measure the efficacy of potential mitigation measures, and determine the optimal allocation of resources. Further investment in existing wildfire technology evaluation capabilities could expedite innovative technology. Currently, utilities are individually responsible for

[39] From 35 in 2018 to 300 in 2019, on ALERTWildfire; Source: Tebor, Celina. "Wildfire camera networks spread across California." *San Diego Union-Tribune*, October 24, 2019. https://www.sandiegouniontribune.com/news/environment/story/2019-10-24/wildfire-camera-networks-spread-across-california.

[40] Amadori, Jason. "Utility Infrastructure Vegetation Management Using LiDAR, Imagery and GIS." *LiDAR Magazine,* 2012. http://lidarmag.com/wp-content/uploads/PDF/LiDARMagazine_Amadori-UtilityVegetationManagement_Vol2No5.pdf; Interviews with industry participants

[41] Baggaley, Kate. "Drones are fighting wildfires in some very surprising ways." *NBC News*, November 16, 2017. https://www.nbcnews.com/mach/science/drones-are-fighting-wildfires-some-very-surprising-ways-ncna820966.

[42] Benner, C.L. et al. *DFA Technology Detects Circuit Device Failures – Experience of Mid-South Synergy*. March 25-28, 2019. http://prorelay.tamu.edu/wp-content/uploads/sites/3/2019/03/20190327.TamuRelayConference.MidSouth.Dfa_.presentation.pdf.

evaluating new technologies, piloting them in their own grids, and evaluating their performance and cost. However, since IOUs can earn a fixed rate of return on approved capital expenditures, utilities may be biased toward designing experiments that will show that a high capital spending initiative is more effective than other low capital cost initiatives. An independent agency could instead objectively assess the effectiveness of a given initiative, as is done in Victoria, Australia (more detail can be found in the Section 4 Case Study of Victoria, Australia).

3.4 Workforce development

References from both California legislation and utility reporting highlight challenges with the existing workforce in terms of both capacity and qualification. At the highest level, there is a nationwide shortage of qualified utility line workers and qualified line clearance tree trimmers who can complete the asset and vegetation management work needed to prevent and respond to wildfires, storms, and other major events.[43] According to utilities, difficulty filling roles such as Certified Arborists and Foresters who design, develop and approve vegetation management plans is limiting planned fuel and vegetation management activities. In their September 2019 update, SCE referenced increased vegetation work across California driving scarcity and competition for human resources as a barrier to meeting its 2019 plan.[44] These roles, and others related to wildfire mitigation, will continue to become increasingly important.

Initial activity related to workforce development in California has already begun. San Jose State University is building their Wildfire Science program[45], and other universities continue to drive efforts to build individual capabilities. However, this is not sufficient and continued ongoing utility investment in people and capabilities will be critical to the successful execution of prevention, response, and recovery activities.

One tool utilities are leveraging significantly to supplement their workforce is increasing their contracted workforce, which can amplify the traditional risk that utilities are facing in operations, including in wildfire risk[46]. To ensure quality management with contractors, Australian utilities focus on managing risk and compliance using outcome-based contracts and extensive audits. These activities include:

Using outcome-based, lump-sum contracts:

- Engages sole contractor to perform scoping, scheduling, and treatment with limited company involvement
- Contractor has full visibility on span and tree information and cuts within rolling annual program
- Migrated own vegetation management software solution to contractor's proprietary solution to improve offline data visibility and enable large data processing

Pursuing high effort audits:

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[43] Assembly Bill 1054, (Holden, Chapter 79, Statutes of 2019), (AB 1054).; Department of Energy. *Quadrennial energy review, Transforming the nation's electricity system: the second installment of the QER.* January 2017. https://www.energy.gov/sites/prod/files/2017/02/f34/Quadrennial%20Energy%20Review--Second%20Installment%20%28Full%20Report%29.pdf

[44] Southern California Edison. *SCE's 2019 Wildfire Mitigation Plan (WMP) Progress Update*. September 17, 2019. https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/SCE%202019%20WMP%20Progress%20Update_R.18-10-007.pdf.

[45] San Jose State University. *"Cluster Hire" at SJSU expected to lead to deeper focus on wildfire science.* November 20, 2019. https://blogs.sjsu.edu/president/2019/11/20/cluster-hire-at-sjsu-expected-to-lead-to-deeper-focus-on-wildfire-science/

[46] Tevelson, R. et al. "How Utilities Can Manage Supplier Risk." *BCG*, August 6, 2019. https://www.bcg.com/en-es/industries/energy/power-utilities/how-utilities-can-manage-supplier-risk.aspx.

