Disclaimer

Baringa

Grid Resilience Reports

Nevada

Energy & Resources | Networks

12/09/2024

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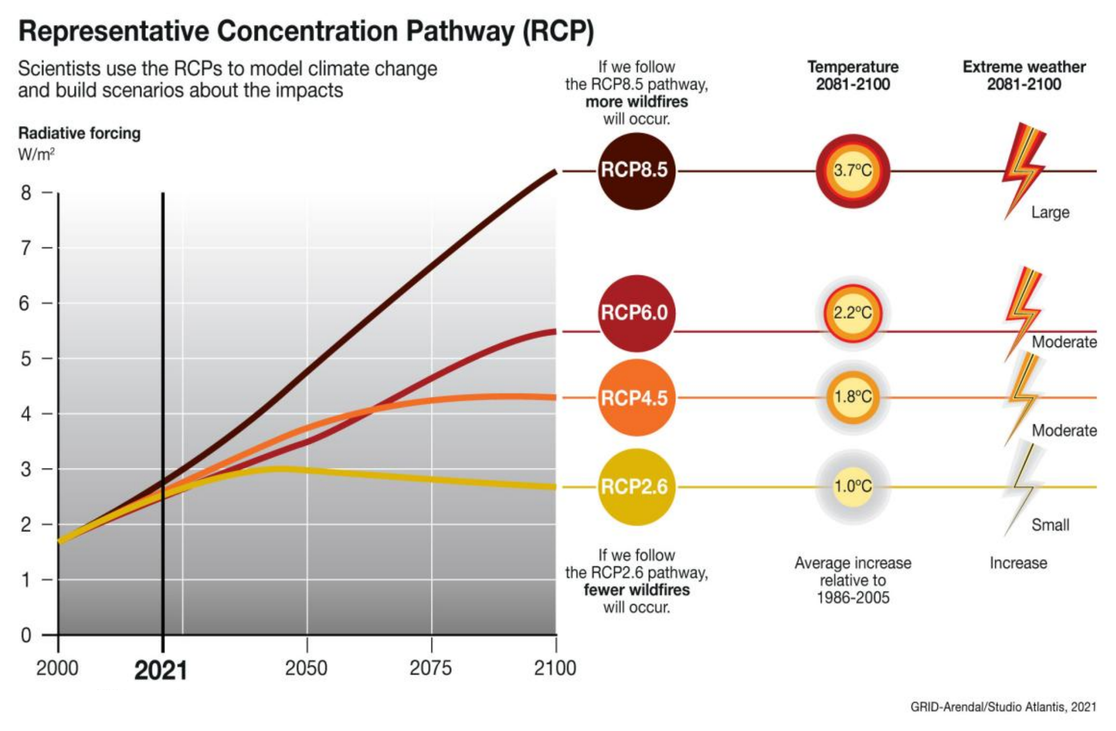
Grid Resilience Reports

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 a Python script that returned the most extreme value (high or low depending on hazard) from grid cells intersecting a particular 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

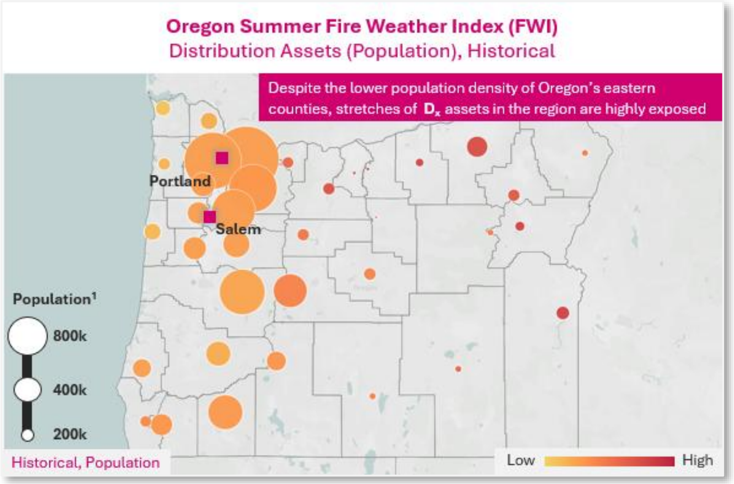
Output: Input metrics applied from a grid cell level to a county level

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)

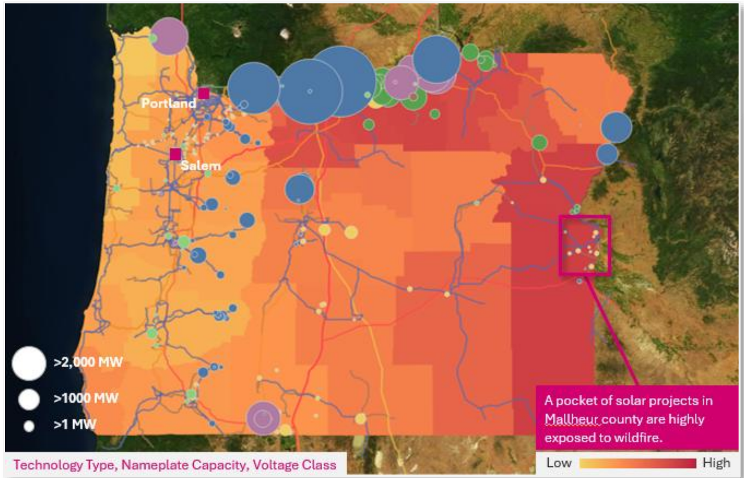
This report is standardized to include 3 different data visualizations that provide insights for Distribution, Transmission, and Generation across 7 extreme weather hazards

