Disclaimer

This document: (a) is proprietary and confidential to Baringa Services Ltd (“Baringa”) and could not be disclosed to or relied upon by any third parties or re-used without Baringa’s consent; (b) shall not form part of any contract nor constitute acceptance or an offer capable of acceptance; (c) excludes all conditions and warranties whether express or implied by statute, law or otherwise; (d) places no responsibility or liability on Baringa or its group companies for any inaccuracy, incompleteness or error herein; and (e) is provided in a draft condition “as is” without warranty. Any reliance upon the content shall be at user’s own risk and responsibility. If any of these terms is invalid or unenforceable, the continuation in full force and effect of the remainder will not be prejudiced.

This report has been prepared by Baringa Services Ltd or a Baringa group company (“Baringa”) specifically for the client named in this report (“Client”) for the sole purpose of assisting the consideration of Client or interested investors (“Investors”) in the potential transaction named in this report (“Transaction”).

This report does not constitute a personal recommendation of Baringa or take into account the particular investment objectives, financial situations, or needs of Client or the Investors in relation to the Transaction. Client and Investors could consider whether the content of this report is suitable for their particular circumstances and, if appropriate, seek their own professional advice and carry out any further necessary investigations before deciding whether or not to proceed with the Transaction. This report could not, under any circumstances, be treated as a document containing complete and accurate information sufficient to make an investment decision. It is the responsibility of the Client and Investors to conduct such due diligence as necessary of any risk factors not identified in this report or which could affect the operation, financial standing and further development prospects of any assets being acquired, charged or sold in the Transaction. Baringa shall not be liable in any way for errors or omissions in information contained in this report based upon publicly available industry data or specific information provided by others (including Client, its affiliates, their advisers, target entity or any third parties). Baringa makes no representations or warranties (express or implied) concerning the accuracy or completeness of the information contained in this report, nor whether such information fully reflects the actual situation described in this report, and all conditions and warranties whether express or implied by statute, law or otherwise are excluded.

Information and data contained in this report is confidential and must not be disclosed to third parties by Client or Investors except as permitted in the relevant Client contract with Baringa or with the written consent of Baringa. This report may not be used in any processes involving the public offering in which shares of stock in a company are sold either privately or on a securities exchange. No part of this Report may be copied, photocopied or duplicated in any form by any means or redistributed (in whole or in part) except as permitted in the relevant Client contract with Baringa or with the written consent of Baringa. Copyright © Baringa Services Ltd 2024. All rights reserved.

Additional Disclaimers

INDEPENDENT ADVISOR

As part of the Bipartisan Infrastructure Law (BIL), the federal government has earmarked non-competitive funding for states and Indian tribes to improve the resilience of their electric grids. Known as the Grid Resilience State and Tribal Formula Grants, this program is designed to strengthen and modernize America's power grid against wildfires, extreme weather, and other natural disasters.

Baringa was commissioned by the Department of Energy (DOE) to participate in a consortium of technical assistance providers known as Grid Resilience and Climate Change Impacts (GRACI) as an independent advisor that supported states in the allocation of their grants.

The following **California Grid Resilience Report** was produced for the California Energy Commission (CEC) as part of the technical assistance program. This report helps states identify future risks from extreme weather by analyzing downscaled climate projections and assessing the impact to various energy assets out to mid- and end-century. Additionally, the report suggests low- and high-cost mitigation and adaptation strategies to address the identified risks.

A custom version of this report was produced for all 11 states in the Western Electric Coordinating Council (WECC). For more information on these additional reports or the GRACI program, please feel free to reach out to the Baringa team.

CERRI DISCLAIMER

The California Energy Commission's (CEC) Community Energy Reliability and Resilience Investment (CERRI) Program funds projects across California that increase community energy resilience and reliability, advance state energy and resilience goals, and create good-paying jobs.

This report was prepared as the result of work sponsored by the U.S Department of Energy. It does not necessarily represent the views of the CEC, its employees, or the State of California. The CEC, the State of California, its employees, contractors, and subcontractors make no warranty, express or implied, and assume no legal liability for the information in this report. This report has not been approved or disapproved by the CEC, nor has the California Energy Commission passed upon the accuracy or adequacy of the information in this report. This report may act as a reference for potential applicants, but will not be factored in how grant applications are scored.

Grid Resilience Reports

California

Energy & Resources | Networks
3/17/2025

Table of contents

Glossary

ACCC – Aluminium Conductor Composite Core

ANL – Argonne National Laboratory

BESS – Battery energy storage system

CCGT – Combined cycle gas turbine

CEC – California Energy Commission

CERRI – Community Energy Reliability and Resilience Investment Program (CERRI) Program

CT – Combustion turbine

CZ – Climate zone

DER – Distributed energy resource

DLR – Dynamic line rating

Dx – Distribution

FWI – Fire Weather Index

GRR – Grid Resilience Report

HV Tx– High voltage (>345 kV)

LV Tx– Low voltage (<100 kV)

MV Tx– Medium voltage (100-287 kV)

N/S/E/W – refer to cardinal directions (North, South, East, West)

O+M – Operations and maintenance

OEM – Original equipment manufacturer

P1, P2, P3 – Peak 1,2, 3

Tx – Transmission

VPP – Virtual power plant

Aligning Grid Resilience Report insights to the CEC Title 24 Climate Zones

Projects located outside of the most exposed climate zones are **still eligible** for CERRI funding.

The Climate Zones identified in the GRR may not directly correspond to the official Title 24 Climate Zones due to mapping of county-level analysis.

*Weather data from the representative city was used to inform CEC's development of Title 24 energy efficiency standards

This report breaks down future climate exposure by the Title 24 Climate Zones in order to **highlight regional priorities by hazard** for Community Energy Reliability and Resilience Investment Program (CERRI) Program applicants.

Proposed projects in counties and climate zones with higher identified exposure are preferred given their ability to mitigate more future risk.

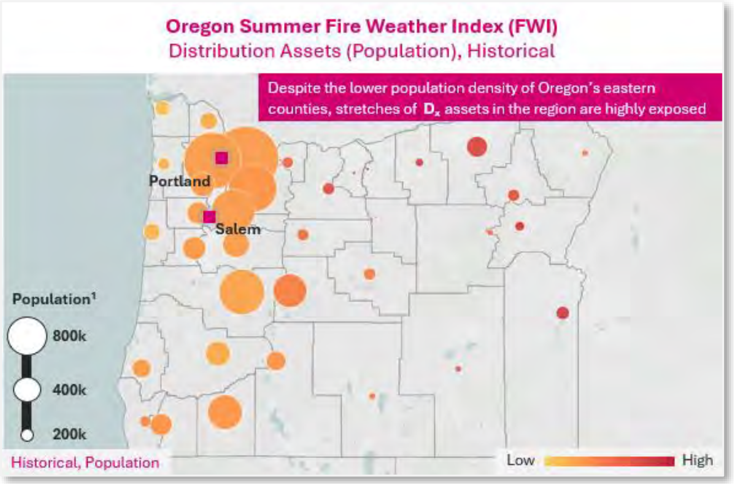
The Title 24 Climate Zones, originally created by the CEC for energy efficiency standards, account for the diversity of climates throughout California.

Working with climate data at the county level, this analysis maps counties to the zones in which the majority of their zip codes were located (see left map).

Climate Zone	Representative City*	Summer Avg. Max Temp	Hist. Summer FWI
1	Arcata	78.9	23.8
2	Santa Rosa	84.5	26.8
3	Oakland	86.7	37.2
4	San Jose-Reid	87.8	37.3
5	Santa Maria	91.9	36.8
6	Torrance	85.2	36.9
7	San Diego-Lindbergh	100.1	58.8
8	Fullerton	86.3	30.5
9	Burbank-Glendale	90.2	59.2
10	Riverside	103.2	65.2
11	Red Bluff	95.8	36.4
12	Sacramento	93.5	35.1
13	Fresno	97.1	40.2
14	Palmdale	103.2	63.0
15	Palm Spring-Intl	103.7	58.8
16	Blue Canyon	93.8	31.0

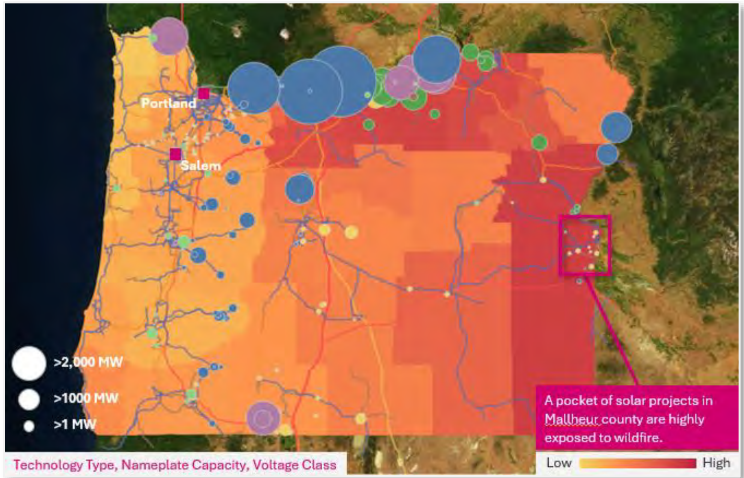
This report is standardized to include 3 different data visualizations that provide insights for Distribution, Transmission, and Generation across 7 extreme weather hazards

1 Distribution Maps



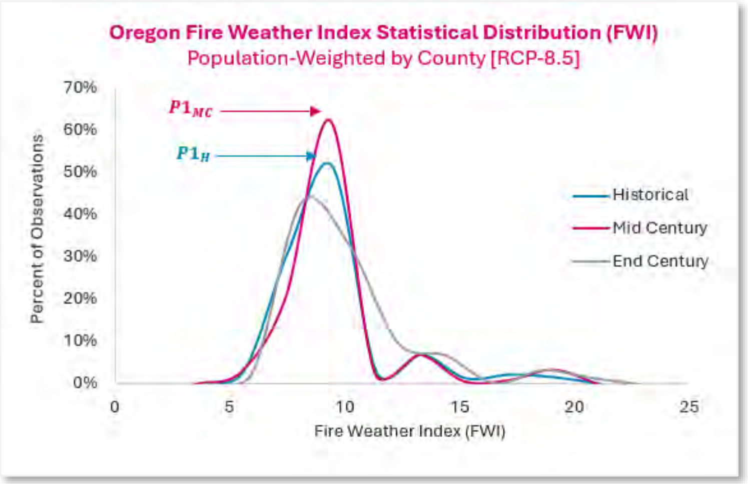
- **Purpose:** Uses population as proxy for volume of distribution assets given that the location of distribution assets is restricted.
- **Interpretation*:** Locate areas of high exposure by identifying counties with coincident large bubbles and dark colors. This indicates a combination of high volume of Distribution (Dx) assets and significantly high extreme weather projections. Lack of utility data inhibits the ability to look at feeder level data.

2 Transmission & Generation Maps



- **Purpose:** Overlays transmission and generation assets on climate projections by county.
- **Interpretation:** Locate areas of high exposure by identifying assets in counties of high risk. Exposure differs by asset class and will be highlighted in Key Insights tables throughout.

3 Statistical Distribution Graphs



- **Purpose:** Contains statistical insights related to each metric. Indicates change in dispersion and severity of risk over time on average
- **Interpretation:** An increase in the width of the peak indicates a decrease in concentration of exposure, meaning more counties are exposed to more severe weather. A shift right in the curve indicates that on average, counties are experiencing more severe weather.

***Note:** Analysis addresses risk given volume of assets and does not account for risk to remote customers at end of radial distribution grids. See example solutions in following slide.

Climate Zone Overviews

Key Hazards by Climate Zone

Climate Zones 1-4 face peak statewide flood exposure, as well as pockets of extreme wind exposure in Climate Zone 3

Climate Zone	Counties	Most Concerning Hazards	Key Asset Impacts	Relevant 40101(d) Investments
1	**Del Norte, Humboldt**	FLOOD, WIND, DROUGHT, RAIN	• Ground-level substation components (HV transformers, control houses, etc.) are highly exposed to flooding and have long lead times and high cost of replacement. • Various unreinforced distribution poles have high probability of failure when exposed to winds >70mph*, far below the 100-year return value for Climate Zone 1.	• **Flooding:** Flood walls, substation elevation, enclosures, control house remediation (see slides 18, 19). • **Wind:** Pole reinforcement, pole material upgrade, decreased spans, vegetation management (see slides 21, 23).
2	**Lake, Marin, Mendocino, Napa, Sonoma**	FLOOD, RAIN	• Ground-level substation components (HV transformers, control houses, etc.) are highly exposed to flooding and have long lead times and high cost of replacement. • Distribution poles can be washed out during flash floods or mudslides.	• **Flooding:** Flood walls, substation elevation, enclosures, control house remediation, pole upgrades (see slides 18, 19).
3	**Alameda, Monterey, San Francisco, San Mateo, Santa Cruz**	WIND, HEAT	• Unreinforced distribution poles can fail when exposed to winds >70mph, far below the 100-year return value for Climate Zone 3. • Monterey County could experience significant extreme heat exposure by end-century, contributing to high asset utilization and potential substation/transformer failure.	• **Wind:** Pole reinforcement, pole material upgrade, decreased spans, vegetation management (see slides 21, 23). • **Heat:** Upgrade transformer capacity, install monitors & sensors, distribution line undergrounding, etc. (see slides 26, 27).
4	**San Benito, Santa Clara**	FLOOD, DROUGHT, HEAT	• Ground-level substation components (HV transformers, control houses, etc.) are highly exposed to flooding and have long lead times and high cost of replacement. • Climate Zone 4 could experience a significant increase in extreme heat exposure by end-century, contributing to high asset utilization and potential substation/transformer failure.	• **Flooding:** Flood walls, substation elevation, enclosures, control house remediation, pole upgrades (see slides 18, 19). • **Heat:** Upgrade transformer capacity, install monitors & sensors, distribution line undergrounding, etc. (see slides 26, 27).

*Salman, A. M. and Li, Y.: Age-dependent fragility and life-cycle cost analysis of wood and steel power distribution poles subjected to hurricanes,

Climate Zones 5-8 face some of the most extreme heat and fire exposure in the state, posing a threat of utility-caused ignitions, increased asset utilization, and direct component failure

Climate Zone	Counties	Most Concerning Hazards	Key Asset Impacts	Relevant 40101(d) Investments
5	San Luis Obispo	FIRE, HEAT, DROUGHT	• Bordering counties with severe fire weather exposure increases the likelihood of distribution system damage from fire propagation. • San Luis Obispo County could be exposed to increasingly severe extreme heat days, contributing to high asset utilization and potential substation/transformer failure.	• **Fire:** Pole wrapping, vegetation management, undergrounding, covered conductors, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, distribution line undergrounding, etc. (see slides 26, 27).
6	Santa Barbara	FIRE, DROUGHT	• Bordering counties with severe fire weather exposure increases the likelihood of distribution system damage from fire propagation. Fire weather exposure is projected to become more severe over time.	• **Fire:** Pole wrapping, vegetation management, undergrounding, covered conductors, and more (see slides 13, 14).
7	San Diego	FIRE, HEAT	• Climate Zone 7 faces peak statewide fire exposure. • Increasingly severe fire weather exposure can increase the likelihood of utility-caused ignitions, resulting in massive liabilities. • Increasingly severe extreme heat exposure necessitates distribution substation and transformer upgrades to combat derating, accelerated degradation, and failure.	• **Fire:** Pole wrapping, vegetation management, undergrounding, covered conductors, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, distribution line undergrounding, etc. (see slides 26, 27).
8	Orange	FIRE, HEAT	• Bordering counties with severe fire weather exposure increases the likelihood of distribution system damage from fire propagation. Fire weather exposure is projected to become more severe over time. • Orange County is projected to experience a 16x increase in days >105°F by end-century, posing a threat of direct failure to distribution substations and transformers.	• **Fire:** Pole wrapping, vegetation management, undergrounding, covered conductors, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, distribution line undergrounding, etc. (see slides 26, 27).

 |

Climate Zones 9 & 10 face increasingly severe wildfire and heat exposure, while zones 11 & 12 are mainly exposed to heavy precipitation and flooding

Climate Zone	Counties	Most Concerning Hazards	Key Asset Impacts	Relevant 40101(d) Investments
9	**Los Angeles, Ventura**	FIRE, HEAT, DROUGHT	• Climate Zone 9 faces FWI levels in the 99th percentile nationwide, indicating significant risk of utility-caused ignitions, distribution pole damage from fire, faults caused by smoke and ash collecting on distribution lines. • While Climate Zone 9 is historically exposed to heat, the frequency of extreme heat days is projected to increase drastically by end-century, causing high asset utilization, accelerated degradation, and direct component failure.	• **Fire:** Pole wrapping, vegetation management, undergrounding, covered conductors, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, distribution line undergrounding, etc. (see slides 26, 27).
10	**Riverside**	FIRE, HEAT	• Climate Zone 10 is exposed to peak statewide fire exposure, posing a significant threat of utility-caused ignition and Dx/Tx line damage. • While Climate Zone 10 is historically exposed to heat, the frequency of extreme heat days is projected to increase drastically by end-century, causing high asset utilization, accelerated degradation, and direct component failure for distribution and transmission lines.	• **Fire:** Pole wrapping, vegetation management, Dx & Tx undergrounding, covered conductors, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, DLR distribution line undergrounding, etc. (see slides 26, 27).
11	**Butte, Colusa, Glenn, Nevada, Placer, Shasta, Sutter, Tehama, Yuba**	RAIN, FLOOD, COLD	• Significant flooding exposure poses a threat of inundation to ground-based substation equipment and uprooting of weak distribution poles. • Snow and icing can increase mechanical loading on nearby vegetation and distribution lines themselves, contributing to outages.	• **Flood:** Flood walls, substation elevation, enclosures, control house remediation, pole upgrades, (see slides 18, 19). • **Cold:** Vegetation management, decreased spans, pole upgrades, undergrounding, etc. (see slides 31, 33).
12	**Amador, Calaveras, Contra Costa, El Dorado, Mariposa, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Tuolumne, Yolo**	RAIN, HEAT, WIND	• Counties in Climate Zone 12 are projected to experience over a 5x in days >105°F by end-century, causing high asset utilization, accelerated degradation, and direct component failure across both transmission and distribution. • Distribution poles can fail when exposed to wind speeds > 70 mph, far below the 100-year return value for eastern counties in CZ-12 along the Sierra Nevada Mountains	• **Heat:** Upgrade transformer capacity, install monitors & sensors, DLR distribution line undergrounding, etc. (see slides 26, 27). • **Wind:** Pole reinforcement, pole material upgrade, decreased spans, vegetation management, (see slides 21, 23).