- Ensures compliance through 100% ground-based audit of all cut spans, in addition to contractor audit
- Auditors follow cutting crew routes and perform timely audits of cut spans; ground-based audits supplemented with desktop audits using pre and post-cut photos supplied by treatment contractors
- Uses LiDAR to perform a compliance check of bushfire prone pre-bushfire season, to measure effectiveness of the maintenance program and highlight any additional spans requiring treatment

Ensuring use of targeted programs:

- Initiated targeted treatment (method and timing) and removal program to reduce costs while maintaining or reducing risk
- Targeted program uses detailed information, including historic LiDAR data and topography to calculate vertical and horizontal growth rates and determine likelihood of trees impacting powerlines to further prioritize vegetation management activities

Further workforce development could also look at examples from British Columbia, Canada. While wildfire response in California is considered among the best in the world, in British Columbia, Canada, the law requires all personnel working in wildfire-prone areas, including utility personnel, be trained and equipped to conduct early stage wildfire suppression. The level of training and equipment required depends on the risk level of the work being conducted. In British Columbia workers are required to have wildfire risk reduction and suppression training, carry tools to suppress ignitions at the earliest stages, and have access to communications equipment to report ignitions. They are required to receive training on how to safely suppress ignitions in their earliest stages as frequently as possible on an annual basis. As a result, some fires can be suppressed before they have an opportunity to grow out of control.

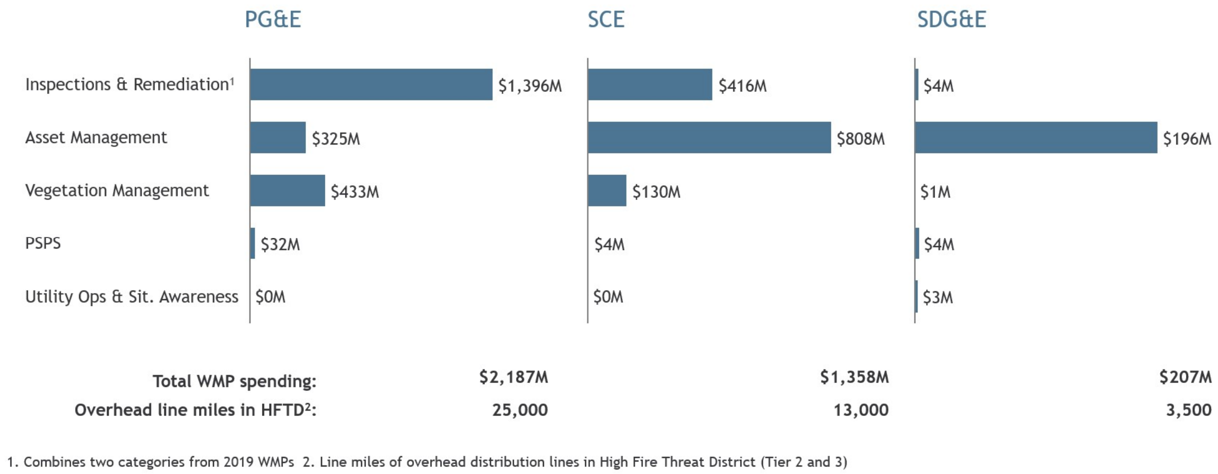
Internally, the WSD is also undergoing efforts to increase its utility wildfire expertise with plans to hire staff with the capability to effectively evaluate WMPs, the data and analytical skills to drive more advanced analytics, and the safety expertise to support safety culture improvements within the utilities.

3.5 Other critical collaboration areas

In addition to the four collaboration areas discussed above, the WSD is responsible for implementing existing and future legislative priorities. This includes a continued focus on proactively reducing utility-related wildfire risk, and more specifically, the evolution of the Wildfire Mitigation Plans. Changes to other legislation and regulation governing utility wildfire mitigation, as well as funding available for prevention and mitigation initiatives, will also direct WSD efforts.

The WSD must also consider the ~~affordability and~~ resource efficiency <u>and feasibility</u> of utilities' wildfire mitigation plans. In 2019, the three large IOUs planned to invest a combined $3.9 billion to mitigate risk of wildfire ignition from their systems, focusing on investments in system hardening, vegetation management, enhanced inspection programs, and situational awareness, as outlined below in Figure 8. Utilities' plans to construct a more resilient system are phased over multiple years to account for planning, permitting, and workforce constraints as utilities execute the backlog of activities that must occur after the disastrous 2017 and 2018 wildfire years. Overall, these investments and risk reduction actions highlight the potential costs, as well as the challenges and tradeoffs, of utility wildfire mitigation efforts.