1 Distribution Maps



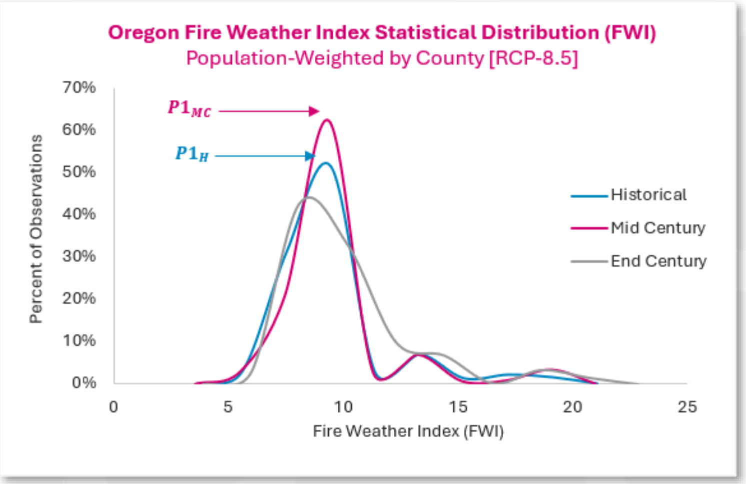
- **Purpose:** Uses population as proxy for volume of distribution assets given that the location of distribution assets is restricted.
- **Interpretation*:** Locate areas of high exposure by identifying counties with coincident large bubbles and dark colors. This indicates a combination of high volume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

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.

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Asset Class Overviews

Summary

L Low M Moderate H High

NVGOE could prioritize T&D hardening addressing heat and fire in southern counties and consider weatherization programs addressing extreme cold in northern and central counties

Key Takeaways

- Consider focusing T&D hardening on S counties, balancing upgrades in population centers like Clark County and rural counties served by radial networks.
- Evaluate DER programs to address generator derating as well as substation/transformer upgrades to mitigate the risk of direct failure from extreme heat.
- Consider new weatherization programs for thermoelectric and wind assets in the N and prioritize T&D hardening in Elko and Nye Counties to combat icing.

Hazard	Exposure	Change to Mid-Century	Generation	Transmission & Distribution	AWPI*	Description
FIRE	H	↑	**Consider investment in emergency response planning and innovative solar O&M programs** • Emergency response planning could leverage new data from monitoring initiatives to decrease restoration times. • Innovative solar cleaning projects or optimized maintenance scheduling could help combat low solar capacity factors during fires.	**Focus hardening efforts in southern counties and HV Tx assets in Clark County** • NVGOE could consider upgrades for southern counties, especially rural areas served by radial Dx lines (i.e. Lincoln and Nye Counties). • A cluster of HV import/export lines in Clark County could be prioritized for hardening.	M	**Gen:** No proposed awards address generator wildfire exposure. **T&D:** Proposals generally address wildfire exposure, but NVGOE could consider future awards for small utilities to upgrade aging and vulnerable Dx assets in rural areas of the state.
HEAT	H	↑	**Explore flexible DER options to offset derating of supply during extreme heat events** • DER proliferation minimizes reliance on a pocket of natural gas plants that will be heavily exposed to extreme heat.	**Consider substation upgrades and more cost-effective Tx hardening methods** • Significant warming requires substation and transformer upgrades to avoid direct failure, especially in newly exposed N counties. • NVGOE could consider dynamic line rating (DLR) to combat Tx derating from extreme heat.	M	**Gen:** No proposed awards address extreme heat exposure. **T&D:** Veg management and line upgrades address heat. No mention of substation upgrades, which face considerable extreme heat exposure and a high likelihood of failure.
COLD	M	↓	**Focus weatherization technologies on highly exposed wind and natural gas generators** • A handful of generators in N counties face continued exposure to icing and other cold-related failures through mid-century.	**Prioritize investments in Elko and Nye Counties** • Despite warming, near-freezing annual minimums persist in Elko and Nye Counties, posing a risk of icing and failure to Dx and Tx assets.	M	**Gen:** No proposed awards address generator cold exposure. **T&D:** NVGOE could also consider Tx structure reinforcement (decreased span, trussing, etc.) to address the threat of icing.

~~* AWPI – Alignment with proposed investment~~

L Low M Moderate H High

NVGOE could consider fortifying substations in NW counties exposed to flooding, increase wind ratings for renewables, and monitor drought to assess impacts on hydro production

Key Takeaways

- NVGOE could prioritize substation fortification for low-lying assets in Washoe and Douglas Counties that are heavily exposed to flooding.
- High peak wind gust return values could justify fortifying wind and solar assets as well as crucial import/export HV Tx lines in Clark County.
- While precipitation and drought have weak climate signals, NVGOE could gather additional data to better assess the impact on hydroelectric production.