 |

Climate Zones 13 & 16 face significant cold and wind exposure given their overlap with the Sierra Nevada mountain range, while zones 14 & 15 are exposed to heat and wildfire

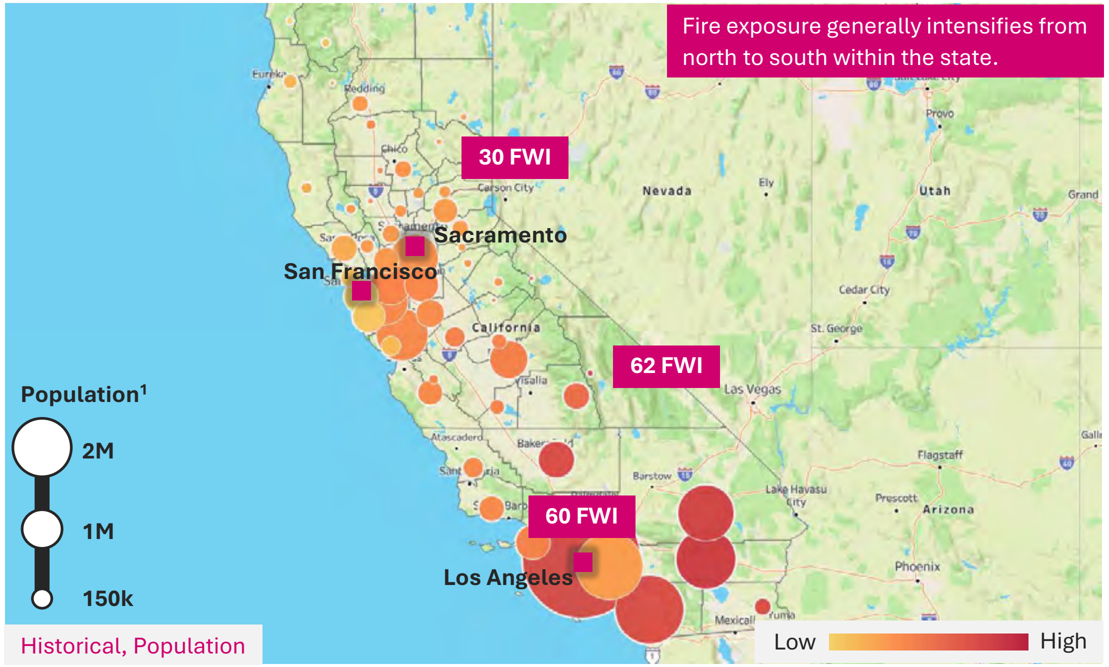
Climate Zone	Counties	Most Concerning Hazards	Key Asset Impacts	Relevant 40101(d) Investments
13	**Fresno, Kern, Kings, Madera, Tulare**	COLD, WIND, DROUGHT	• Below-freezing average annual minimum temperatures pose a threat of snow/icing which increases mechanical loading on nearby vegetation and Tx/Dx lines themselves, contributing to outages. • Severe wind exposure in Kern County poses a threat of line contact and tower damage to a high volume of Tx assets.	• **Cold:** Vegetation management, decreased spans, pole upgrades, undergrounding, structure rebuilds, etc. (see slides 31, 33). • **Wind:** Pole reinforcement, pole material upgrade, decreased spans, vegetation management, structure rebuilds, etc. (see slides 21, 23).
14	**San Bernadino**	FIRE, HEAT, COLD	• While Climate Zone 14 is historically exposed to heat, the frequency of extreme heat days is projected to increase drastically by end-century, causing high asset utilization, accelerated degradation, and direct component failure. • Fire and heat can damage and derate key import/export transmission lines in Climate Zone 14. • Coincidence of fire, heat, and cold exposure could justify upgrades addressing multiple hazards simultaneously (i.e. undergrounding, reconductoring, etc.)	• **Fire:** Pole wrapping, vegetation management, Dx & Tx undergrounding, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, DLR, etc. (see slides 26, 27). • **Cold:** Decreased spans, pole upgrades, structure rebuilds, etc. (see slides 31, 33).
15	**Imperial**	FIRE, HEAT	• Climate Zone 15 is exposed to peak statewide fire exposure, posing a significant threat of utility-caused ignition and distribution infrastructure damage from fire spread. • While Climate Zone 15 is historically exposed to heat, the frequency of extreme heat days is projected to increase drastically by end-century, causing high asset utilization, accelerated degradation, and direct component failure. • Fire and heat can damage and derate key import/export transmission lines in Climate Zone 15.	• **Fire:** Pole wrapping, vegetation management, Dx & Tx undergrounding, covered conductors, and more (see slides 13, 14). • **Heat:** Upgrade transformer capacity, install monitors & sensors, DLR, distribution line undergrounding, etc. (see slides 26, 27).
16	**Alpine, Inyo, Lassen, Modoc, Mono, Plumas, Sierra, Siskiyou, Trinity**	COLD, FLOOD, RAIN	• Climate Zone 16 is exposed to peak statewide cold exposure. • Snow/icing cause mechanical loading on nearby vegetation and Tx/Dx lines themselves, contributing to outages. • Significant flooding exposure poses a threat of inundation to ground-based substation equipment and uprooting of weak distribution poles.	• **Cold:** Decreased spans, pole upgrades, structure rebuilds, etc. (see slides 31, 33). • **Flood:** Flood walls, substation elevation, enclosures, control house remediation, pole upgrades (see slides 18, 19).

Wildfire

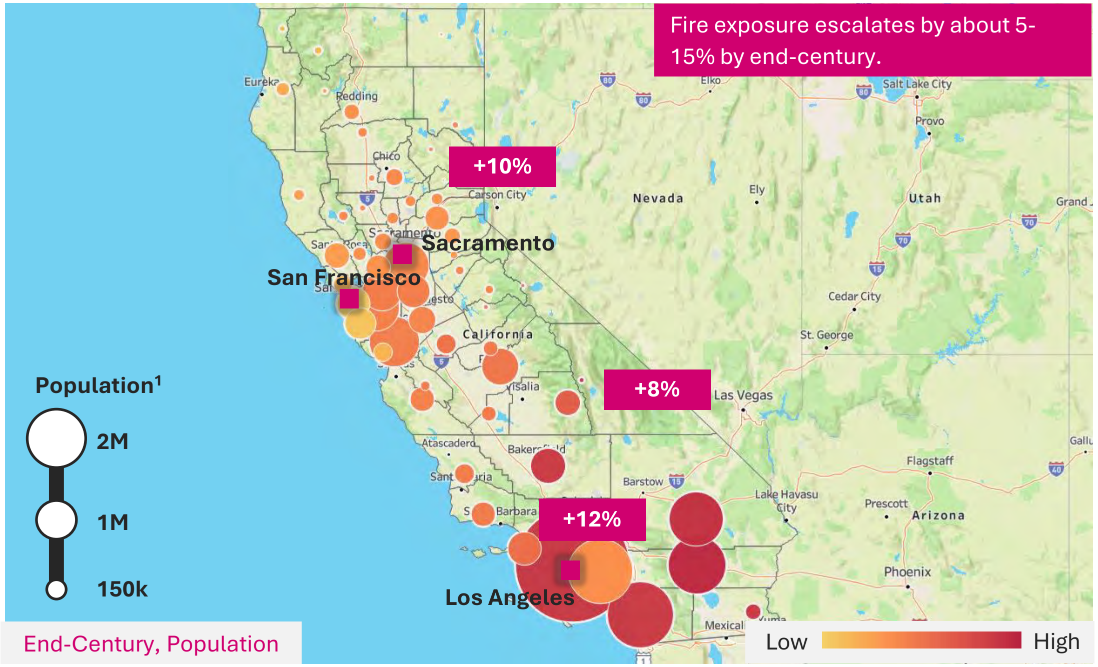
Asset Analysis

Applicants could consider prioritizing southern counties for fire mitigations, balancing funding between highly exposed population centers and vulnerable Dx assets in rural counties

California Summer Fire Weather Index (FWI)
Distribution Assets (Population), Historical



California Summer Fire Weather Index (FWI)
Distribution Assets (Population), End-Century [RCP-8.5]



KEY OBSERVATIONS

- Historical wildfire exposure is **concentrated in California's southeastern counties, especially CZ-7/14.**
- **Southern population centers are heavily exposed to wildfire,** posing a threat to a high density of Dx assets.
- While central counties (CZ-12/13) do not face peak fire exposure, **high levels of drought could make fires difficult to extinguish.**

KEY OBSERVATIONS

- FWI increases by up to 8 points across the state, demonstrating the importance of utilizing **forward-looking climate projections for state-wide fire mitigation planning.**

Los Angeles County — Los Angeles County is exposed to FWI levels in the 99th percentile nationally, putting a large volume of distribution assets at risk.

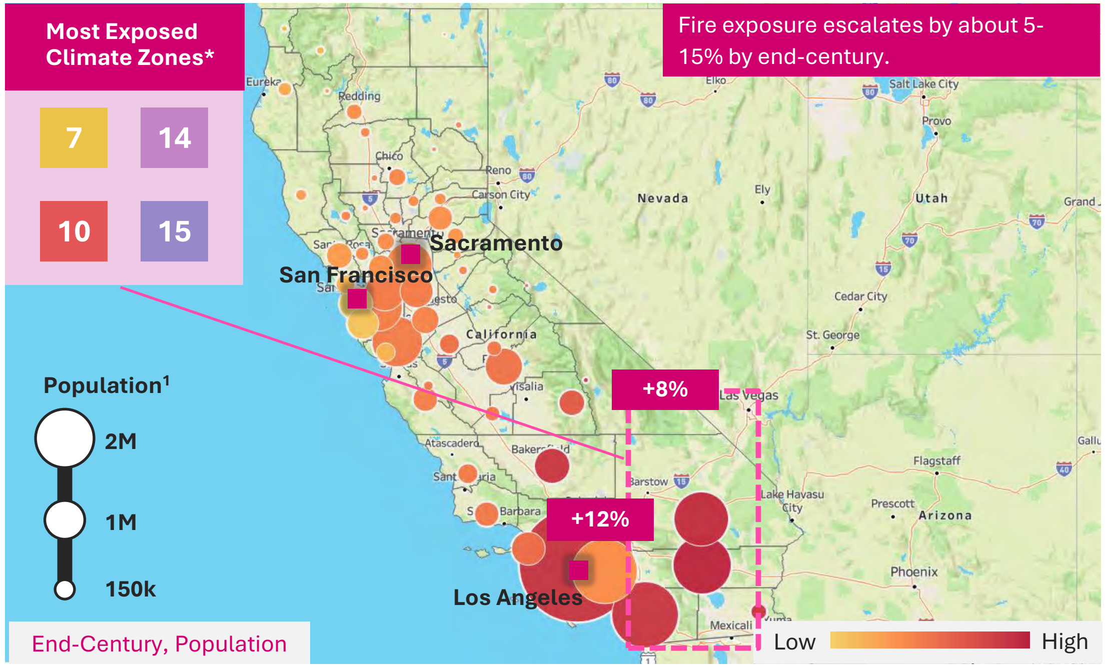
Source: ClimRR, US Census Bureau, City and Town Population Totals

 |

Distribution system adaptations and mitigations can vary in cost. Wildfire stands as a unique hazard due to high cost of ignition for utilities, potentially justifying more expensive solutions.

California Summer Fire Weather Index (FWI)

Distribution Assets (Population), End-Century [RCP-8.5]



Cost Threshold	40101(d) Eligible Projects
$ **Low-Cost Projects (<$50,000)**	• **Pole Upgrades:** Replacing wooden poles with more fire-resistant material like steel, concrete, etc.) • **Pole Wrapping:** Wrapping poles with a fiberglass mesh covered in an intumescent coating. • **Vegetation & Fuel Load Management:** Innovative vegetation management solutions (drone deployments, spot-trimming, etc.), problem tree trimming, fuel reduction. • **Reclosers, Circuit Breakers, Relays, Fuses:** Detect and isolate faults automatically. When a transient fault occurs, such as a lightning strike or tree branch touching a power line, the recloser temporarily opens the circuit to clear the fault and then automatically closes again. Supports robust PSPS programs.
$$ **High-Cost Projects (>$50,000)**	• **Reconductoring:** Replacing existing conductors with new more efficient ones (e.g. ACCC). Improves insulation of conductors such that they are less flammable or can better withstand high temperatures. • **Undergrounding:** Reinstalling conductors underground to prevent ignition and damage during wildfire. • **Covered Conductors:** Covering conductors with insulating materials can reduce faults related to extreme heat (sagging of lines), ignition during wildfires, corrosion, wind damage from lines touching, or trees falling on lines. Covered conductors can also protect line workers.

Source: Grid Deployment Office "Low-Cost Grid Resilience Projects"

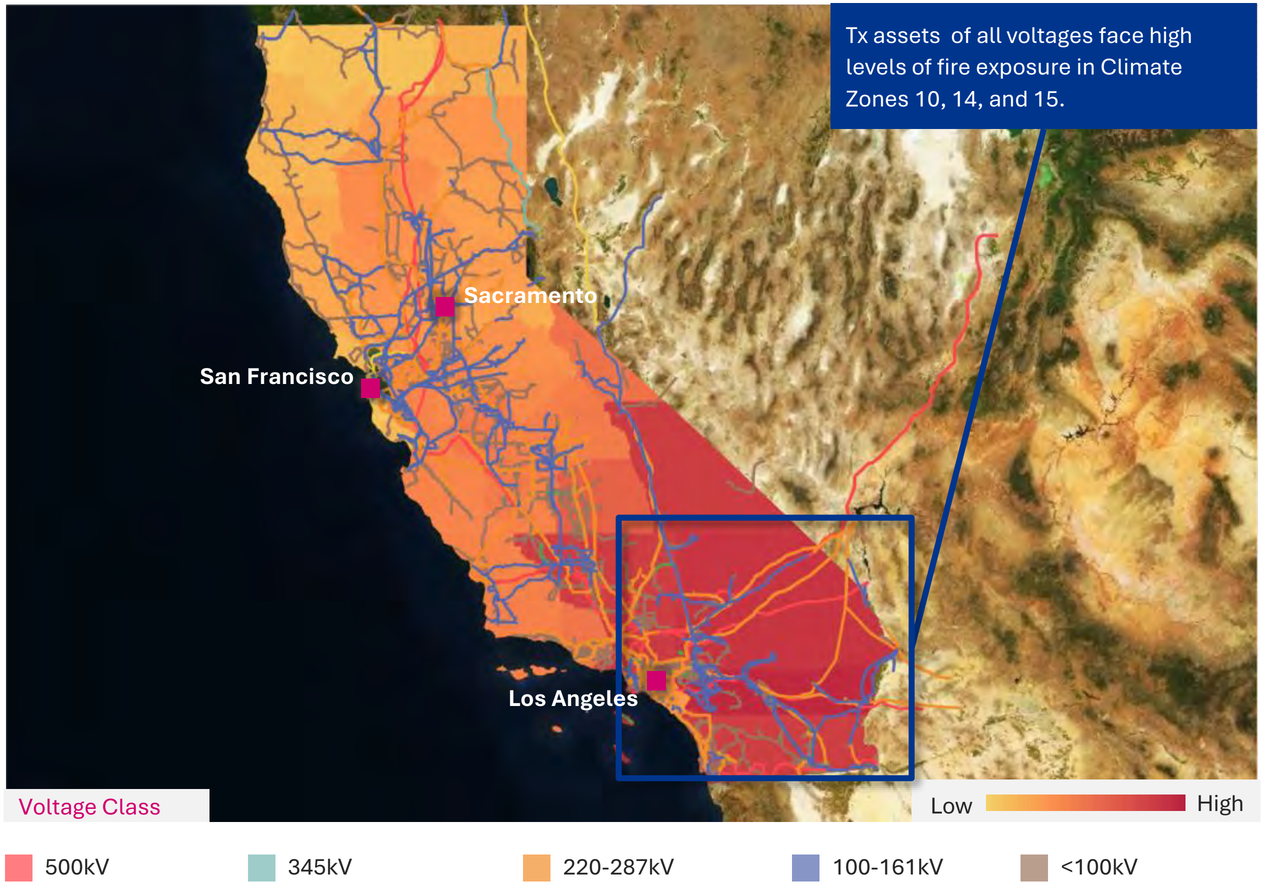
CERRI Dx SUGGESTIONS

- Conducting asset-level vulnerability assessments is the optimal way of deriving cost-effectiveness of investment.
- Wildfire is unique in that cost of ignition is significantly high, making it easier to justify high-cost investments for even lower risk locations.
- Recent LA fires coupled with high FWI projections indicates high-cost investments could be beneficial in wildland-urban interface.