Figure 8: 2019 utility WMP proposed cost estimates by category for PG&E, SCE, and SDG&E



Source: 2019 Wildfire Mitigation Plans filed by PG&E, SCE, SDG&E

The annual WMP plan priorities for each of the three largest IOUs vary slightly, as outlined in Figure 9 below. Together, utilities and regulators must balance longer-term investments, such as grid topology improvements that provide sustained risk reduction but require many years to be implemented, with short-term investments such as vegetation management, early detection of ignition, and monitoring of high risk conditions in proximity to utility infrastructure. These initiatives are low-cost and have a short-term impact; however they are not sufficient to address the long-term wildfire risks in California.

Figure 9: 2019 WMP plan priorities for PG&E, SCE, and SDG&E

PG&E

- Vegetation Management & Enhanced Inspections
- Wildfire Response
- System Hardening
- Situational Monitoring (e.g., installing weather cameras)
- Operational Practices (e.g., de-energization)
- Tech Research /Development

SCE

- Ignition Reduction in High-Risk Areas
- Fire Suppression
- System Hardening
- Communication

SDG&E

- Ignition Reduction in High-Risk Areas
- Fire Suppression
- Wildfire safety and recovery

Source: Summary of IOU WMPs referenced in Governor Newsom's Strike Force. *Wildfires and Climate Change: California's Energy Future.* 12 April 2019, based on "Pacific Gas and Electric Company's Wildfire Mitigation Plan," and "San Diego Gas and Electric Company's (U 902 E) Wildfire Mitigation Plan," and "Southern California Edison Company's (U 338-E) 2019 Wildfire Mitigation Plan"

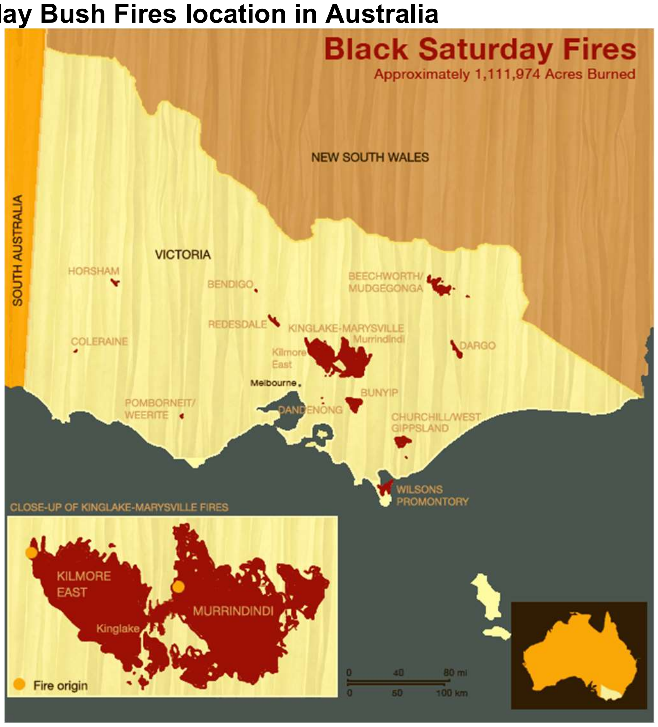
Implicit financial incentives also influence resource allocation decisions by utilities. In California, investor-owned utilities are generally incentivized to make purchases of capital equipment over operational investments, assuming they earn a set rate of return on their capital investments through cost recovery mechanisms in the general rate case (GRC). Furthermore, the process of approving and monitoring utility wildfire mitigation investments falls to different stakeholders within the CPUC from those who approve and monitor the utilities' activities.[47] This complicates the assessment of utility wildfire mitigation resource efficiency, compliance, and enforcement. The WSD must coordinate with other CPUC divisions to evaluate the technical feasibility, resource efficiency, and ambition of utilities' wildfire mitigation plans, and collaborate with agencies like CAL FIRE and Cal OES to understand how utilities' activities might add to or detract from the effectiveness of broader wildfire mitigation efforts.

4 Case study: Victoria, AU response to 2009 wildfires

Background

Wildfires, known locally as "bushfires," are a natural part of the ecology of the Australian state of Victoria. However, the extreme scope and intensity of wildfires on the day known as "Black Saturday," on February 7, 2009, caused the death of 173 people.[48] Like California's recent wildfires, including the 2018 Camp Fire, record-breaking hot and windy weather conditions led to fast-moving wildfires of extreme ferocity.

Figure 10: Black Saturday Bush Fires location in Australia



Source: PBS. "Survivors of the Firestorm, Black Saturday Bush Fires (MAP)". April 15, 2011. https://www.pbs.org/wnet/nature/survivors-of-the-firestorm-black-saturday-bush-fires-map/6503/.

Victoria took action after these 2009 wildfires to reduce the future risk associated with wildfires. The 2009 Victorian Bushfires Royal Commission set out a state-wide strategy to ensure that those lessons are clearly defined and actioned upon. The Commission conducted an extensive

[47] WMP approval (in 2020) is led by the Wildfire Safety Division, while enforcement falls to the Safety Enforcement Division and the GRC requests are analyzed by the Energy Division.
[48] 2009 Victorian Bushfires Royal Commission. *Final Report*. July 2010.

investigation into the causes of, the preparation for, the response to and the impact of the fires that burned throughout Victoria in late January and February 2009.