Hazard	Exposure	Change to Mid-Century	Generation	Transmission & Distribution	AWPI*	Description
FLOOD	L	↑	**Most supply technologies are not significantly exposed to flood** • Solar and battery facilities in Washoe County are exposed to peak statewide flood levels and could be considered for fortification.	**NVGOE could prioritize substation fortification** • High density of HV substations in Washoe and Douglas Counties are heavily exposed to flooding, which can cause direct failure. • NVGOE could also consider upgrades to aging or weak distribution poles.	M	**Gen:** Lack of exposure makes gen a lower priority for investment. **T&D:** No projects targeting substations, unaligned with the significant substation exposure.
WIND	M	N/A	**NVGOE could consider investments to buttress solar racking and anticipate turbine cutouts** • Consider encouraging IPPs to procure solar racking rated for higher wind speeds.	**Critical HV ties Clark County could be prioritized for structure reinforcement** • Consider rethinking regional design standards for poles given historical thresholds, especially in eastern counties.	M	**Gen:** No wind/solar reinforcement despite significant exposure. **T&D:** Veg management & pole upgrades are aligned, but Tx reinforcement projects could also be considered.
DROUGHT	M	→	**Most generators are exposed to peak statewide drought levels in Clark County** • NVGOE could monitor the impacts of drought on production from the Hoover Dam. • Drought conditions could derate production for solar & natural gas assets in Clark County.	**Drought exposure does not have a material impact on transmission and distribution assets.**	L	**Gen:** No projects addressing drought exposure directly. Microgrid funding could help offset potential derating of electricity supply during extreme drought events.
RAIN	L	→	**NVGOE could seek out additional data to understand future hydroelectric production** • Coordinate with SEOs to assess upstream precipitation effects on hydro output. • Consider the effect of warming on snow melt.	**Precipitation exposure does not have a material impact on transmission and distribution assets.**	M	**Gen:** No proposals address drought, but NVGOE could gather additional information to assess the true impact on hydro output and its implications for resource planning and scheduling.

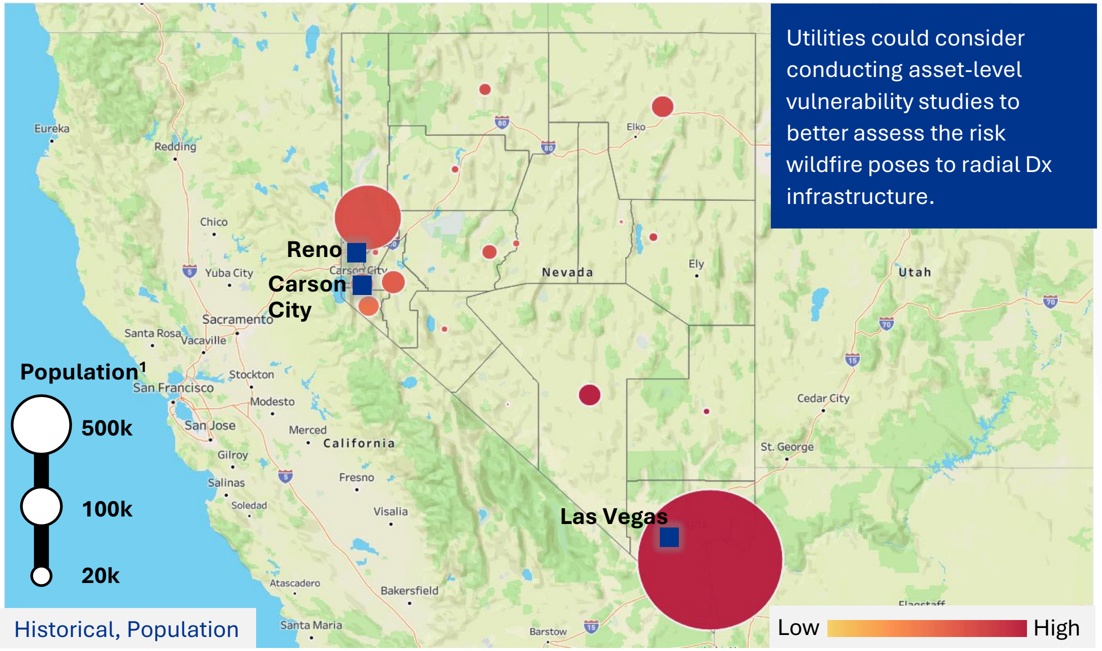
* AWPI = Alignment with proposed investment

Wildfire

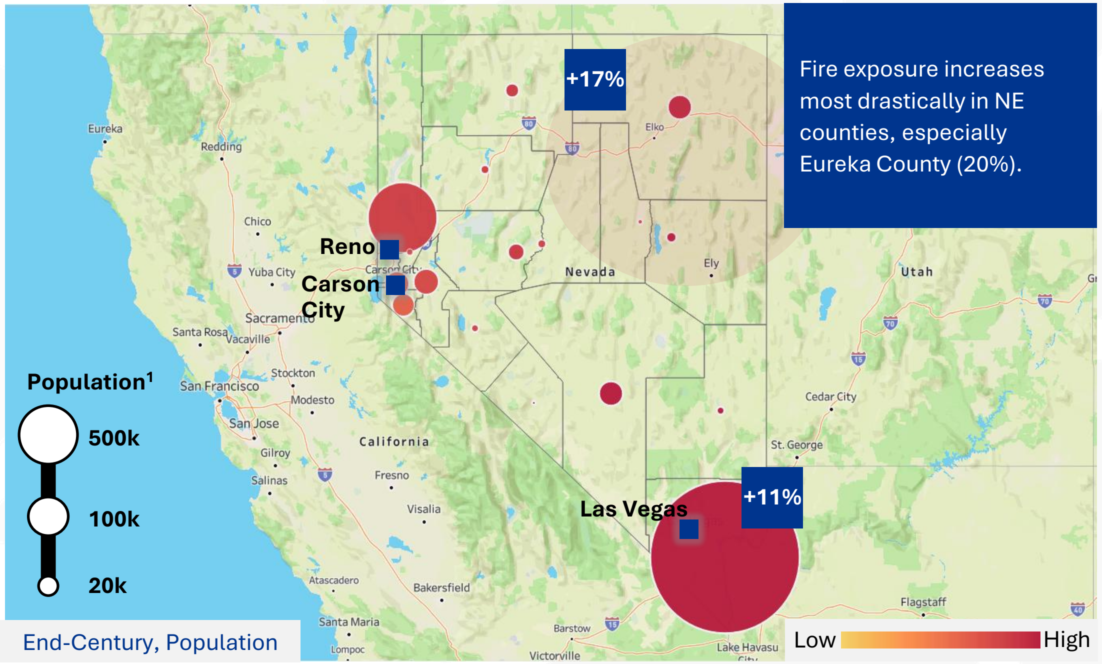
Asset Analysis

NVGOE could ensure that wildfire mitigation projects are effectively addressing high exposure in Clark County, but also encourage utilities to consider upgrades to radial Dx lines