*Projects outside of the most exposed climate zones are still eligible for 40101(d) funding

Applicants could consider hardening projects for critical import/export HV Tx lines in Climate Zones 10, 14, and 15 that face peak state-wide wildfire exposure

California Summer Fire Weather Index (FWI)
Transmission, Mid-Century [RCP-8.5]



Key Highlights	Analysis

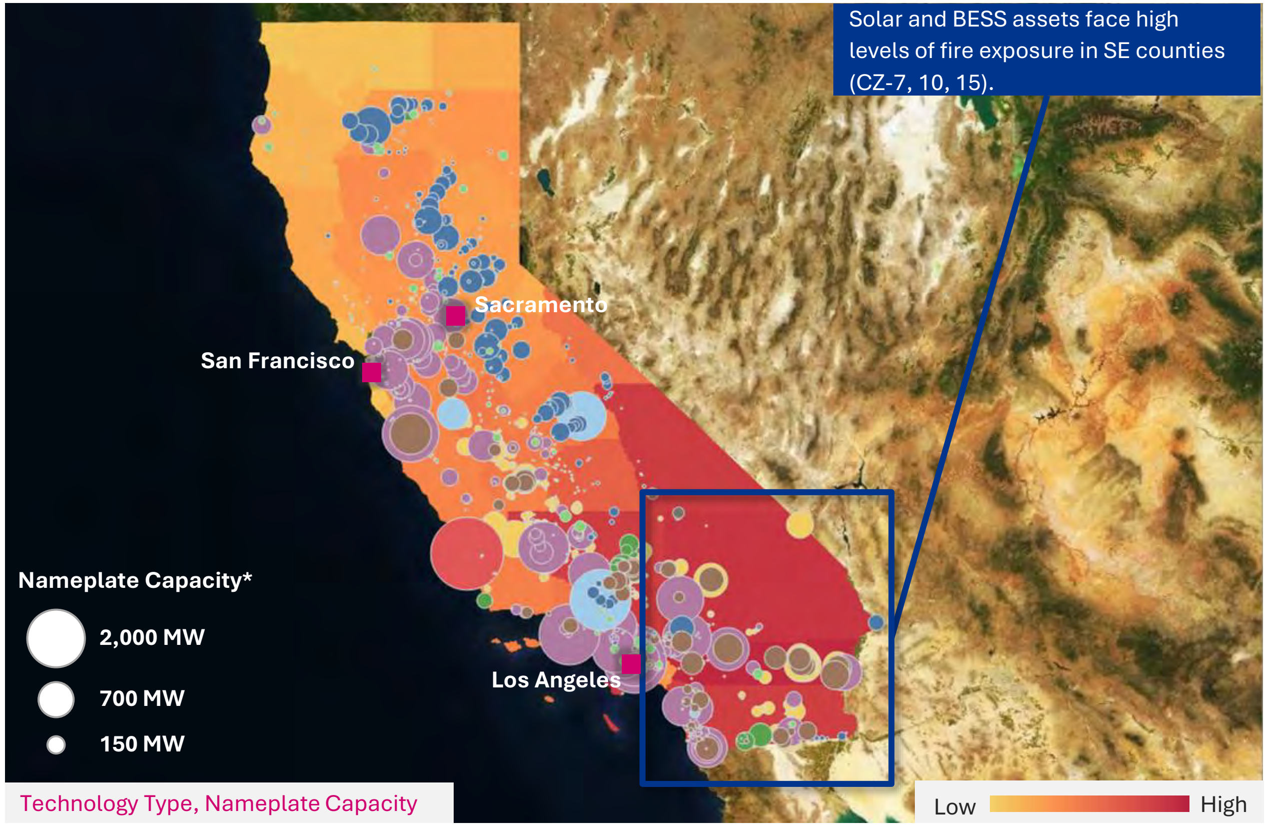
Transmission	• **500 kV Tx lines connecting CA to AZ and NV are highly exposed in SE counties (CZs-10, 14, 15)** and could be considered for hardening given their criticality during extreme weather events.
	• **Tx assets in San Bernardino County could be prioritized** given high levels of exposure for a high-density of assets that are crucial for power flows to and from Los Angeles County.
	• **40101(d)-Allowable Investments:**
	  • **Low-Cost:** Vegetation Management, Reclosers, Circuit Breakers, Relays, Fuses
	  • **High-Cost:** Undergrounding, Reconductoring

Source: ClimRR, EIA860, HIFLD

 |

Applicants could prioritize hardening projects for solar/BESS assets in Climate Zones 10, 14, and 15 that face severe wildfire exposure, posing a threat of derating or thermal runaway

California Summer Fire Weather Index (FWI)
Generators, Mid-Century [RCP-8.5]



Onshore Wind	Coal Plant	Hydroelectric	Nuclear	Solar Photovoltaic
Biomass	Natural Gas Plant	Pumped Storage	Batteries	Other

Limited applicable wildfire investments under 40101(d)

Key Highlights	Analysis
Solar/BESS	• Solar assets in San Bernardino, Riverside, and other southeastern counties (CZ-10, 14, 15) are highly exposed to fire. • Soot and ash from burns **decreases capacity factors solar assets** by collecting on panels and reducing irradiance. • Wildfire may also pose a threat of **thermal runaway and degradation to a high volume of BESS assets in S counties (CZ-10, 15).** • **40101(d)-Allowable Investments for BESS:** • **High-Cost:** Resilience-focused BESS projects with alternative chemistries (i.e. non Li-ion, flow batteries), innovative battery enclosures, upgraded fire suppression/ thermal management systems (variable cost based on size of system)

*Generator nameplate capacities may exceed those shown in the legend

Source: ClimRR, EIA860, HIFLD

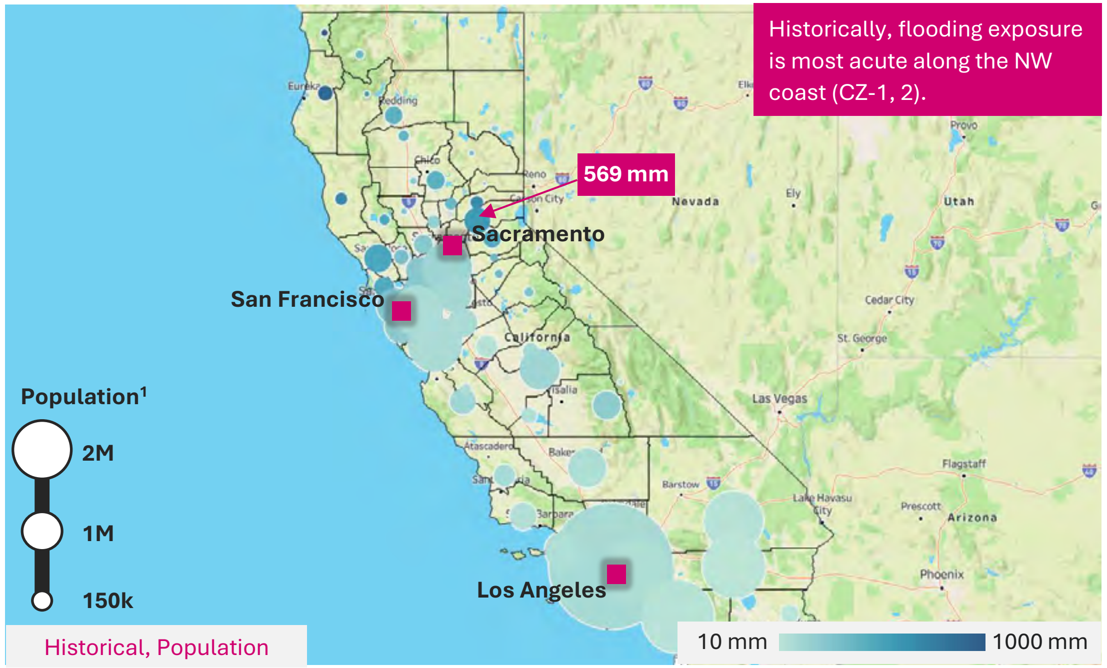
 |

Flood

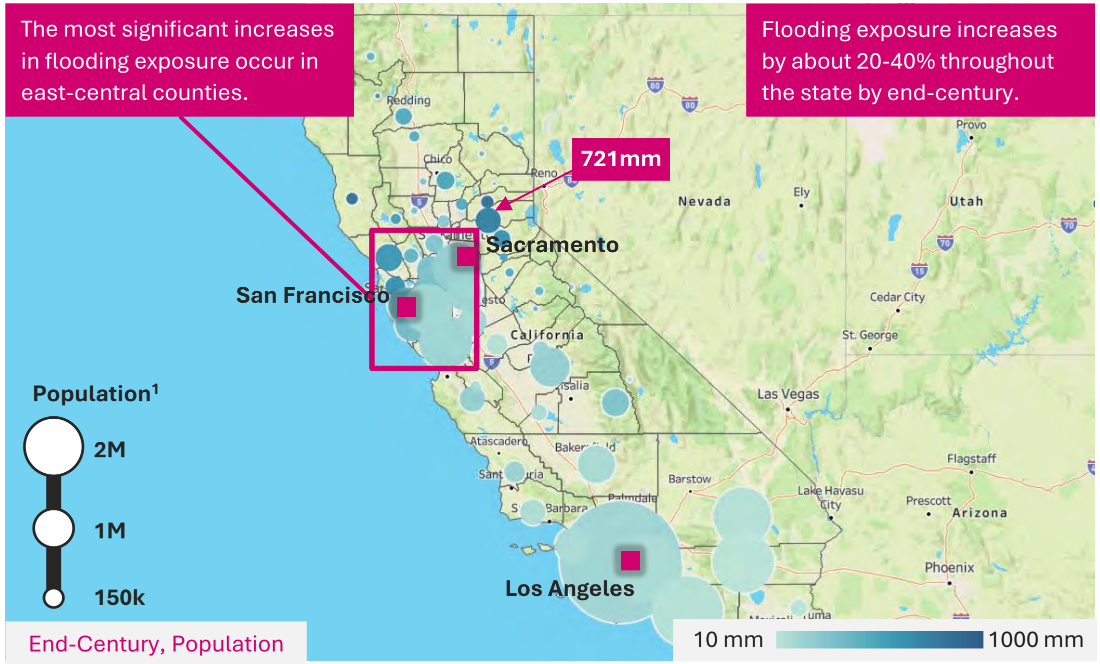
Asset Analysis

Applicants could consider projects fortifying low-lying Dx substations and weak Dx poles in northern counties (CZ-1, 2, 16) and continue to monitor future flooding severity

California Average Annual Surface Runoff (mm/year)
Historical [SSP5-8.5]



California Average Annual Surface Runoff (mm/year)
End-Century [SSP5-8.5]



KEY OBSERVATIONS

- Surface runoff mainly captures pluvial flooding risk, or flooding that occurs when heavy rainfall overwhelms the ground's absorption capacity.
- **Flooding exposure generally increases from south to north** throughout the state given N CA's higher precipitation levels and abundance of rivers (CZ-1, 2, 16).
- **Low soil permeability in S CA could increase the risk of pluvial flooding.**

KEY OBSERVATIONS

- Applicants could prioritize projects to **fortify low-lying Dx substations in north-central counties (CZ-11)** facing increasing flood exposure over time.

Placer County

Flood exposure is projected to increase ~26% by end-century, posing a substantial threat to a significant volume of substations and distribution poles.

Source: ClimRR, US Census Bureau, City and Town Population Totals

 |

Map taken from previous slide

Most flood risk accrues to ground-level assets (transformers, control house, etc.). Long outage restoration times and expensive equipment failures could justify high-cost investments.

California Average Annual Surface Runoff (mm/year)
End-Century [SSP5-8.5]

Cost Threshold	40101(d) Eligible Projects
$ **Low-Cost Projects (<$50,000)**	• **Pole Upgrades:** Replacing wooden poles with more weather-resistant material (steel, concrete, etc.). • **Flood Walls:** Building walls to prevent flood waters from entering substation.
$$ **High-Cost Projects (>$50,000)**	• **Enclosures:** Building enclosures around critical equipment that are exposed to elements. • **Substation Elevation:** Raising the substation on pylons or concrete surfaces. • **Control House Remediation:** Upgrading control houses to current building codes and flood adaptation standards.

Source: Grid Deployment Office "Low-Cost Grid Resilience Projects"

CERRI Dx SUGGESTIONS

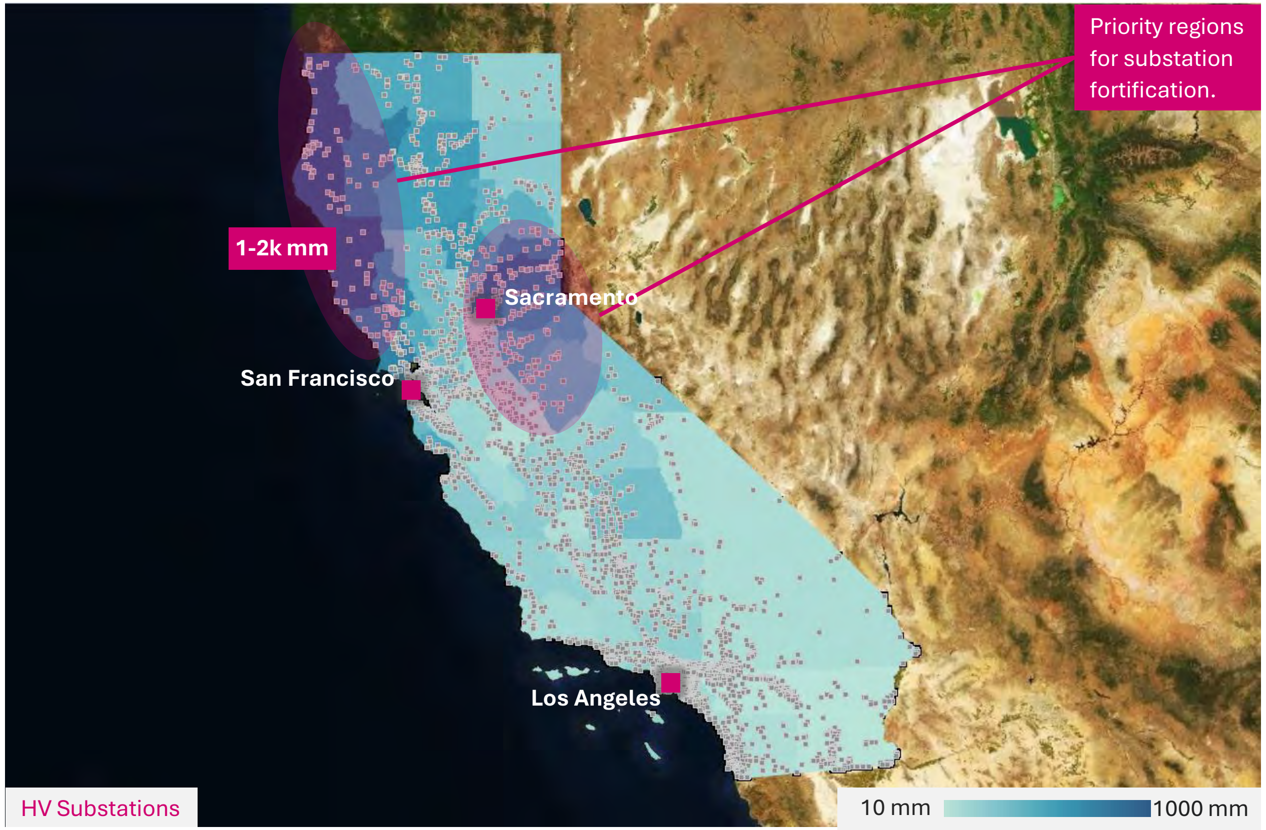
- Most of the equipment impacted by flooding are ground-level substation components (HV transformers, control house, etc.). This equipment is expensive, with often long lead times.
- High failure cost could justify high-cost adaptations at highly specific locations.
- Conducting asset-level vulnerability assessments is the optimal way of deriving cost-effectiveness of investment.