The recommendations stemming from the Commission’s work give priority to protecting human life, and are designed to reflect the shared responsibility that governments, fire agencies, communities and individuals have for minimizing the prospect of a wildfire tragedy of similar scale.

Importantly, action was taken to implement these recommendations with reference to 4 areas: 1) mitigation through education and community planning; 2) data and analytics to establish a single source of truth, 3) financial incentives to reduce wildfire risk from utilities and 4) piloting innovative technologies.

Part 1: Mitigation through education and community planning

After 2009, Victoria decided to make wildfire prevention and education a priority. Action was taken to understand that wildfire is a natural part of Australia’s ecosystem and that responsibility for reducing wildfire risk should be spread across all stakeholders, including the general public. Victoria made wildfire risk reduction a community effort, with a focus on community planning and education beginning from elementary school. With encouragement of individuals to take part in wildfire mitigation, the public is more likely to be prepared for an emergency, perform maintenance at home to provide defensible space, and take steps around their community to reduce bushfire risk.

Part 2: Data and analytics to establish a single source of truth

Fire spread simulations are used by stakeholders to establish a common source of truth. Stakeholders using Phoenix RapidFire, a wildfire risk simulation tool, include local Bushfire Committees, fire suppression professionals, regulators, utilities, and others widely across Victoria. Australian utilities use Phoenix to identify areas likely to ignite catastrophic wildfires and have prioritized these for utility grid hardening. Phoenix enables stakeholders across the state to align on priorities and coordinate risk reduction and response activities. In one region of Victoria, Phoenix was used to show that fuel management activities can reduce the risk from wildfire by nearly 35%, making it easier to demonstrate the value of spending resources on various initiatives.

Part 3: Financial incentives to reduce wildfire risk from utilities

In Victoria, the state has also provided incentives to utilities in a program called the F-Factor Scheme that penalizes them for ignitions weighted by their severity, as outlined earlier in this document in Figure 4. Under the F-Factor Scheme, utilities are given a target for ignitions that is set by the Australian Energy Regulator (AER) and determined by the proportion of fire starts that have historically been incurred by each utility. The target is weighted by severity in terms of impact on communities and ignition severity is informed by the Phoenix RapidFire model. Should a utility cause more ignitions than the target, the state reduces the rate they can charge customers in the coming year. As a result, utilities have implemented more cost-effective ignition reduction policies, and focused ignition reduction on the highest risk areas.

Part 4: Piloting Innovative Technologies

The State of Victoria developed a coordinated, data-driven approach to targeting high-risk areas with cost-effective solutions. The Powerline Bushfire Safety Program uses the Phoenix consequence modeling, as well as utility performance data, to identify the location of high-risk parts of the grid, then identify the optimal solutions, while staying within the capital controls imposed by the state on public- and private-sector spending. As part of this program, Victoria implemented independent technology evaluation and piloting capabilities. This enables more rapid evaluation of new technologies and also provides a neutral evaluation of new technologies. This capability has enabled Victoria to rapidly deploy these technologies quickly and uniformly across the state. In particular, in cooperation with electricity distributor AusNet Services, the state installed Rapid Earth Fault Current Limiters (REFCLs), which immediately reduce the voltage upon the detection of a fault, dramatically reducing ignition risk. Through both laboratory testing and demonstrations using live distribution networks, the state validated the technology’s safety and efficacy. The state then incorporated REFCLs into mandated protection standards, with all at-risk circuits being equipped by 2023. “When this program is complete, REFCLs are expected to provide at least a 60% reduction in risk on over…more than half the state’s high-voltage distribution lines.”[49].

[49] Victoria State Government Environment, Land, Water and Planning. “High Voltage Network Assets Program.” 2019. https://www.energy.vic.gov.au/electricity/powerline-replacement-fund/powerline-bushfire-safety-program/network-assets-program/high-voltage-network-assets-program.

5 Conclusion

Overall this report highlights actions the WSD and utilities are currently taking, and can take to improve their wildfire mitigation efforts. The strategy and roadmap laid out in the main section of this report address not only the ideas and issues identified here, but also outline actions to move towards a more resilient future by embracing longer-term thinking and taking a more robust strategic approach focused on the most impactful decisions – all with a local lens. And it is only with collaborative, coordinated efforts that the current state of wildfire mitigation efforts will improve.

While the specific characteristics of California must be taken into account when considering adoption of global wildfire mitigation practices, including its communities and local risk drivers, these global approaches represent an important starting point for considering new ways to address wildfire risk here in California.