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



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



KEY OBSERVATIONS

- Historical **wildfire exposure is concentrated in Nevada's southern counties,** but summer FWI levels are relatively high across the state.
- Rural **customers in Nye and Lincoln Counties could be particularly exposed** because they are more likely to be served by long, radial Dx lines.
- Prevalence of **undergrounding, vegetation management, and monitoring** proposals indicate alignment with exposure.

KEY OBSERVATIONS

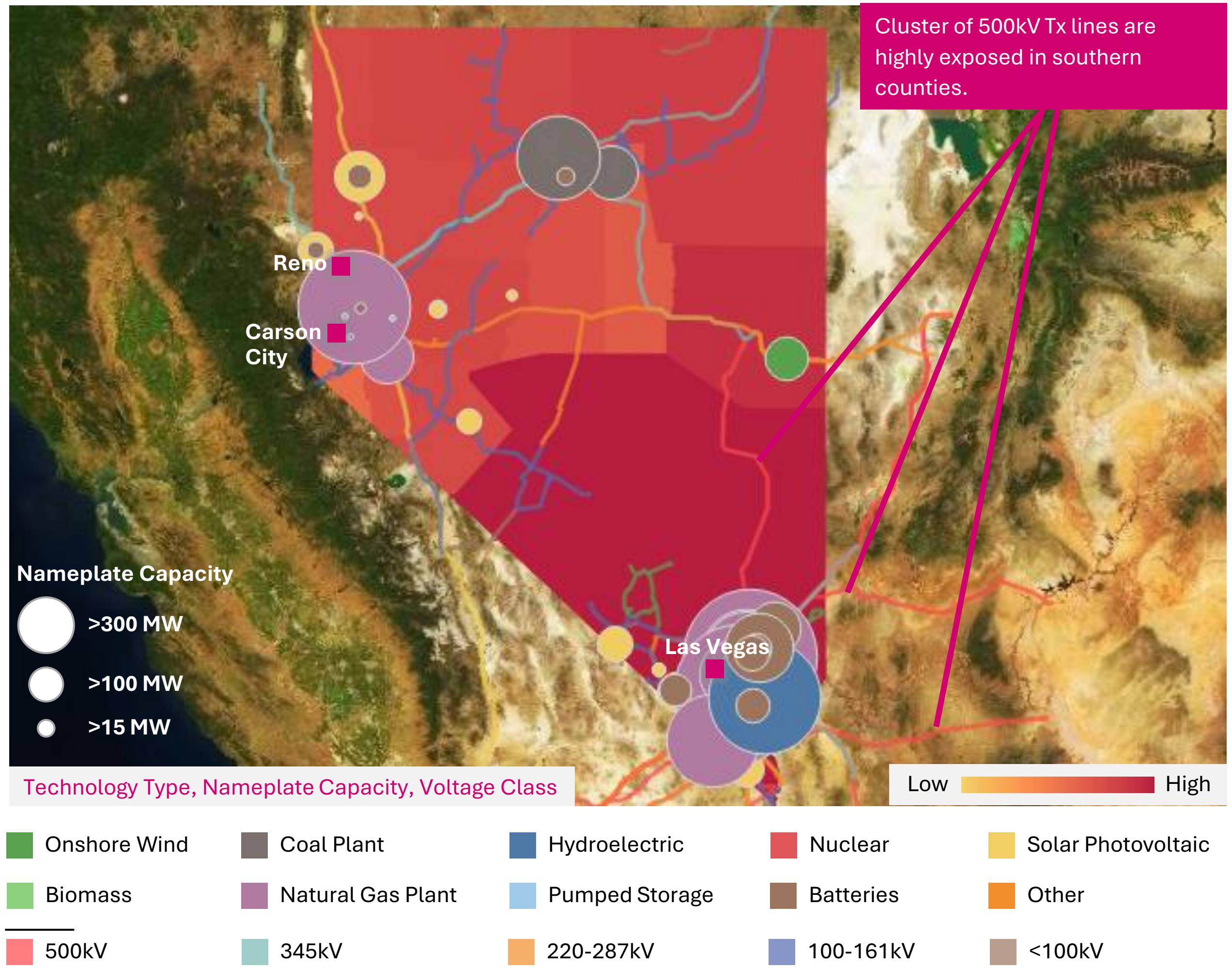
- FWI increases by about 10-20% across the state by end-century, demonstrating the importance of utilizing **forward-looking climate projections for state-wide fire mitigation planning.**

Clark County Largest population center in the state faces peak statewide fire exposure, posing a threat to a large volume of Dx assets.