*Projects outside of the most exposed climate zones are still eligible for 40101(d) funding

 |

Applicants could consider HV substation fortification in N counties (CZ-1, 2, 16), particularly two pockets centered around Nevada and Humboldt Counties

California Average Annual Surface Runoff (mm/year)
HV Substations, Mid-Century [SSP5-8.5]



HV Substation

Key Highlights	Analysis

Substation	• High-voltage substations will be exposed to fluvial flooding if located in a flood plain or riverbank without necessary protections.
	• **Significant pockets of HV substations will be exposed to flooding in N counties (see map)** and could be considered for elevation, enclosure, or other fortifications.
	• **40101(d)-Allowable Investments:**
	  • **Low-Cost:** Flood Walls
	  • **High-Cost:** Enclosures, Substation Elevation, Control House Remediation (i.e. structural elevation, equipment upgrades, proper insulation/sealing, structural repairs)

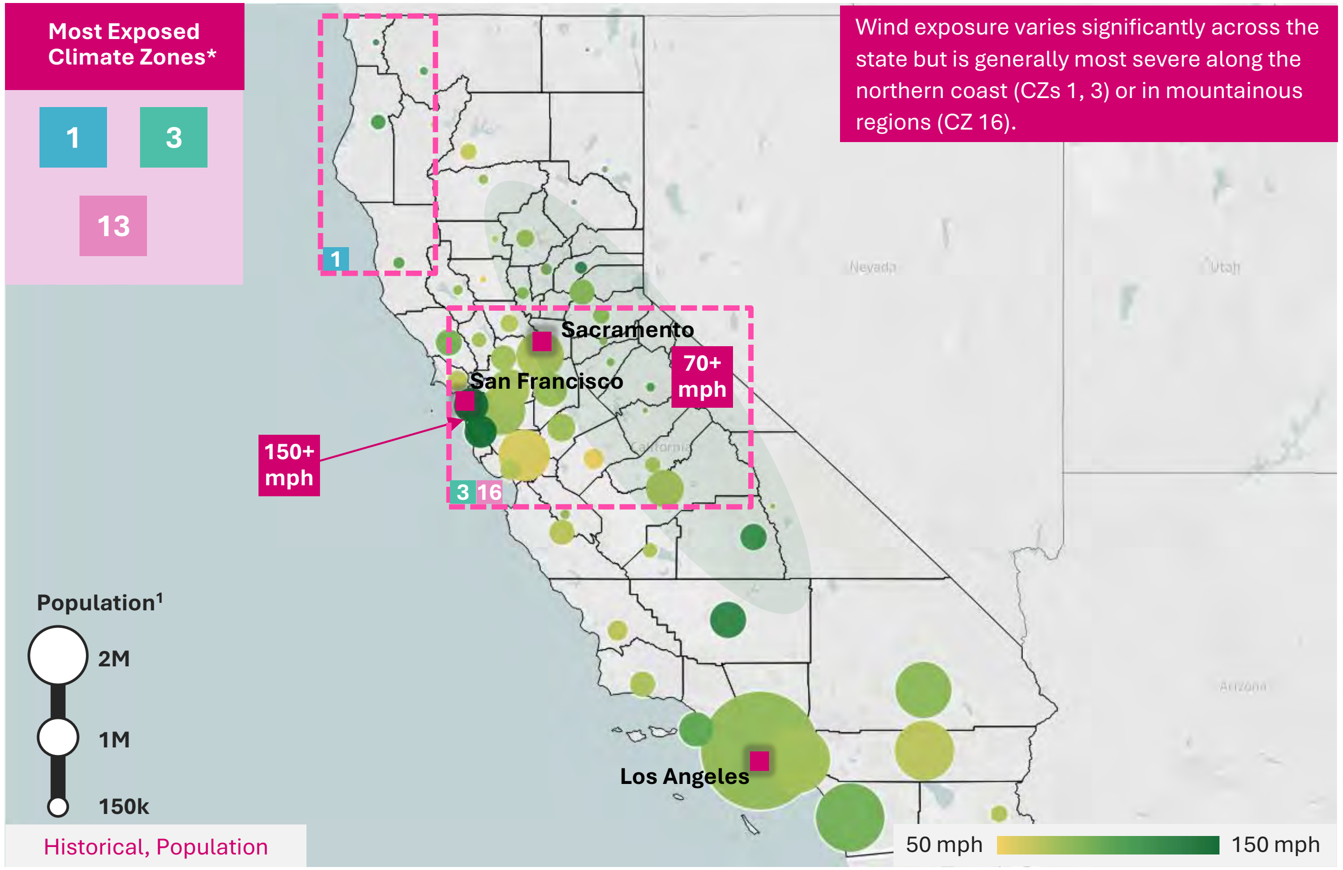
Source: ClimRR, EIA860, HIFLD

Wind

Asset Analysis

Vegetation management and Dx pole upgrades could be prioritized for rural counties along the Sierra Nevada range and investigated in the above-ground residential networks in the Bay Area

California 100-year Wind Speed (mph)
Historical



Key Highlights	Analysis

Distribution	• Given weak climate signals, wind speeds are derived using historical data and do not vary at high spatial resolution.
	• **40101(d)-Allowable Investments:**
	  • **Low-Cost:** Pole Reinforcement (Trussing, Guy Cables, Concrete Base, etc.), Pole Material Upgrades, Decreased Span, Break Away Disconnect, Vegetation Management
	  • **High-Cost:** Undergrounding

Sierra Nevada Mountains	• **Wind exposure is generally high in counties along the Sierra Nevada mountain range (CZ 16).** • Asset owners could **consider Dx pole reinforcements and veg. management in these rural counties** given the risk for prolonged outages if radial lines are damaged.

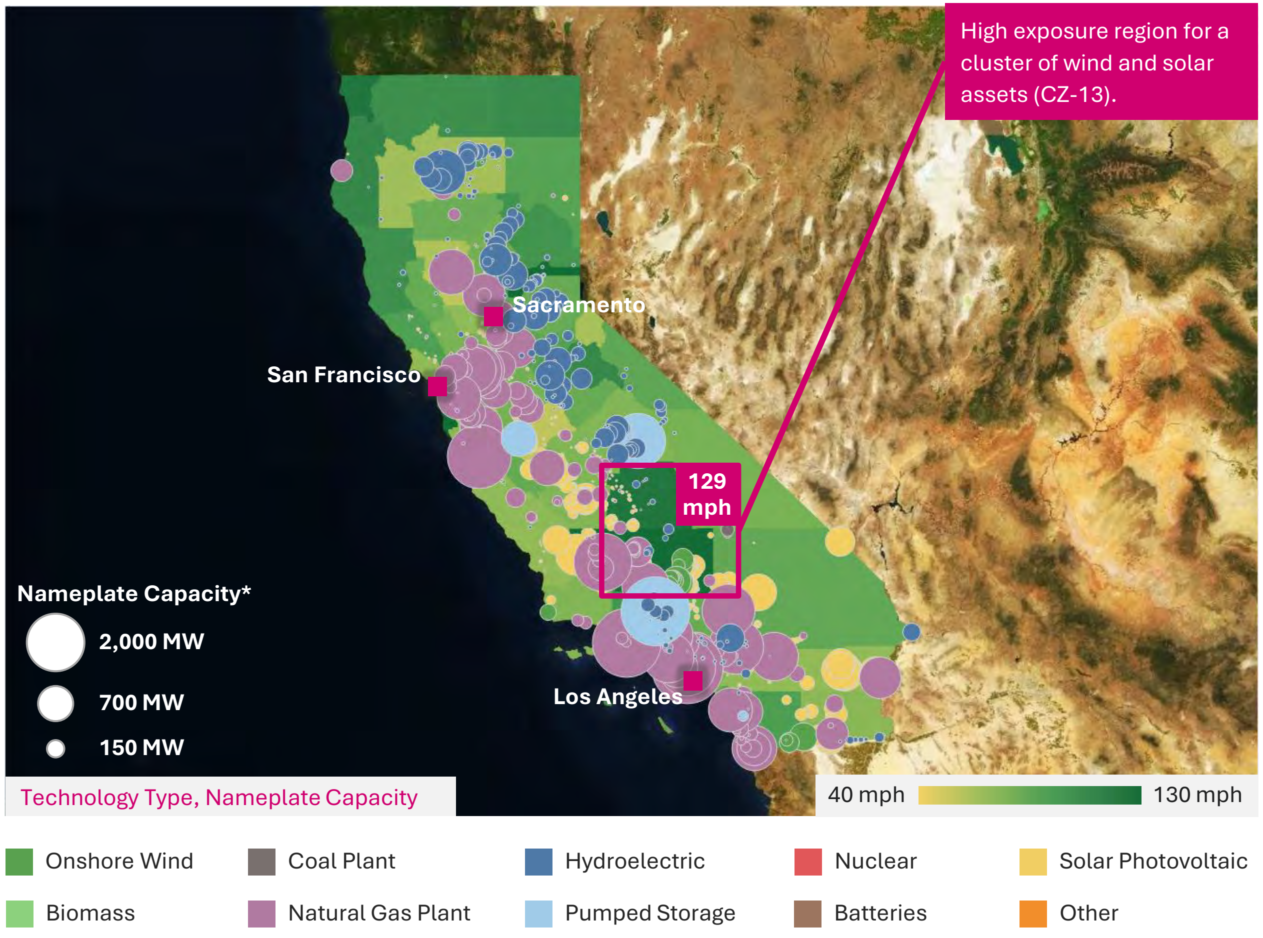
*Projects outside of the most exposed climate zones are still eligible for 40101(d) funding

Source: DRI, EIA860, HIFLD

 |

Asset owners could consider weatherization upgrades for renewable assets in Kern County to address high wind exposure

California 100-year Wind Speed (mph)
Generation, Historical



Key Highlights	Analysis
Solar	• A pocket of solar farms in Kern and Los Angeles Counties are exposed to high return values >90 mph. • Depending on the OEM, solar panels are only rated to 90 mph, **indicating need for rack reinforcement and vegetation management.** • **40101(d)-Allowable Investments:** • **Low-Cost:** Through-Bolting, Higher Grade Steel, Three-Rail Racking System, Wind-Calming Fence
Wind	• Wind farms cutout speeds can vary between 45-70 mph, indicating that in high wind speed events, the turbines stop producing. • **A cluster of wind farms in Kern County are exposed to 100-year return values significantly higher than typical cutout thresholds,** diminishing critical supply near load centers during extreme wind events. • **40101(d)-Allowable Investments:** • **High-Cost:** Wind Direction Controls

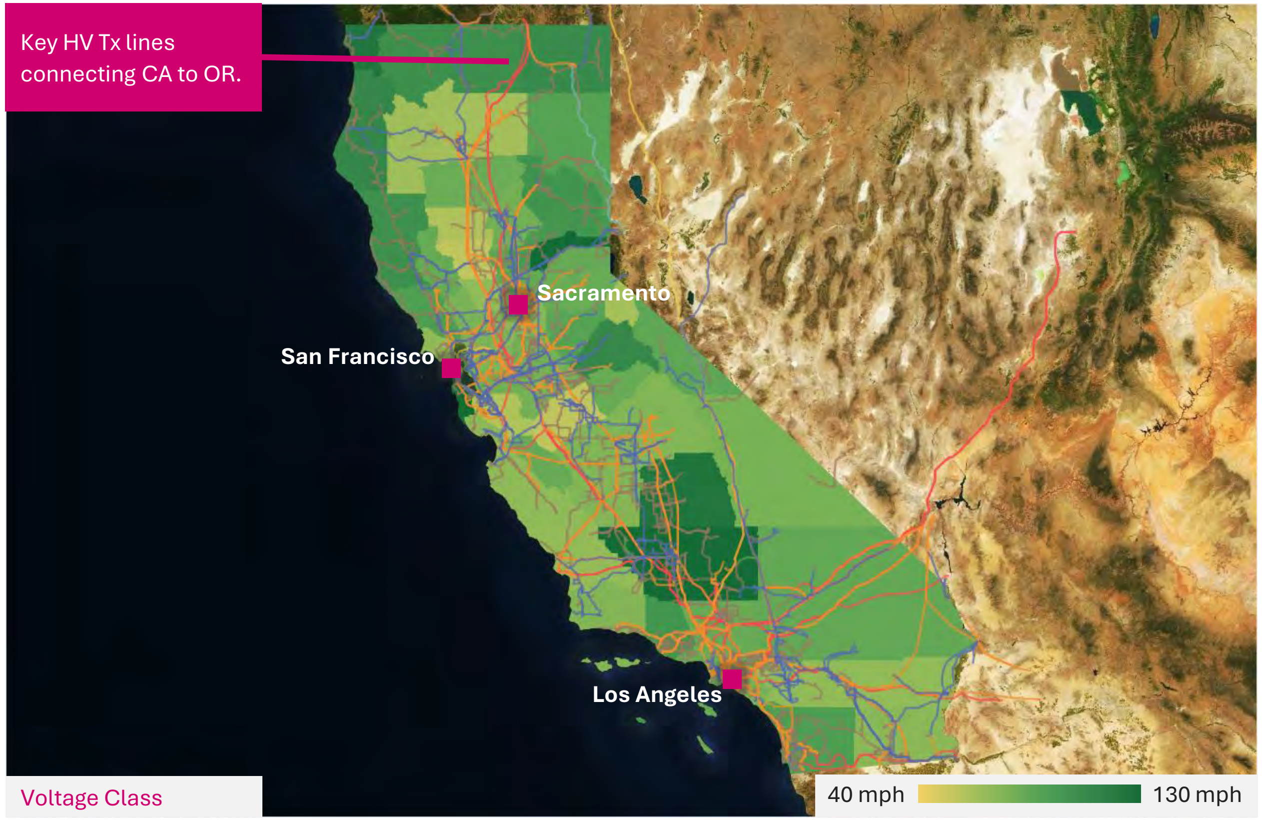
*Generator nameplate capacities may exceed those shown in the legend

 |

Source: DRI, EIA860, HIFLD

HV Tx lines in Modoc County and a dense transmission junction in Kern County are exposed to high wind speed return values and could be considered for structure reinforcement

California 100-year Wind Speed (mph)
Transmission, Historical



500kV | 345kV | 220-287kV | 100-161kV | DC

Key Highlights	Analysis

Transmission	• A pair of 500kV Tx lines in Modoc County are exposed to wind speed return values >100mph.
	• Applicants could **consider reinforcing Tx structures or decreasing spans along these lines** given their critical connection to OR, which allows for the import of low-cost hydroelectric power and export of CA solar.
	• Large junction of N-S transmission lines in Kern and Tulare Counties experience high wind exposure. Given that this region has coincident wildfire risk, asset owners could **investigate vegetation management, structure reinforcement, or ongoing maintenance practices** to also prevent ignition.
	• **40101(d)-Allowable Investments:**
	  ◦ **Low-Cost:** Decreased Spans, Vegetation Management
	  ◦ **High-Cost:** Undergrounding, Structure Rebuild

 |

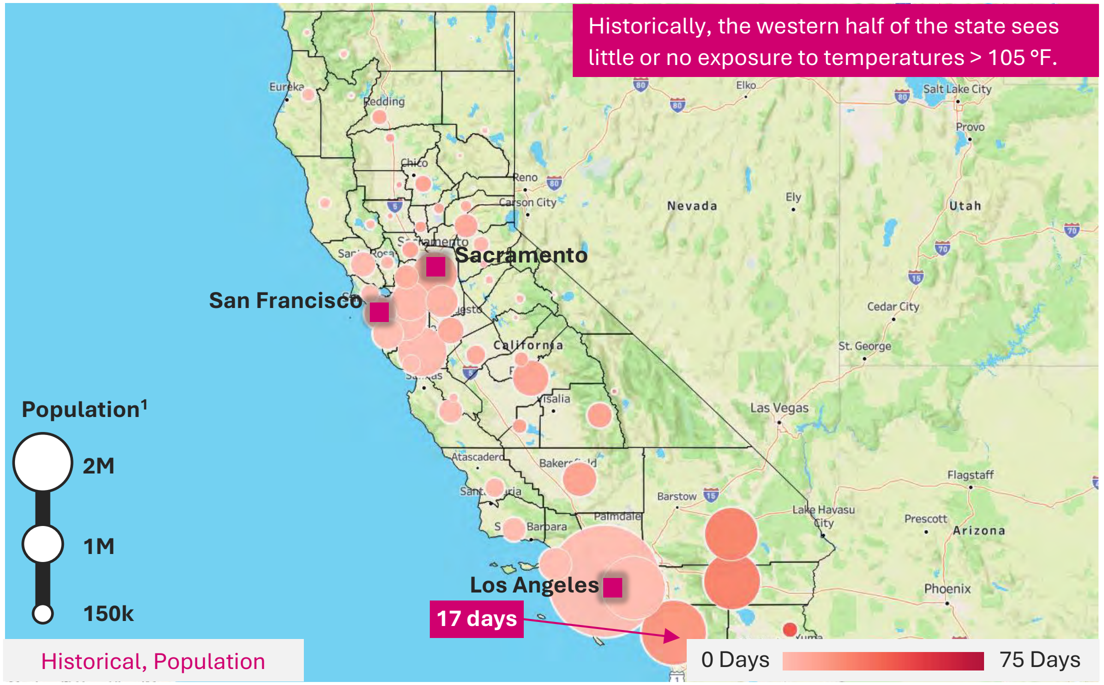
Source: DRI, EIA860, HIFLD

Heat

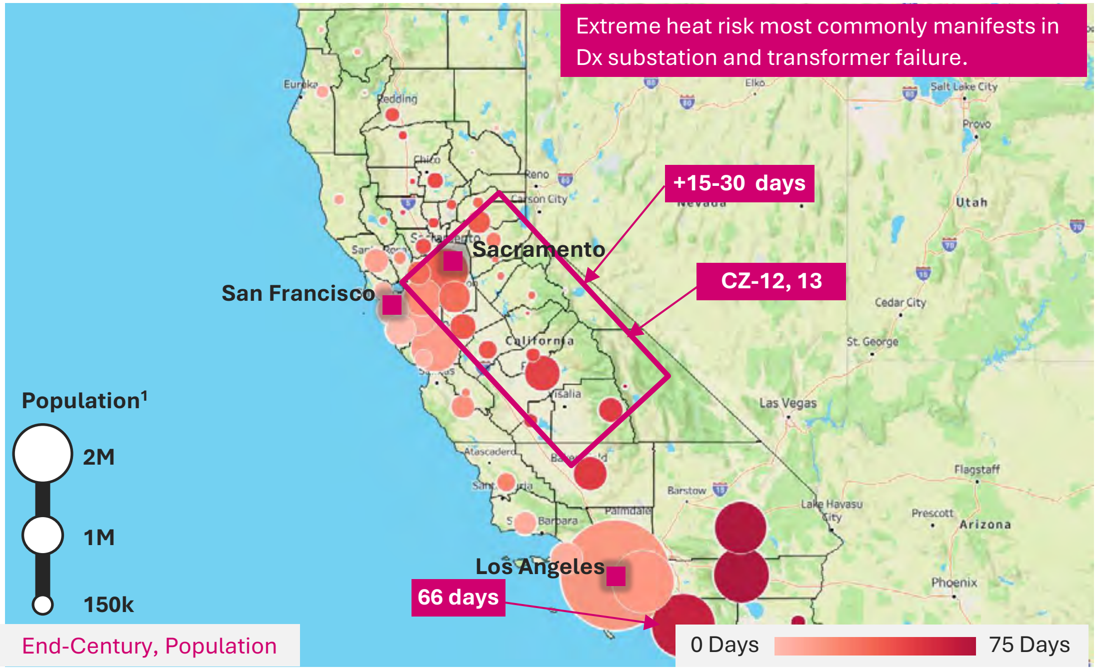
Asset Analysis

Applicants could consider Dx substation and transformer upgrades to combat increasing heat exposure, especially in CZs-12, 13 which are not historically exposed to extreme temperatures

California Days Above 105 °F
Distribution Assets (Population), Historical



California Days Above 105 °F
Distribution Assets (Population), End-Century [RCP-8.5]



KEY OBSERVATIONS

- Historically, exposure to days > 105 °F is concentrated in southern counties (CZ-7, 10, 14, 15), while much of the eastern half of the state faces moderate exposure to this threshold.
- 105 °F is an important threshold for distribution assets and substations, **which can fail when exposed to two consecutive days above 104 °F.**[2]

KEY OBSERVATIONS

- By end-century, nearly every county is exposed to a significant number of days > 105 °F annually, causing **high asset utilization, derating, and potential failure.**

San Diego County Escalation from 17 to 66 days of extreme heat exposure necessitates **substation, transformer, and Dx line upgrades to mitigate potential failure and avoid derating.**

¹Population bubbles are continuous and therefore labels are approximate. ²EPRI Climate READi

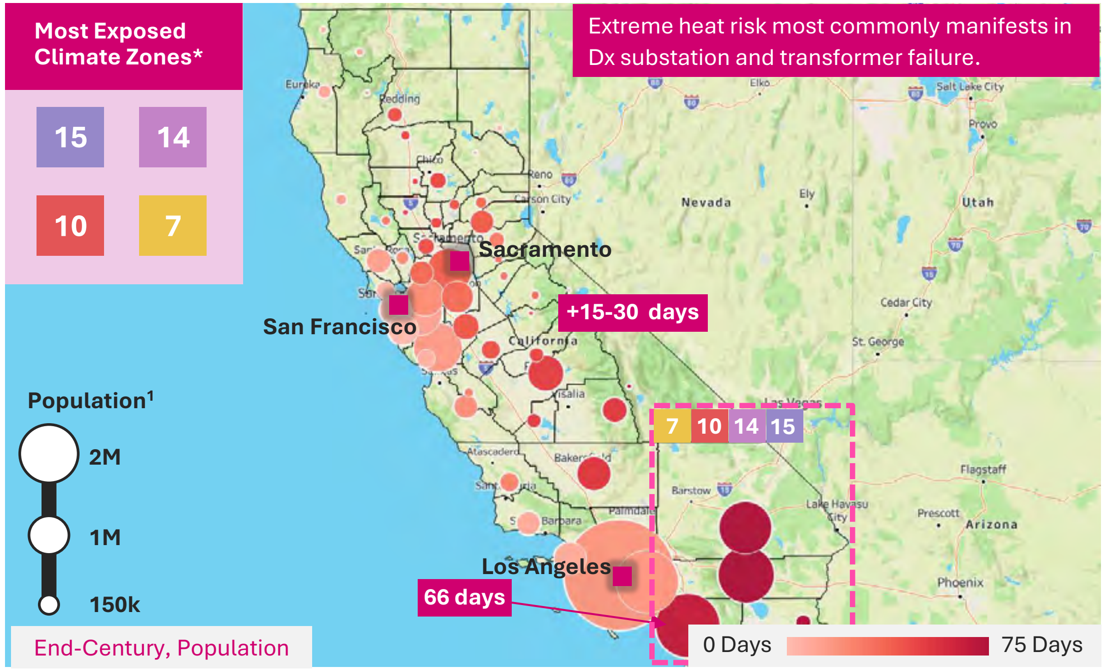
Source: ClimRR, US Census Bureau, City and Town Population Totals

 |

Areas of high heat risk coupled with increased projected demand could justify high-cost infrastructure investments. Low-cost alternatives exist in intermediate risk regions.

California Days Above 105 °F

Distribution Assets (Population), End-Century [RCP-8.5]



CERRI Dx SUGGESTIONS

- Extreme heat increases asset degradation through utilization and increased system load through heightened cooling demand.
- In areas of high heat risk and projected new demand (housing developments, data centers, EVs, etc.), higher cost investments could be justified.
- Low-cost alternatives are good options to yield higher capacity and increased reliability without having to invest in large infrastructure changes.

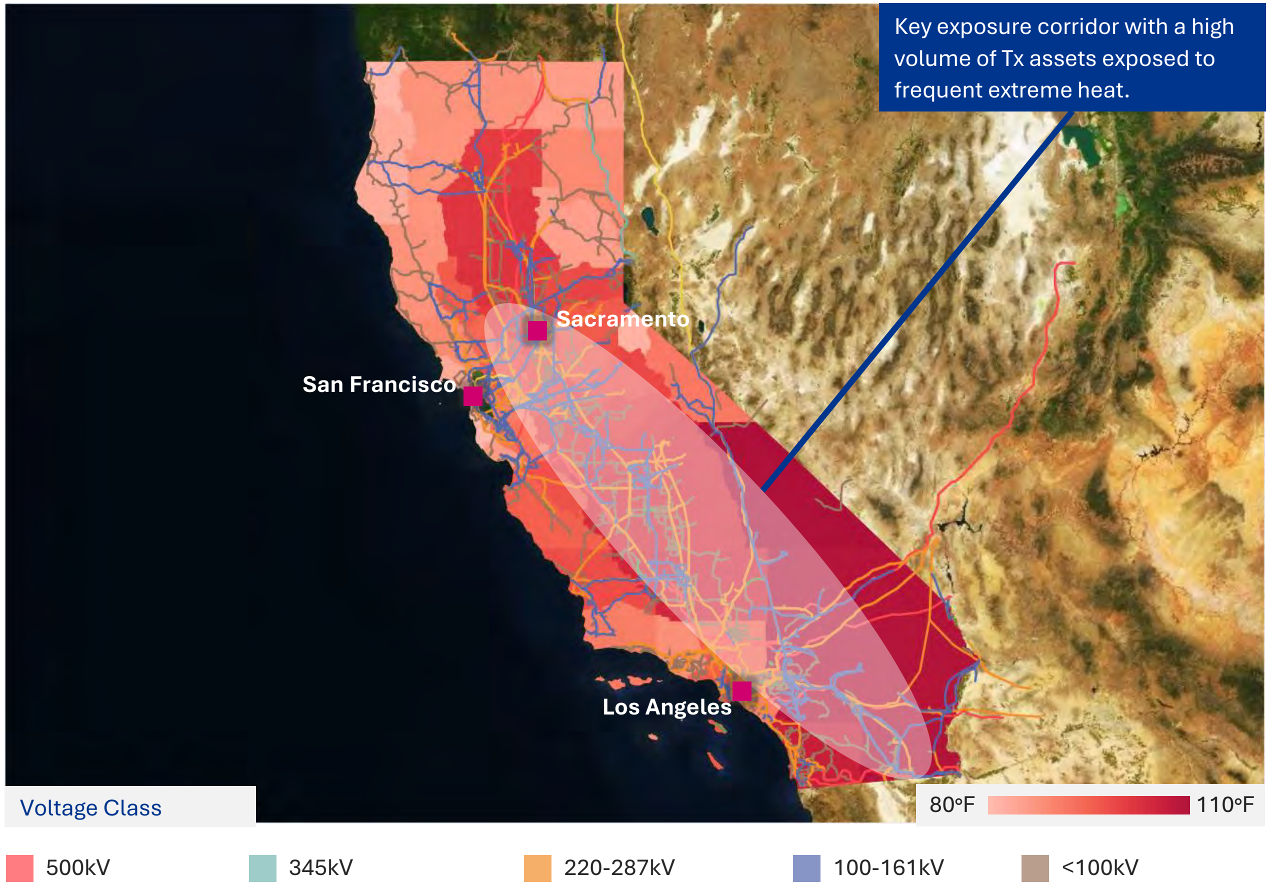
*Projects outside of the most exposed climate zones are still eligible for 40101(d) funding

Cost Threshold	40101(d) Eligible Projects
$ Low-Cost Projects (<$50,000)	• **Dynamic Line Rating (DLR):** Increases capacity of line by determining real-time thermal capacity ratings from weather. • **Vegetation Management:** Removing encroaching vegetation that violates clearance during line sag events. • **Monitors & Sensors:** Monitors and sensors increase situational awareness on the system and improve asset health analytics. For example, investing in temperature monitors for a substation that serves a large development would ensure the single pathway of power into the community is maintained.
$$ High-Cost Projects ($50,000)	• **Upgrading Transformer Capacity:** Installing higher capacity transformers to accommodate new system peaks and increased demand. Upgrading should account for both extreme weather events and general system demand growth. • **Reconductoring:** Replacing existing conductors with new, more efficient ones (e.g., ACCC). Improves insulation of conductors such that they are less flammable or can better withstand high temperatures. • **Undergrounding:** Reinstalling conductors underground to prevent ignition and damage during wildfire. • **Covered Conductors:** Covering conductors with insulating materials can reduce faults related to extreme heat (sagging of lines), ignition during wildfires, corrosion, wind damage from lines touching, or trees falling on lines. Covered conductors can also protect line workers.

Source: Grid Deployment Office "Low-Cost Grid Resilience Projects"

Applicants could consider reconductoring or grid-enhancing technologies to increase the capacity of southern Tx lines that are likely to derate due to extreme heat exposure

California Summer Average Maximum Temperature (°F)
Transmission, Mid-Century [RCP-8.5]



Key Highlights	Analysis

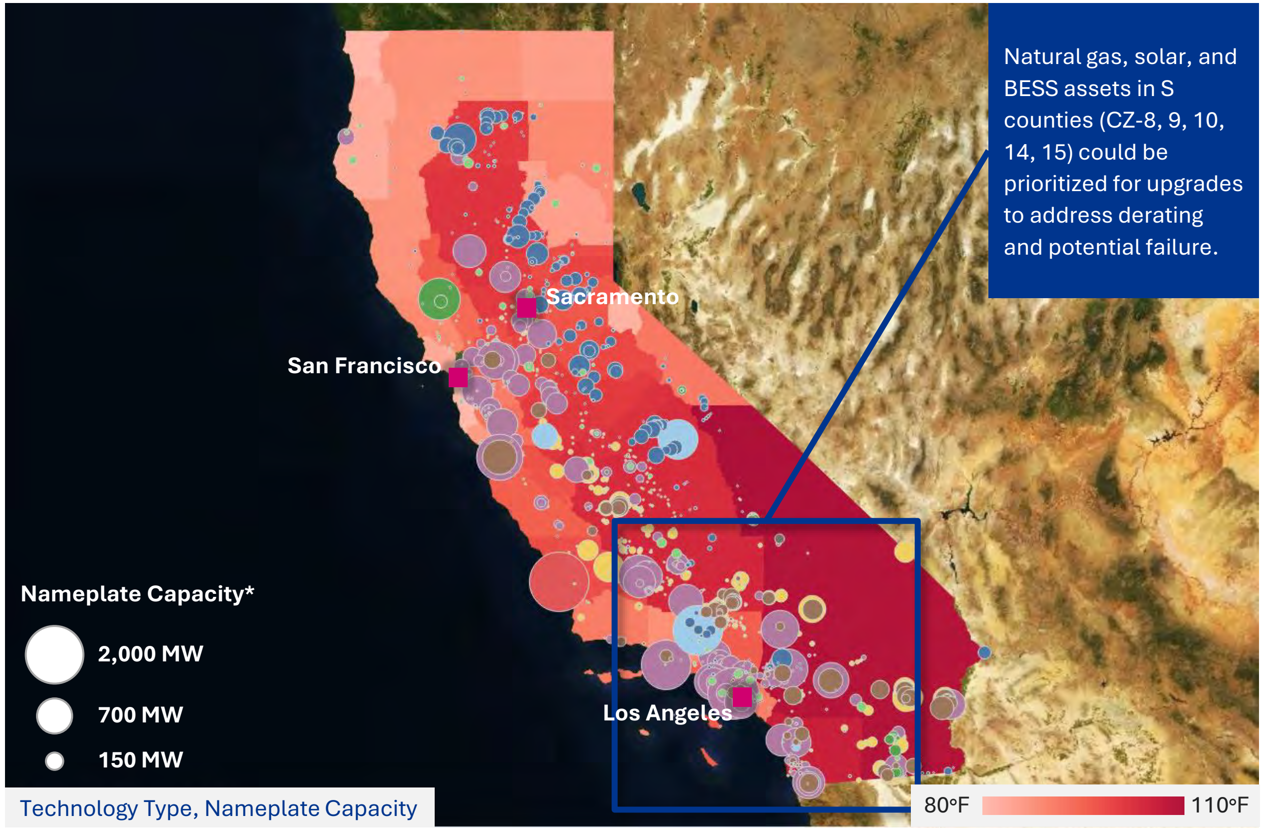
Transmission	• The network of 500kV lines runs through a heat corridor in the center of the state, which can cause **capacity derates and line sag.**
	• CA's **"CHARGE 2T" program** will work to combat derating across PG&E and SCE service territories through **reconductoring and dynamic line rating (DLR).**
	• **Applicants could consider additional undergrounding and reconductoring,** among other adaptations, to address increasing extreme heat exposure.
	• **40101(d) Eligible Investments:**
	  • **Low-Cost:** Vegetation Management, Monitors & Sensors, Dynamic Line Rating (DLR), Reclosers/Circuit Breakers, Relays, Fuses
	  • **High-Cost:** Reconductoring, Undergrounding

Source: ClimRR, EIA860, HIFLD

 |

Asset owners could explore flexible capacity options such as expanded VPP programs to address significant extreme heat exposure and associated derating

California Summer Average Maximum Temperature (°F)
Generators, Mid-Century [RCP-8.5]



Onshore Wind	Coal Plant	Hydroelectric	Nuclear	Solar Photovoltaic
Biomass	Natural Gas Plant	Pumped Storage	Batteries	Other
500kV	345kV	220-287kV	100-161kV	<100kV

Source: ClimRR, EIA860, HIFLD

Key Highlights	Analysis
Thermoelectric	• Thermoelectric generators that rely on water-based cooling methods will **experience production derates** as extreme heat raises average water temperatures. . • **40101(d) Eligible Investments:** • **High-Cost:** Back-Up BESS

Solar & BESS	• Solar assets throughout the state are significantly exposed to extreme heat, contributing to **production derating** at temperatures above 77°F.
	• High temperatures **accelerate BESS degradation.**
	• **40101(d) Eligible Investments:**
	  • **Low-Cost:** Distributed controls and sensors to manage existing DERs
	  • **High-Cost:** Development of microgrids that enhance system adaptative capacity during disruptive events

*Generator nameplate capacities may exceed those shown in the legend

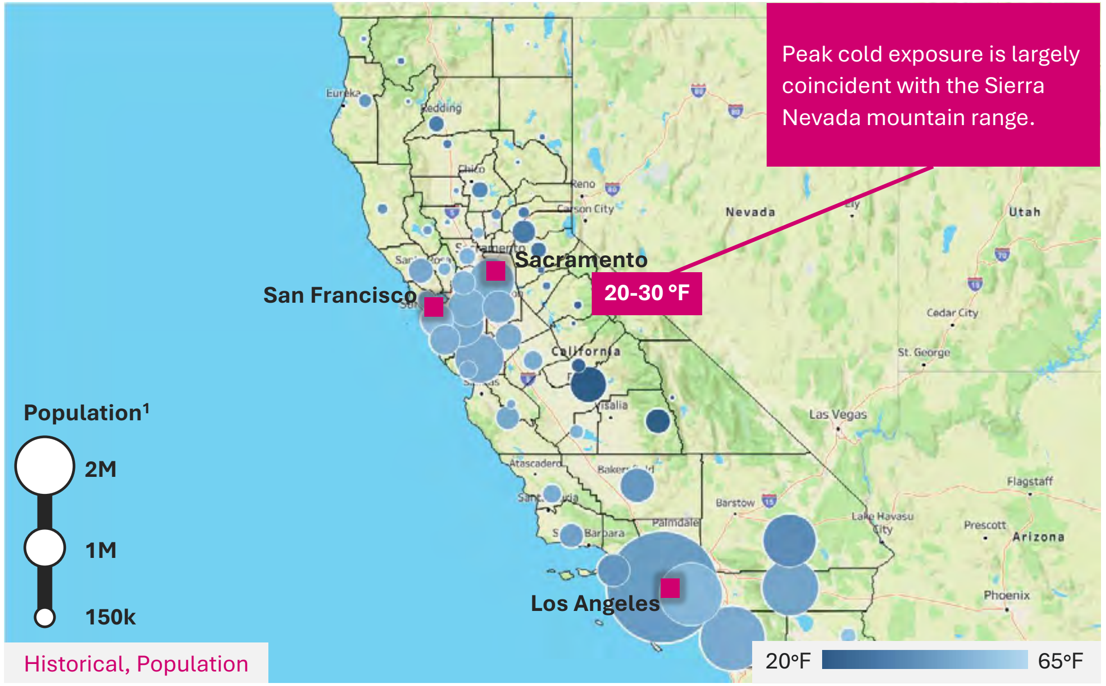
 |

Cold

Asset Analysis

Applicants could consider Dx pole upgrades and undergrounding projects to address cold exposure, especially in E counties that face continued sub-freezing minimum temperatures

California Average Annual Minimum Temperature (°F)
Distribution Assets, (Population) Historical



California Average Annual Minimum Temperature (°F)
Distribution Assets, (Population), End-Century [RCP-8.5]

KEY OBSERVATIONS

- Cold exposure is concentrated in E counties (CZ-13, 16), especially along the Sierra Nevada mountains, where **below-freezing annual minimum temperatures and high levels of snowfall pose a threat to Dx assets.**
- Applicants could **consider Dx pole upgrades and substation enclosures** to combat snow loading and potential freezing in E counties.