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

NVGOE could consider Tx hardening for crucial import/export lines in S counties and last mile lines in exposed rural areas, as well as projects addressing wildfire-related access issues

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



Source: ClimRR, EIA860, HIFLD

Key Highlights	Analysis
Transmission	• **HV import/export lines in Clark and Lincoln counties could be prioritized for hardening upgrades** given their critical role in electricity transfer during extreme weather events. • Last mile Tx lines are crucial for rural customers, and are heavily exposed in Nye, White Pine, and Esmeralda Counties. • NVGOE could consider ensuring vegetation management of ROWs remains maintained.
Renewables	• Solar assets in Nye and Clark counties face high levels of wildfire exposure. • Soot and ash from burns **decrease capacity factors for solar assets by decreasing irradiance.**
Restoration	• Wildfire causes **ingress/egress issues** through destruction of roads and transportation, slowing restoration times for all assets. • NVGOE could **consider funding projects addressing wildfire-related access issues** given its impact across all asset classes and new data to act on from monitoring initiatives.

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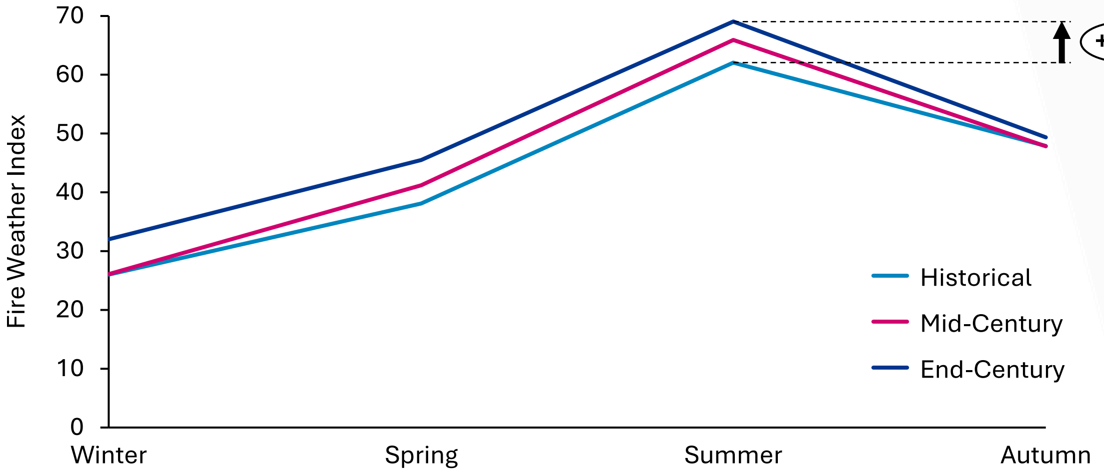
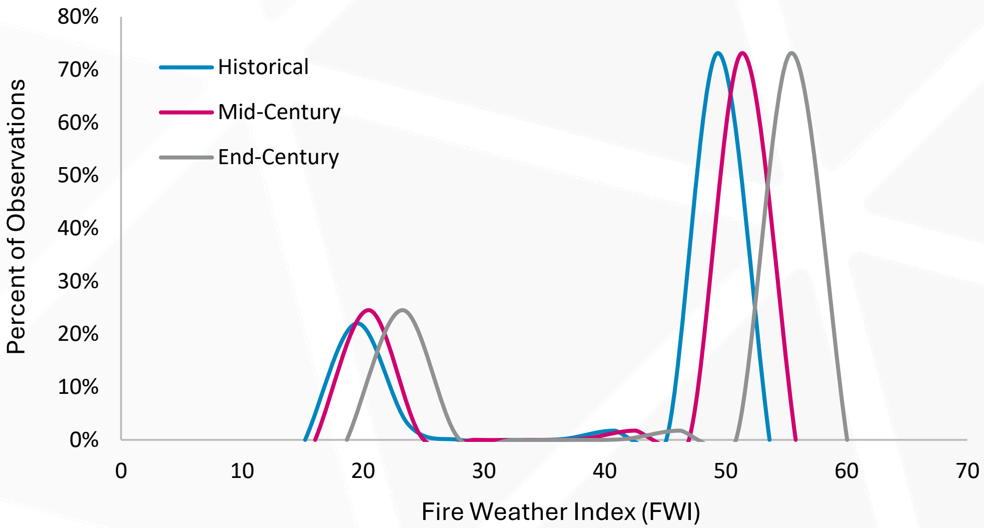
Nevada wildfire season is projected to increase both in duration and severity over time, with the most significant pocket of risk consolidated in Clark County

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



Nevada 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 between spring and autumn by about 11% from historical FWI.
- Elevated wildfire exposure around the summer suggests a **lengthening of the wildfire season** combined with an **increase in severity.**
- The change in length of wildfire seasons suggest that **the window for scheduled maintenance during the shoulder seasons is diminishing.**