KEY OBSERVATIONS

- Climate projections cannot predict acute extreme events like polar vortices and winter storms, **underrepresenting cold exposure.**

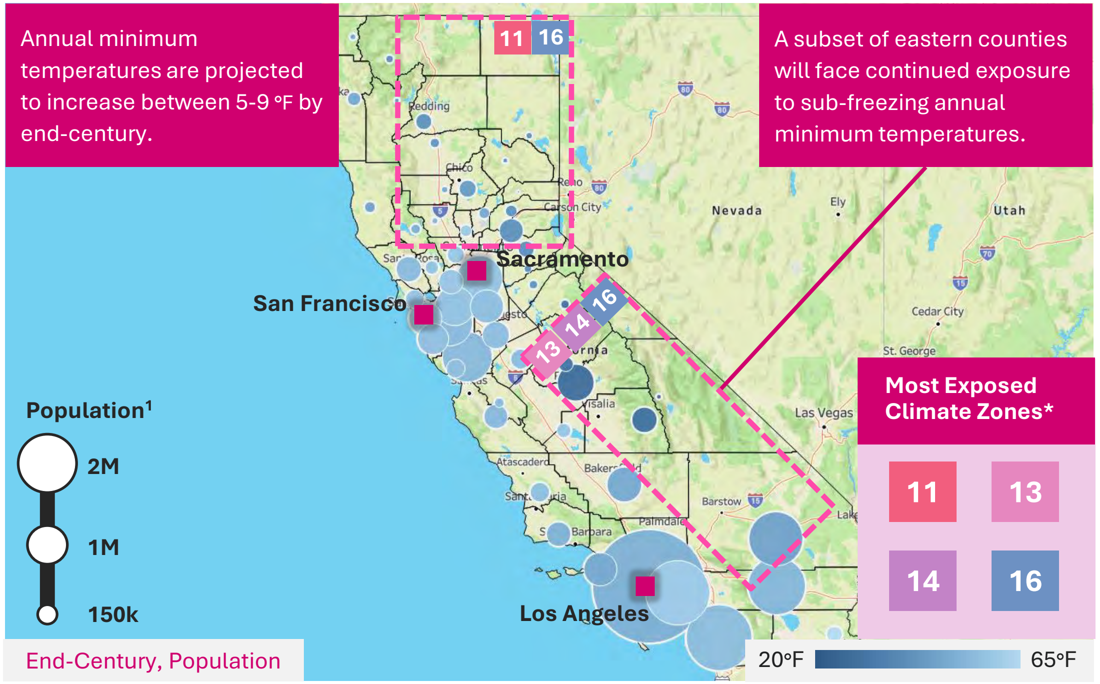
Fresno County Despite warming, Fresno County faces continued sub-freezing annual minimum temperatures, posing a threat of icing and snow loading to a high volume of Dx assets.

Source: ClimRR, US Census Bureau, City and Town Population Totals

 |

When coupled with precipitation and wind, cold events cause failures that could be mitigated by low-cost investments. Regions with multi-hazard risk could underground equipment.

California Average Annual Minimum Temperature (°F)
Distribution Assets, (Population), End-Century [RCP-8.5]



CERRI Dx SUGGESTIONS

- When coupled with extreme wind and precipitation, cold events can cause line failures, often due to falling vegetation and debris, making vegetation management an apt low-cost investment in risk areas.
- Regions that are exposed to multiple hazards such as cold, wildfire, heat, could justify high-cost investments like undergrounding given high avoided costs.

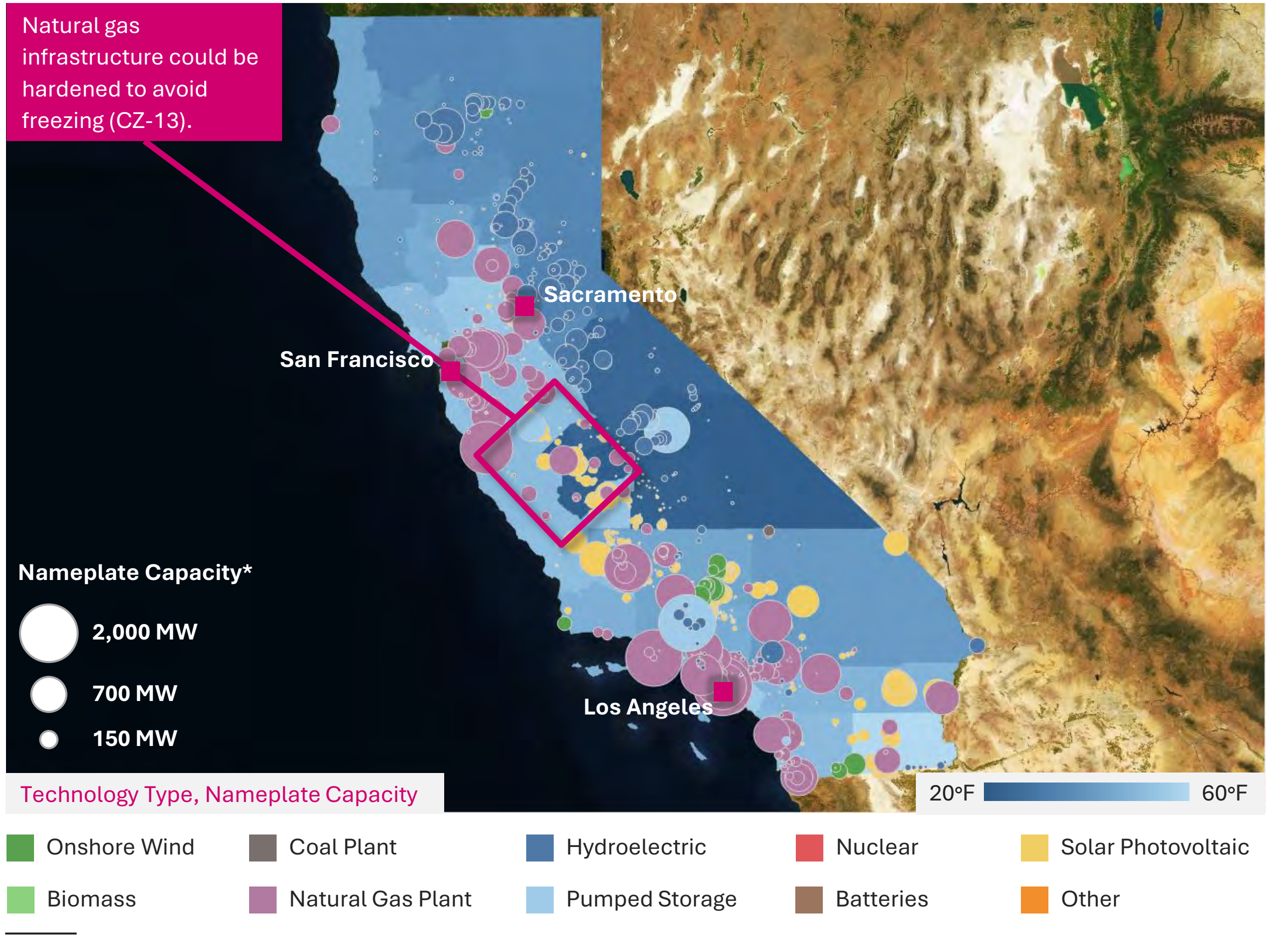
*Projects outside of the most exposed climate zones are still eligible for 40101(d) funding

Cost Threshold	40101(d) Eligible Projects
$ Low-Cost Projects (<$50,000)	• **Vegetation Management:** Removing encroaching vegetation that prove problematic under load from ice accumulation. • **Pole Upgrades:** Replacing wooden poles with material like steel, concrete, etc. that can withstand higher mechanical loads. • **Dead-End Structures:** Installing poles where tension is applied on one side, decreasing the likelihood of cascading failures. • **Decreased Span:** Increasing the number of poles on a line section, decreasing the distance between poles.
$$ High-Cost Projects (>$50,000)	• **Undergrounding:** Reinstalling conductors underground to prevent failure from ice accumulation and other hazards.

Source: Grid Deployment Office “Low-Cost Grid Resilience Projects”

Applicants could evaluate whether natural gas assets in Climate Zone 13 are sufficiently hardened to avoid freezing or snow damage.

California Average Annual Minimum Temperature (°F)
Generators, Mid-Century [RCP-8.5]



Key Highlights	Analysis

Natural Gas	• Asset owners could **evaluate whether plants and pipelines have sufficient heating infrastructure** to prevent wellhead freeze-offs or ignition failures.
	• **40101(d) Eligible Investments:**
	  • **Low-Cost:** Anti-Icing Materials and Coatings, Cold Weather Package, Thermal Insulation
	  • **High-Cost:** Engine and Other Components (Crankshafts, Valves, Filters, Pumps, etc.)

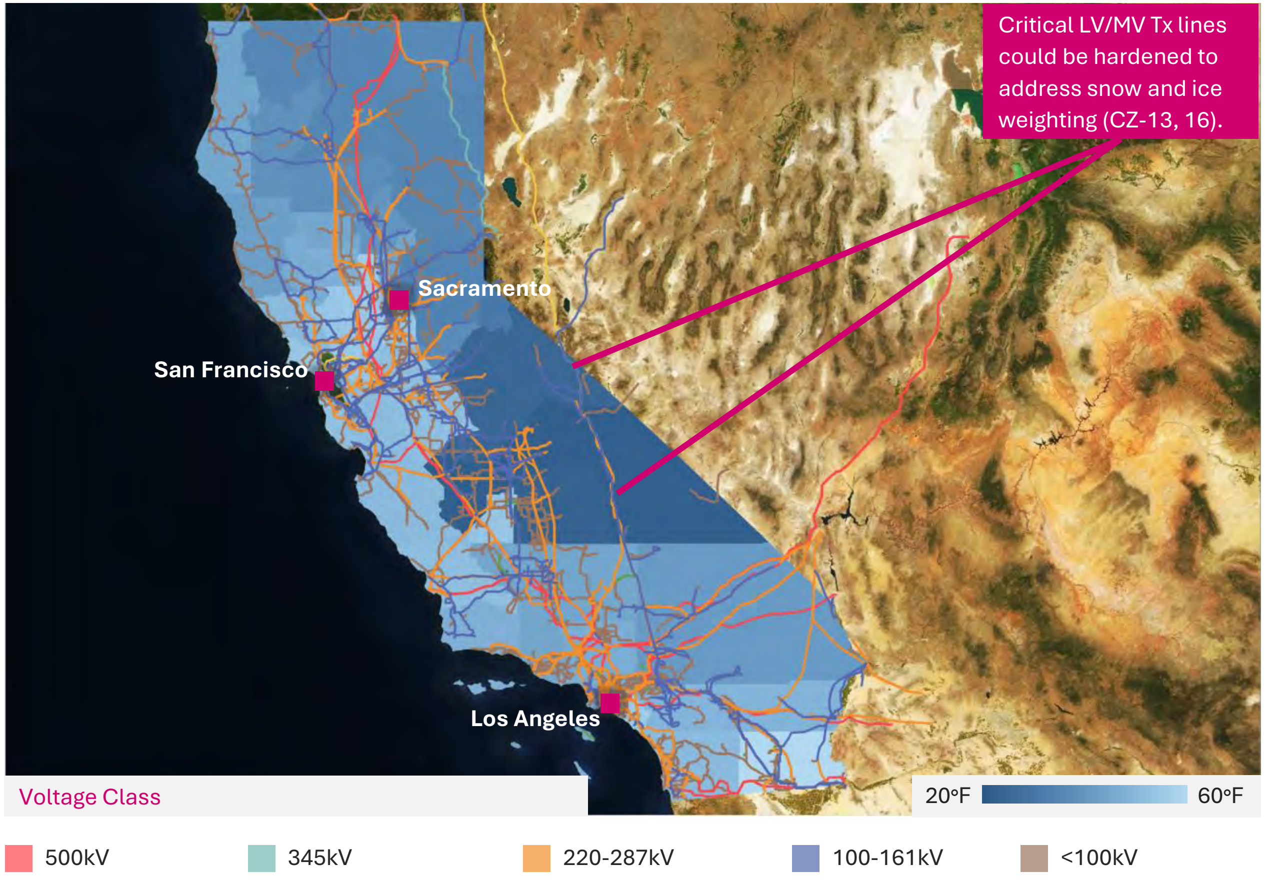
*Generator nameplate capacities may exceed those shown in the legend

Source: ClimRR, EIA860, HIFLD

 |

Applicants could ensure that Tx lines providing interconnection to last-mile customers in Inyo and Mono Counties are sufficiently hardened to withstand snow/ice accumulation

California Average Annual Minimum Temperature (°F)
Generators, Mid-Century [RCP-8.5]



Key Highlights	Analysis

Transmission	• Low and medium-voltage Tx lines are highly exposed to cold in east-central counties (CZ-13, 16) and provide **crucial interconnection for last-mile customers.**
	• This region sees above state average levels of annual precipitation, posing a risk of snow and icing.
	• Asset owners could ensure that these lines and structures are rated to handle the additional weight of snow and ice.
	• **40101(d) Eligible Investments:**
	  • **Low-Cost:** Vegetation Management, Dead-End Structures, Breakaway Disconnect Systems
	  • **High-Cost:** Undergrounding, Reconductoring, Structure Rebuilds

Source: ClimRR, EIA860, HIFLD

 |

Appendix

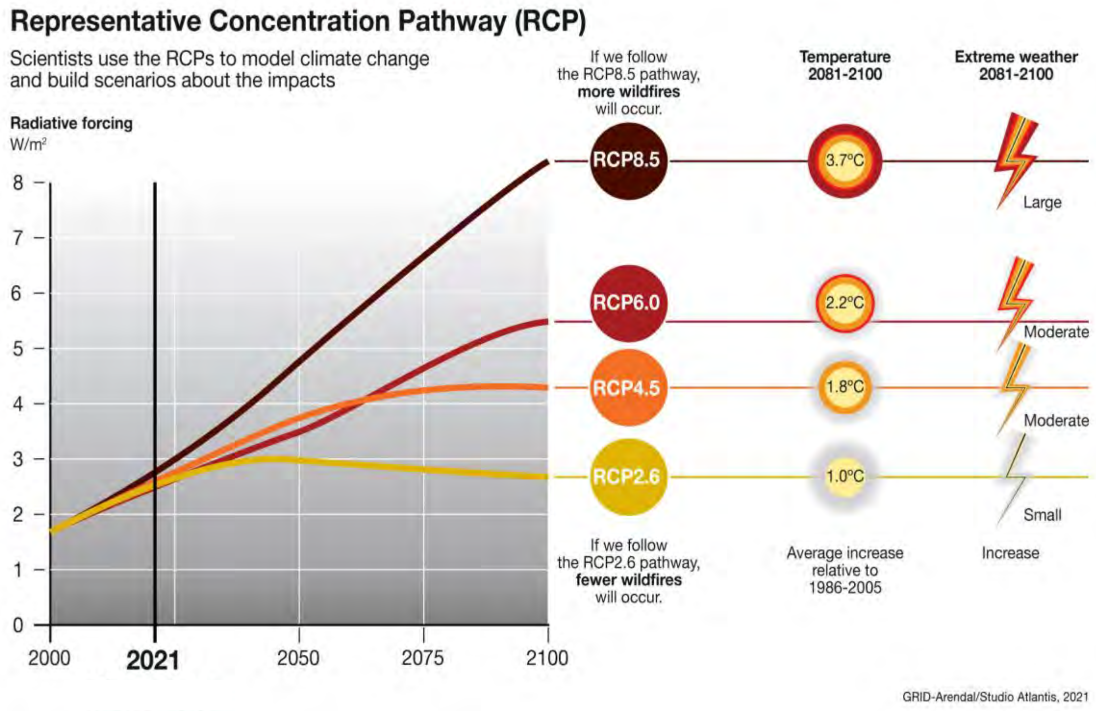
Grid Resilience Reports

Climate Science Background, Data Sources, and Analysis Approach

RCPs and SSPs provide viable climate pathways for an uncertain future

Generating Emission Scenarios

- **Representative concentration pathways (RCPs) project GHG concentrations:** Defined by the IPCC in 2014 as scenarios of future emission concentrations and other radiative forcing that align to climate projections.[1] RCPs use assumptions relating to policy decisions and individual behavior that may change future GHG emissions concentrations.[1] SSPs have largely replaced RCPs.
- **Shared socioeconomic pathways (SSPs) provide 5 'storylines' to contextualize RCPs** and to provide the various future pathways possible.[2] They consider how the world could evolve socioeconomically and politically, including how various levels of climate change mitigation and adaptation could be achieved and will influence future climate scenarios.[3]
- RCPs included in the CLIMRR dataset include RCP 4.5 and RCP 8.5.
- SSPs included in the Hydrosource dataset include SSP585, SSP370, SSP245, and SSP126.



Modeling Scenario: RCP 4.5

- **"Moderate" scenario**: Emissions peak around 2040 and then slowly begin to decline.[4] Temperatures warm about 3.2 °F from a 2000 baseline.[5]
- CO2 emissions plateau before falling mid-century, as energy use sharply declines and there is large scale reforestation.[6]

Modeling Scenario: RCP 8.5

- **"Rapid growth" scenario:** Emissions continue to rise throughout the twenty-first century.[4] Temperatures warm about 6.6 °F from a 2000 baseline.[5]
- CO2 emissions are three times higher than the present by end-century, with a large increase in methane emissions and continued fossil fuel use.[6]

[1] Source: ComEd Vulnerability Study 2023
[2] Source: Jupiter
[3] Source: Carbon Brief
[4] Source: Help (cal-adapt.org)
[5] CoastAdapt
[6] Climate Copernicus

 |

Baringa leverages national downscaled climate datasets with high granularity to assign county-level climate exposure

	CLIMRR by Argonne National Lab (ANL)	HydroSource by Oak Ridge National Lab (ORNL)	RAWS by Western Regional Climate Center (WRCC)
Dataset Description	The Climate Risk and Resilience Portal (CLIMRR) provides highly localized climate projections from mid- to end-century using a supercomputer to model 60 climate variables.	HydroSource is a comprehensive national water energy digital platform consisting of hydropower-related data set, models, visualizations, and analytics tools.	The Wildland Fire Remote Automated Weather Stations (RAWS) data set provided by WRCC is a quality-controlled repository of hourly data for 17 select weather metrics from a network of weather stations across western states.
Data Provider Description	Argonne National Lab is a federally-funded science and engineering research center sponsored by the Department of Energy.	Oak Ridge National Lab is a federally funded research and development center sponsored by the Department of Energy.	The Western Regional Climate Center is one of 6 Regional Climate Centers in the United States. WRCC works jointly with NOAA to coordinate climate activities and conduct applied research on climate issues in the West.
Years Covered	Historical, Mid-Century, End-Century	1980-2099	2000-2022
Spatial Resolution	12 km (aggregated to county)	County	Weather station (aggregated to county)
Hazards	RAIN, FIRE, HEAT, COLD, DROUGHT	FLOOD	WIND

 |

Baringa leverages national downscaled climate datasets with high granularity to assign county-level climate exposure (cont.)

	CLIMRR by Argonne National Lab (ANL)	HydroSource by Oak Ridge National Lab (ORNL)	RAWS by Western Regional Climate Center (WRCC)
Key Metrics	Seasonal Fire Weather Index; Annual Precipitation; Cons. Days w/o Precipitation; Days Above X°F Heat Index; Annual Cooling Degree Days; Seasonal Max Temperature; Annual Min Temperature; Annual Heating Degree Days; Seasonal Min Temperature	Annual VIC Runoff (SSP585)	Hourly Max Wind Gust
Mapping/Analysis	Used Python script that returned the most extreme value (high or low depending on hazard) from grid cells intersecting a particular county. Script included assigns to county the max/min value of CLIMRR data across all grid cells that fall within county.	Averaged across the 7 different climate model values provided for the SSP585 warming scenario to return a single, composite runoff level for each county in each year. 2000 was used for historical, 2050 for mid-century, and 2090 for end-century.	Mapped weather stations to their respective counties. If a county had multiple weather stations, the station with the highest average hourly value was selected to represent the county. Counties with no stations were mapped to the closest station in a neighboring county. GEV analysis was conducted using the pyextremes EVA function to derive return periods.
Rationale	• Reputable data provider • Accessible, open-source data allows for our methodology to be reproduced/quality checked • Provides climate projections for hazards with a significant climate signal • More than sufficient spatial resolution to gauge climate exposure at a county level	• Reputable data provider • Climate projections forecast change in exposure over time • Same spatial resolution as outage data (county level) • Data set includes pluvial flooding (from flash floods and surface runoff) which is more likely to contribute to outages because it is faster-acting and can hit urban centers	• Reputable data provider • Wind does not have a strong climate signal, so projections were not required • Sufficient density of stations per state to assign to counties • Quality checked • Hourly resolution was sufficient for deriving return periods

Baringa is leveraging forward-looking climate projections to inform its technical assistance work for states in WECC

Wind

Source: **Western Regional Climate Center (WRCC)**
Input metric: Hourly max wind speed (mph)
Output: Wind speed at key return periods via GEV distribution

Wildfire

- Source: **CLIMRR (ANL)**

Input metric: Fire weather index (FWI) by grid cell
Output: Maximum fire weather index by county

Precipitation

Source: **CLIMRR (ANL)**
Input metric: Annual total precipitation (in/year) by grid cell
Output: Max annual total precipitation (in/year) by county

Drought

Source: **CLIMRR (ANL)**
Input metric: Consecutive days with no precipitation by grid cell
Output: Max consecutive days with no precipitation by county

Heat

Source: **CLIMRR (ANL)**
Input metrics:

- Days above 95, 105, 115, 125 °F
- Annual cooling degree days
- Seasonal maximum temperatures

Output: Input metrics applied from a grid cell level to a county level

Cold

Source: **CLIMRR (ANL)**
Input metrics:

- Annual minimum temperature
- Annual heating degree days
- Seasonal minimum temperatures

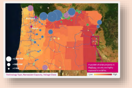
Output: Input metrics applied from a grid cell level to a county level

Flood

Source: **Hydrosource (ORNL)**
Input metric: Annual Variable Infiltration Capacity (VIC) model runoff (mm/year)
Output: Average annual VIC runoff (pluvial flooding) for 4 warming scenarios and 3 time periods (historical, mid-century, end-century)

 |

Increasing granularity of analysis at the customer feeder would require conducting asset-level vulnerability assessments using utility-sourced outage and component data.

ASSET RESILIENCE JOURNEY	STRATEGIC ANALYSIS	ASSET VULNERABILITY ASSESSMENT	CLIMATE-ADJUSTED ASSET INVESTMENT PLAN
	Qualitative assessment of future risk	**Quantitative** assessment of future risk in dollars	**Economic assessment** of cost-benefit tradeoffs
Climate Data	Historical Data or **Best practice:** Coarse Projections (15 -25km)	High-Res Projections (90m-3km)	High-Res Projections (90m-3km)
Asset Data	Publicly available	GPS Coordinates (lat/longs), design standards, costs of failure including value of lost load	GPS Coordinates (lat/longs), design standards, costs of failure including value of lost load
Failure Mode Analysis	By asset class	Asset level	Asset level
Financial Impact	NA	Risk Score **Best practice:** Quantified dollars of risk	Quantified dollars of risk
Investment Substantiation	NA, directional analysis	Quantitative, based on avoided risk only	**Prioritizes adaptations based on NPV of investments**
Examples:	 **GRACI:** Grid Resilience Reports	**SCE:** CAVA Report	**Industry examples are in development**

Increased modeling complexity

STRATEGIC — **INCREASED EFFICIENCY OF CAPITAL ALLOCATION** — INVESTMENT-GRADE

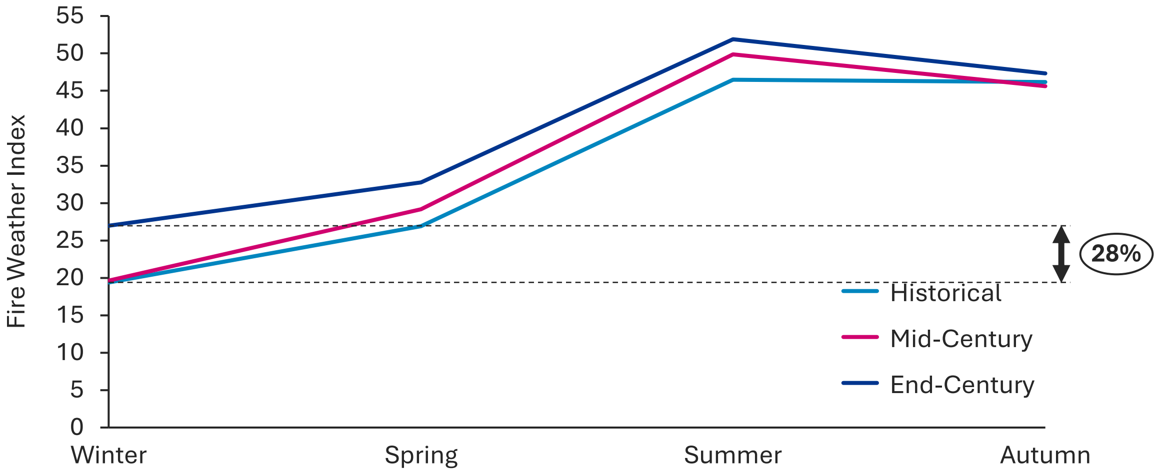
 |

Statistical Analysis

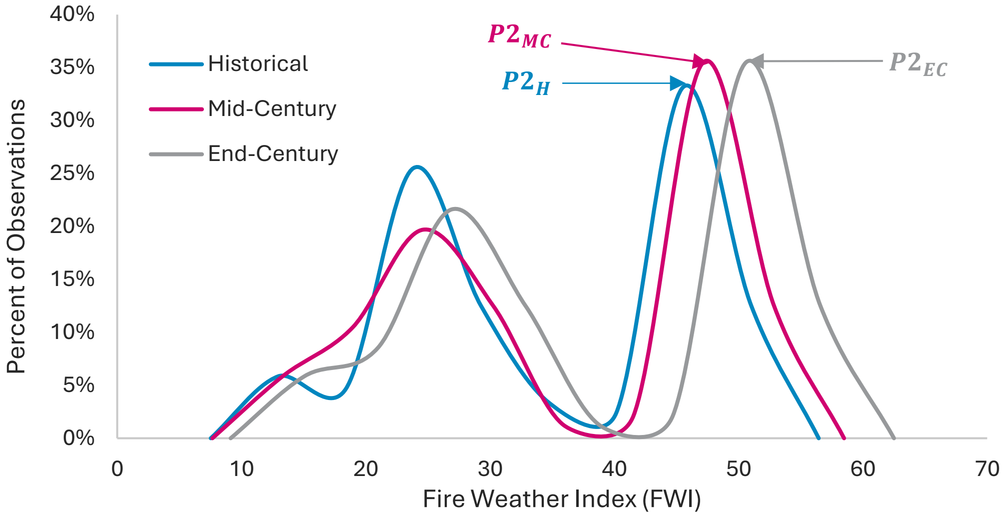
Statistical insights and hazard trends

Fire exposure increases slightly by mid-century during summer, but intensifies more significantly by end-century from winter-summer, shortening the maintenance window

California Average Seasonal Fire Weather Index (FWI)
Population-Weighted by County [RCP-8.5]



California Fire Weather Index Statistical Distribution (FWI)
Population-Weighted by County [RCP-8.5]



KEY OBSERVATIONS

- **End-century wildfire exposure is elevated**, with the sharpest increase occurring in the winter by about 28% from historical FWI.
- Elevated wildfire exposure from winter through summer indicates a **lengthening of the wildfire season,** starting earlier in the calendar year.
- The change in length of wildfire season suggests that **the window for scheduled maintenance during the shoulder seasons is diminishing, especially in the winter and spring.**

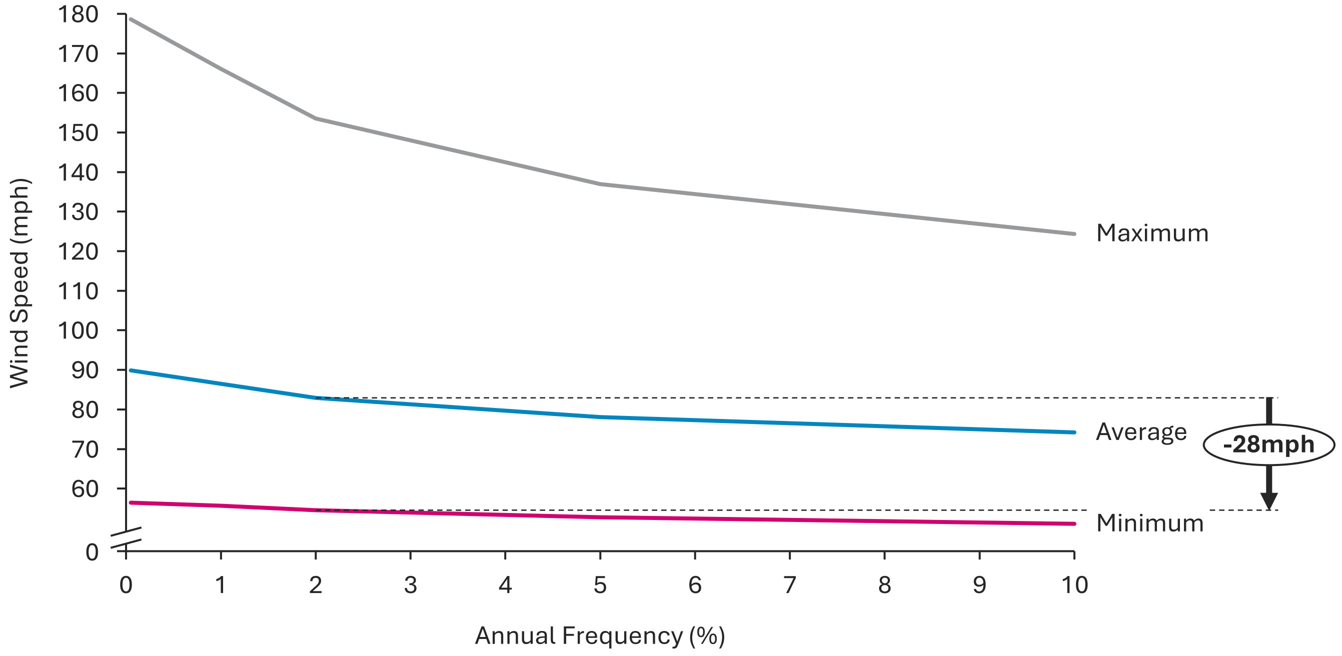
KEY OBSERVATIONS

- Rightward shifts of the curves indicates **increasing severity of wildfire exposure over time, particularly in the most exposed regions.**
- Increased height of P2 (Peak 2) over time indicates that a **larger spatial extent will be exposed to the high FWI levels (~45/50).**
- Bi-modal shape represents **two distinct regions of fire exposure in the state,** a lower exposure region (N/NW) facing FWI levels around 20-30, and a high exposure region (S/SE) exposed to levels around 40-50.

 |

Historically, there is a 1% chance that the average wind speed seen across California counties is ~86 mph annually

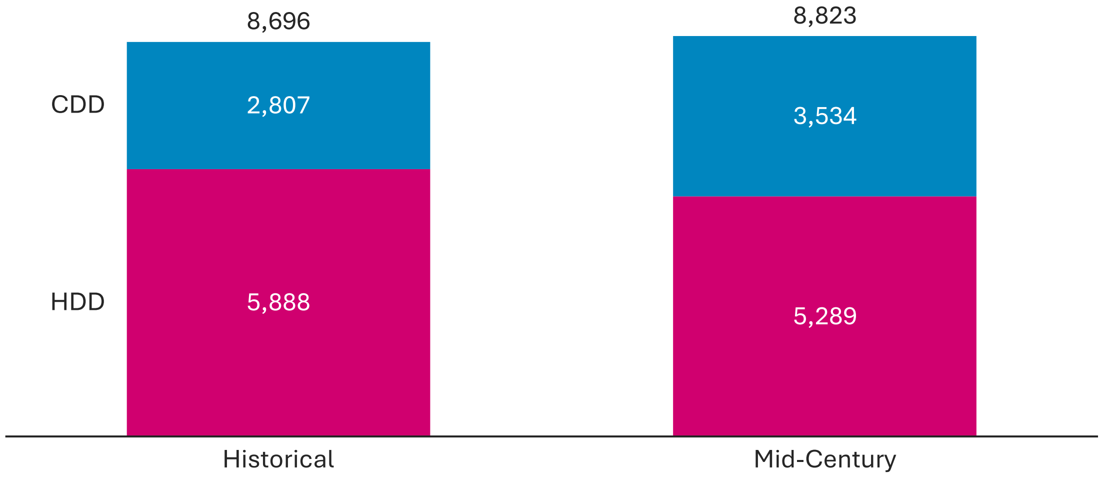
California Wind Frequency vs Severity (2000 – 2022)
Historical, Average by County



Key Highlights	Analysis
High System Averages	• Historically, there is a 1% chance that the average wind speed seen across California counties is ~86mph annually. • The 10% annual likelihood drops to about 74 mph, indicating high system wind speeds are common across counties. • CA return values tend to be higher than neighboring states, indicating that applicants could consider above regional average investment in wind-related adaptations.
Volatility Across Counties	• There is a sizeable band between the maximum and minimum counties around the mean. • This high variance indicates that wind adaptations could be focused on a smaller regions rather than over large service territories. • Climate Zones 1, 3, and 13 should be prioritized for hardening to address wind exposure.