KEY OBSERVATIONS

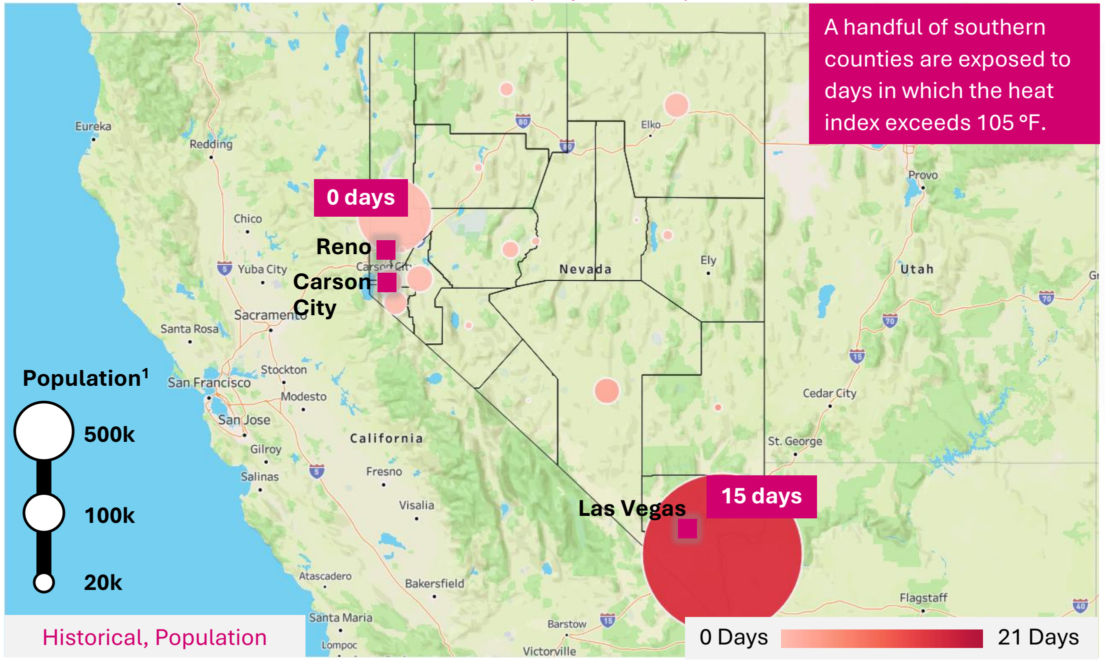
- Rightward shift of the curve **indicates increasingly severe wildfire exposure across the state over time.**
- Peak around 50-60 FWI **indicates increasingly severe exposure for Clark County,** dominating the percent of observations due to high population.
- Despite the concentration of exposure in Clark County, NVGOE could also **consider exposure in less populated regions clustered around 20 FWI,** which becomes significantly **more severe by end-century.**

Heat

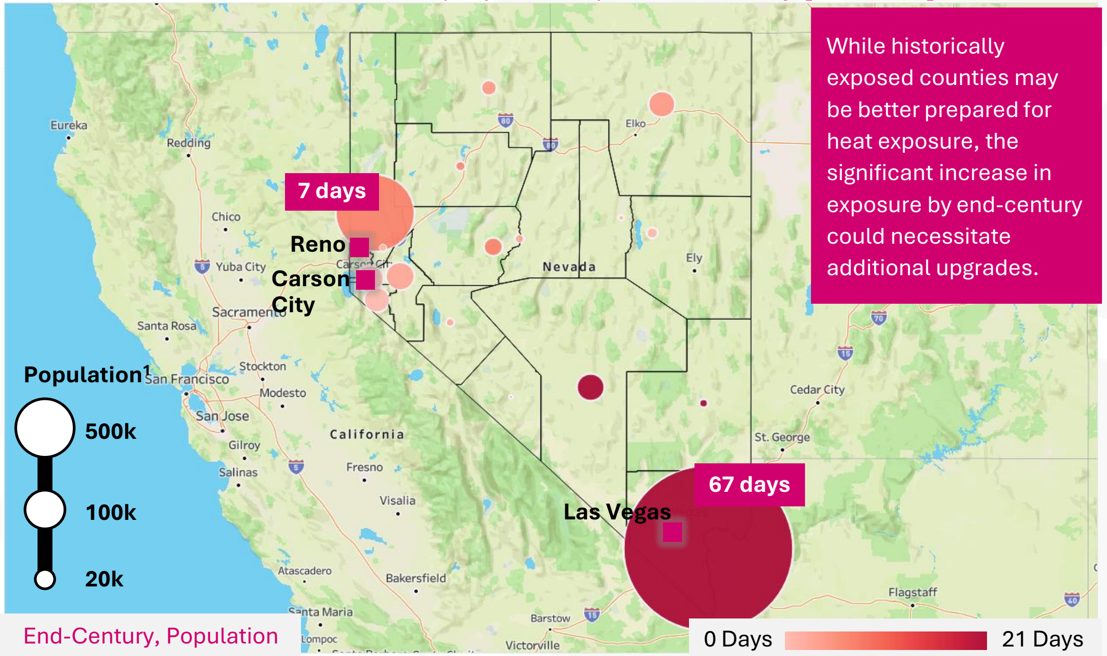
Asset Analysis

NVGOE could prioritize substation, transformer, and Dx line upgrades to combat increasing heat exposure, especially in areas with limited redundancy and high load growth

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



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



KEY OBSERVATIONS

- Currently T_x and D_x assets in Nye, Clark, and Lincoln Counties have **exposure to days above 105 °F.**
- 105 °F is a particularly important threshold for distribution assets and substations, **which can fail when exposed to two consecutive days above 104 °F.**[2]

KEY OBSERVATIONS

- Southern counties are expected to face **about 40-70 days >105 °F annually, causing high asset utilization, derating, and potential failure.**

Washoe County The increase from 0 to 7 days of extreme heat exposure necessitates substation, transformer, and Dx line upgrades, especially if nighttime temperatures warm.

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

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

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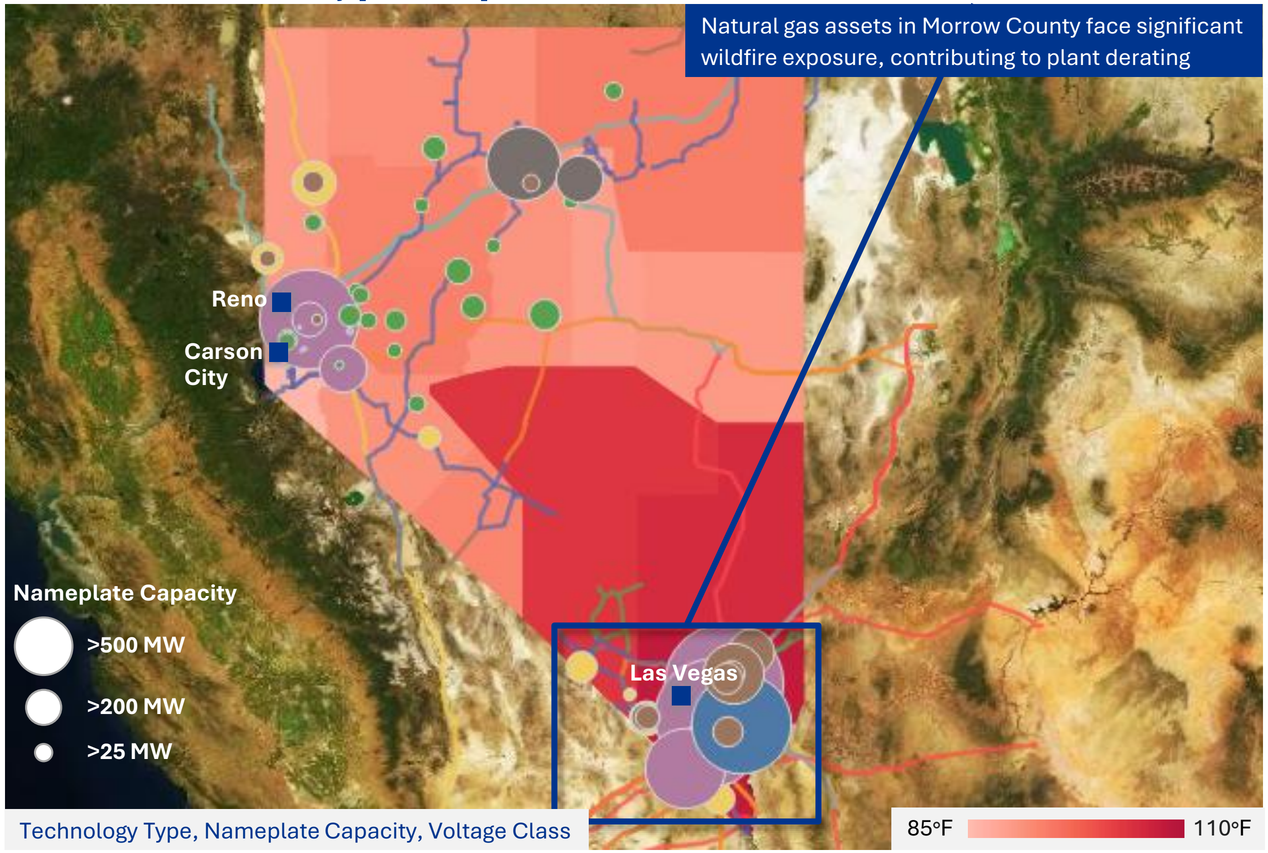
NVGOE could prioritize cost-effective line upgrades, GETs, deployment of DERs, and vegetation management to combat supply derating and line sag resulting from extreme heat

Nevada 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. • NVGOE could explore additional DER deployment for flexible supply.
Solar & BESS	• Solar assets in Clark and Nye counties are significantly exposed to extreme heat, contributing to **production derating** at temperatures above 77°F. • High temperatures accelerate BESS degradation, making premature failure more likely.
Transmission	• A cluster of MV/HV lines are exposed to high levels of extreme heat in Clark County, which can cause capacity derates and line sag. • Undergrounding, vegetation management, and line upgrades proposals address these issues, but NVGOE could also **consider dynamic line rating (DLR) to combat Tx derating.**