Increasing exposure to extreme heat may contribute to derating, capacity violations, and substation failure, indicating the need for hardening in newly exposed portions of the state

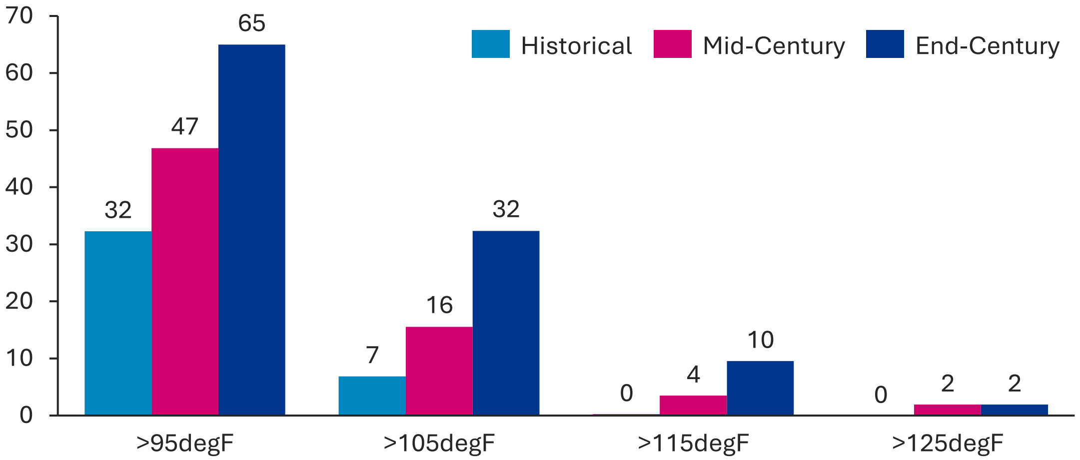
California Average Annual Cooling & Heating Degree Days (CDD & HDD)
Population-Weighted by County [RCP-8.5]



KEY OBSERVATIONS

- Between historical and mid-century, **the ratio of CDD to HDD increases,** with the share of the average number of CDD jumping from about 48% to 67%.
- This results in **increased summer asset utilization and degradation**, but **impacts to winter utilization remain unclear** depending on heating electrification trends.
- Given the larger populations of southern counties, this metric could **underrepresent cold exposure for northern asset owners.**

California Average Annual Days Exceeding Daily Max Heat Index Thresholds
Population-Weighted by County [RCP-8.5]



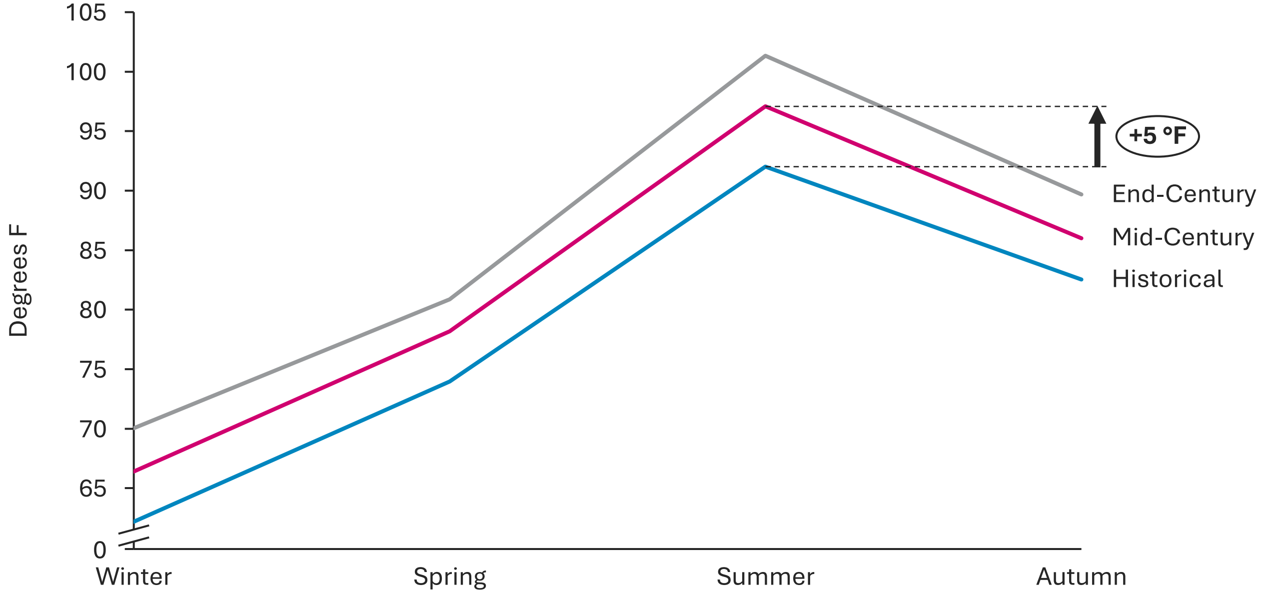
KEY OBSERVATIONS

- Increasing extreme heat exposure will cause an **increase in peak load** and likely contribute to **derating** and **capacity violations** for Tx and thermal generating units.
- Over 2x increase in days > 105 °F by mid-century poses a **substantial risk to distribution substations**, which can fail after two consecutive days above 104 °F without sufficient cooling infrastructure.
- Increasing state-wide averages indicates that **new regions will be exposed to extreme heat and could be prioritized for upgrades.**

 |

Average summer temperature maximums are projected to increase by mid-century, increasing the duration and magnitude of high system utilization

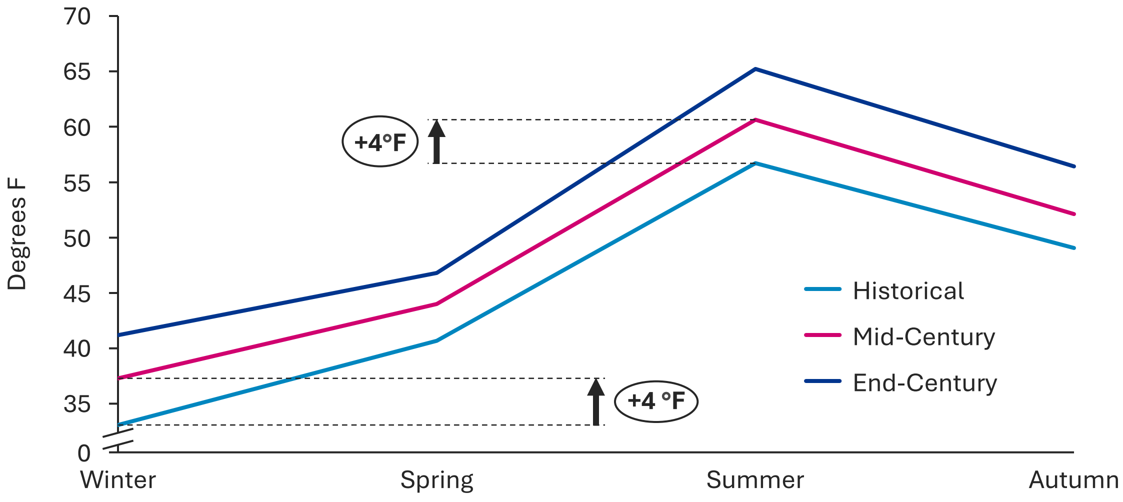
California Average Seasonal Maximum Temperature (°F)
Population-Weighted by County [RCP-8.5]



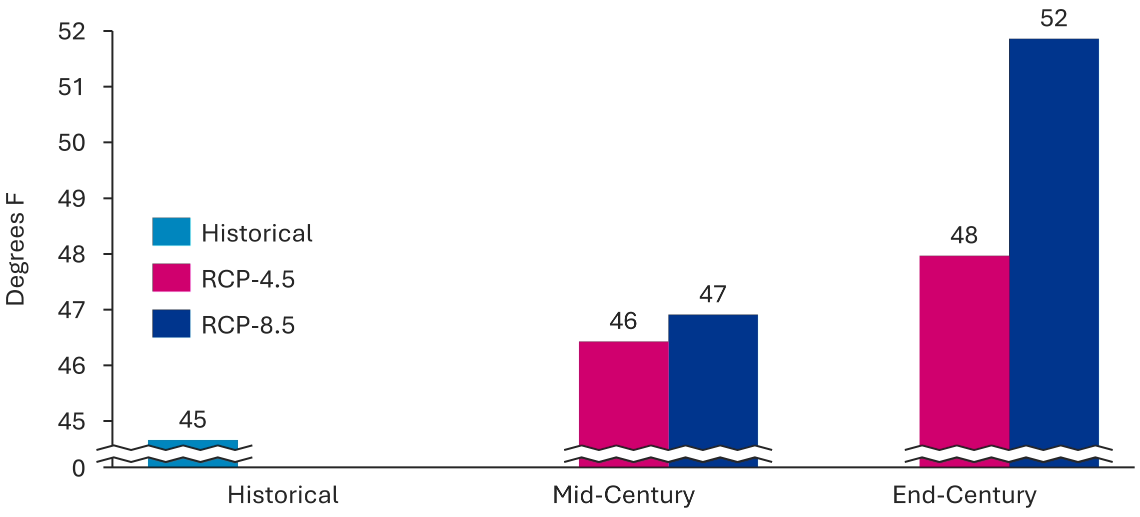
Key Highlights	Analysis
Summer Warming	• **Heat risk increases most drastically in summer**, with a 5 °F increase in the average seasonal max by mid-century, **increasing system utilization and accelerating degradation.**
Shorter Shoulder Seasons	• Warming is generally less pronounced in shoulder seasons, although increased spring and autumn maximums could **extend the duration of high system utilization and shorten maintenance windows.**
Extreme Heat	• Average summer maximums reaching 97 °F by mid-century and 101 °F by end-century indicates an **increasing frequency of extreme temperatures that can cause significant derating, capacity violations, and direct failure across all asset classes.**

Despite a general warming of minimum temperatures, exposure to extreme cold may persist in some portions of the state given relatively constant average annual minimum temperatures

California Average Seasonal Minimum Temperature (°F)
Population-Weighted by County [RCP-8.5]



California Average Annual Minimum Temperature (°F)
Population-Weighted by County [RCP-4.5, RCP-8.5]



KEY OBSERVATIONS

- Significant winter warming (+4 °F by mid-century) could decrease overall heating load, but the **impact on electricity demand ultimately depends on the speed of heating electrification.**
- Summer minimums remaining around 65 °F indicates that assets may be able to cool overnight, but this could be monitored at a county-level.
- Resilience upgrades like **undergrounding, covered conductors, or cable upgrades can address heat and cold exposure simultaneously.**

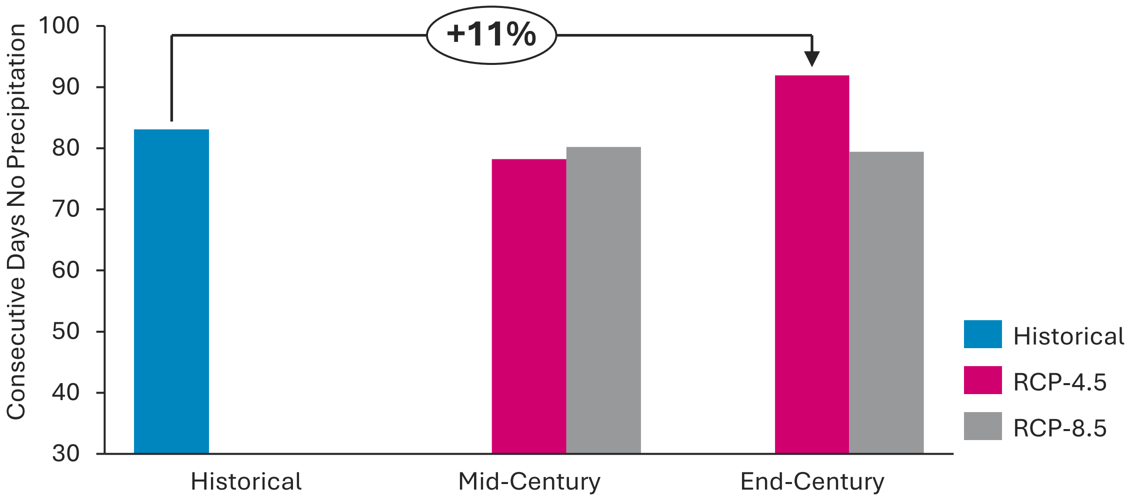
KEY OBSERVATIONS

- Only about 3 °F of annual minimum temperature warming (RCP-4.5) indicates that cold exposure could persist to end-century.
- Diverging temperature projections by end-century demonstrates projection uncertainty and the importance of continued monitoring.
- Regarding extreme cold, global climate models do not resolve for extreme cold events like polar vortexes, so **assets could still face similar levels of exposure to cold-related failures.**

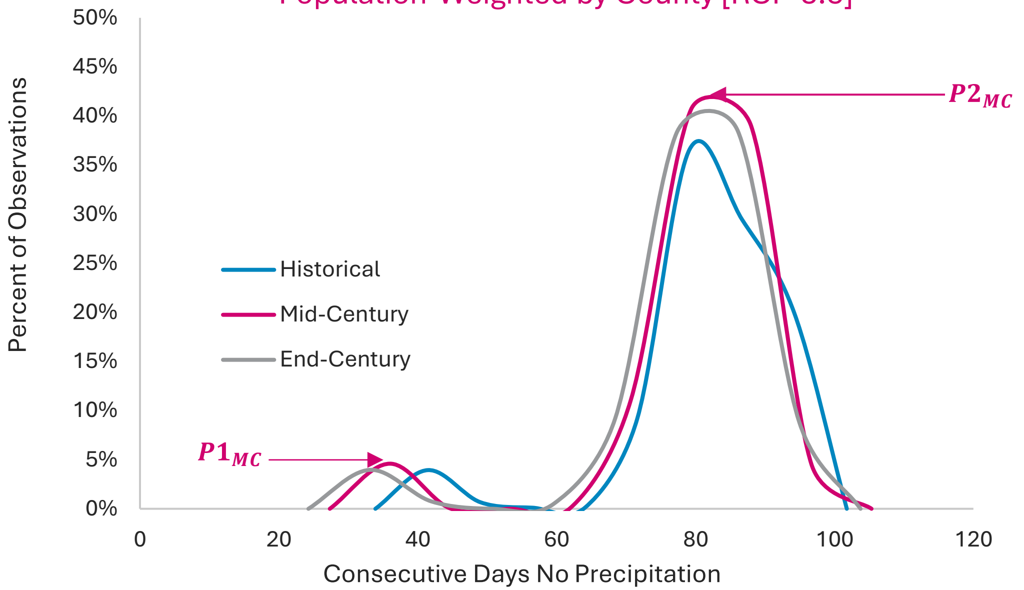
 |

Drought exposure is generally projected to stay constant over time, but divergence at the county level could be monitored closely to determine the impact on electricity generation

California Average Annual Consecutive Days with No Precipitation
Population-Weighted by County [RCP 4.5, RCP-8.5]



California Average Consecutive Days with No Precipitation Statistical Distribution
Population-Weighted by County [RCP-8.5]



KEY OBSERVATIONS

- Projections indicate **relatively constant average state-wide drought levels, although this obfuscates increases and decreases projected at the county level.**
- Higher drought exposure for RCP-4.5 than RCP-8.5 demonstrates that **drought risk does not scale linearly with temperature.**
- Diverging trends across counties and warming scenarios indicates that **asset owners could monitor drought exposure at the local level.**

KEY OBSERVATIONS

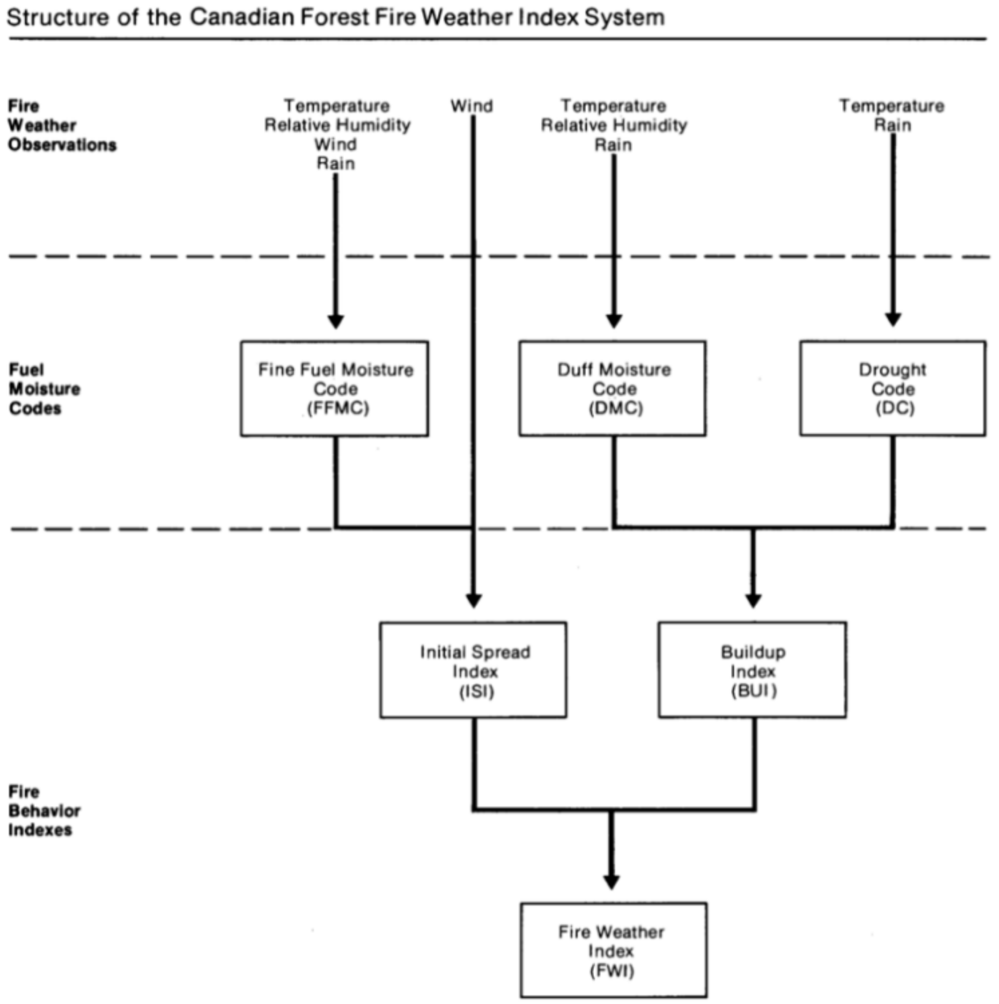
- Leftward shift of P1 (Peak 1) indicates that **drought exposure will become less severe in the least exposed regions of the state.**
- Increasing height of P2 (Peak 2) by mid-century indicates that **more of the population will be exposed to about 80 cons. days w/o precipitation.**
- The kink in the historical curve around 100 days indicates that the **most exposed regions will face decreasing severity of drought exposure by mid-century and end-century by a small margin.**

 |

Fire Weather Index Explainer

Background on Fire Weather Index Methodology

Fire Weather Index synthesizes weather and moisture content data into a normalized value representing the danger of fire spread once ignition has occurred.



KEY TAKEAWAYS

- FWI is a useful metric for evaluating weather-based conditions that heighten the **danger of wildfire spread once ignition has occurred.**
- **Initial Spread Index**: Measures the **expected rate of fire spread,** based on wind speed and moisture content of fine fuels/forest litter (Fine Fuel Moisture Code).
- **Buildup Index:** Measures **the total amount of forest fuel available for consumption,** based on the **moisture content of intermediate organic layers**, such as decomposing plant matter (Duff Moisture Code), and the **moisture content of deep organic layers and soils,** which corresponds to drought measures (Drought Code).
- Daily FWI values were calculated using readings from Argonne's downscaled 12km climate data and averaged annually or seasonally across RCP-4.5 and RCP-8.5.
- Percentiles (below) were calculated based on **FWI values across all 12km grid cells in the contiguous U.S.**

FWI Class	Percentile range in historical period	FWI values in Class
Low	0–25th percentile	0–9 FWI
Medium	25–50th percentile	9–21 FWI
High	50–75th percentile	21–34 FWI
Very High	75–90th percentile	34–39 FWI
Extreme	90–98th percentile	39–53 FWI
Very Extreme	Above 98th percentile	Above 53 FWI

Source: ClimRR, US Census Bureau, City and Town Population Totals