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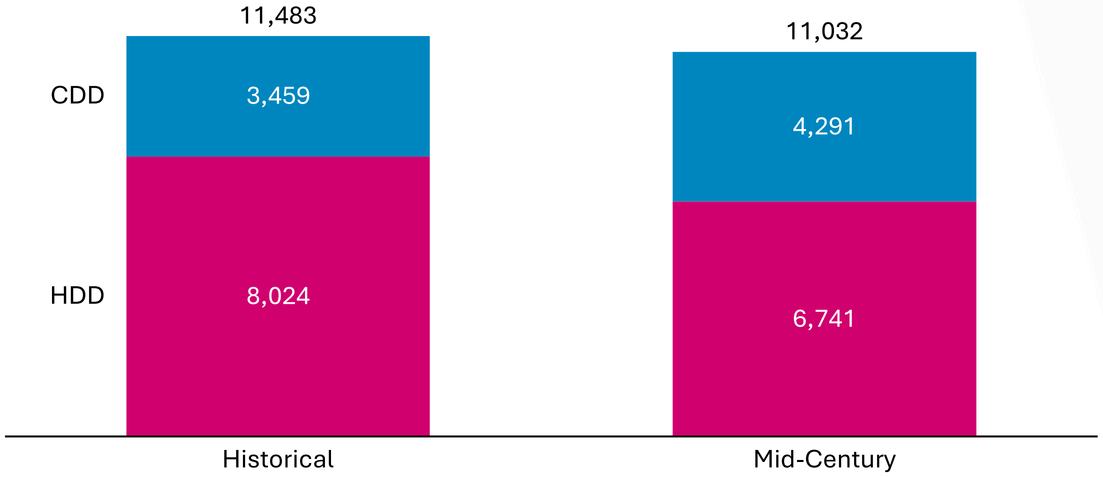
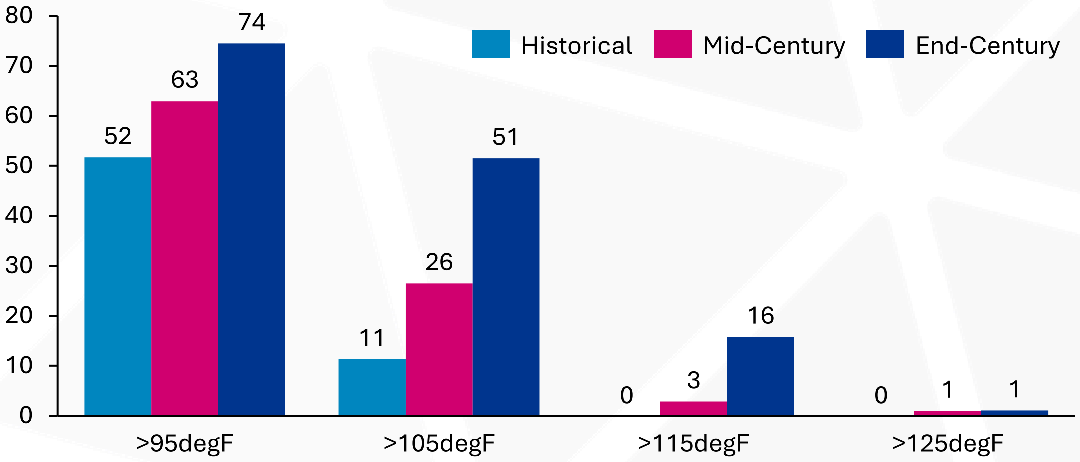
Warming temperatures in NV will contribute to derating, capacity violations and substation failure, indicating the need for distribution asset upgrades in historically unexposed counties

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



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



KEY OBSERVATIONS

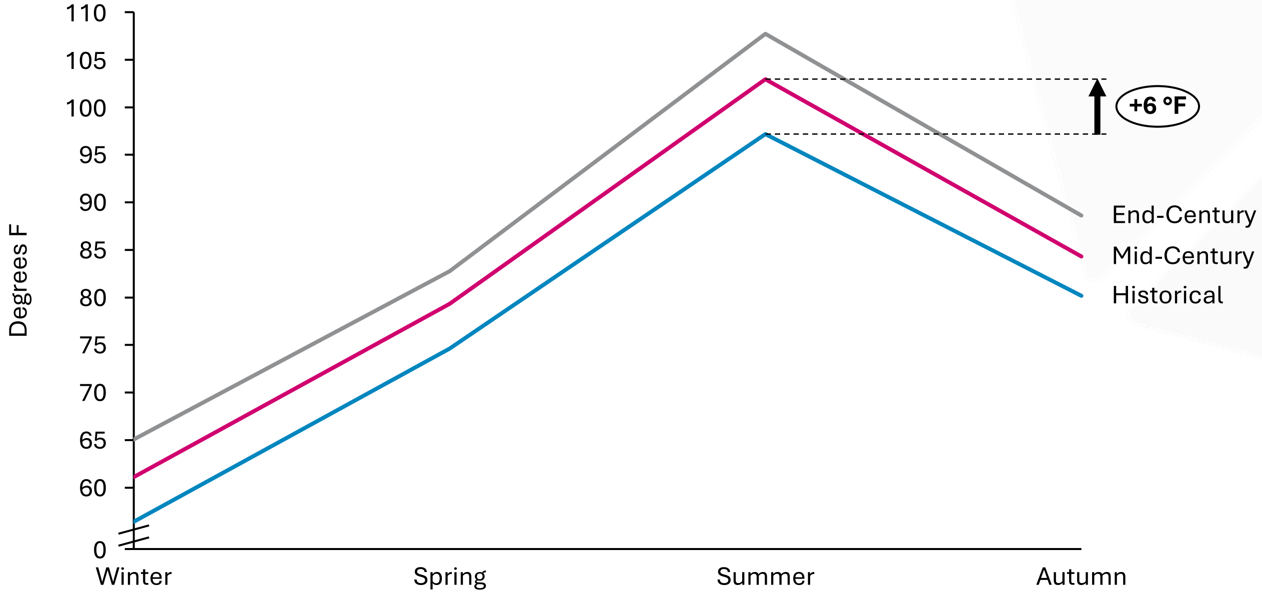
- Between historical and mid-century, **the ratio of CDD to HDD increases** from about 30% to 38%.
- This results in **increased summer asset utilization and degradation**, but **impacts to winter utilization remain unclear** depending on heating electrification trends.
- Given that the most significant warming occurs in the summer (see next slide), the **additional CDD will most likely occur during times of peak demand, putting additional strain on the system.**

KEY OBSERVATIONS

- Historical extreme heat exposure indicates that infrastructure may already be rated for high temperatures, but **counties that do not have historic exposure should consider Dx substation/line upgrades given warming.**
- 5x increase in days > 105 °F by end-century will **accelerate Dx asset aging, cause derates across all asset classes, and pose a substantial risk of direct failure to Dx substations.**
- NVGOE could monitor the timing of extreme heat, as **warmer nights shorten asset cooldown windows and could contribute to failures.**

Average summer temperature maxes are projected to increase by mid-century, increasing the duration and magnitude of high system utilization and posing a threat of failure to Dx assets

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



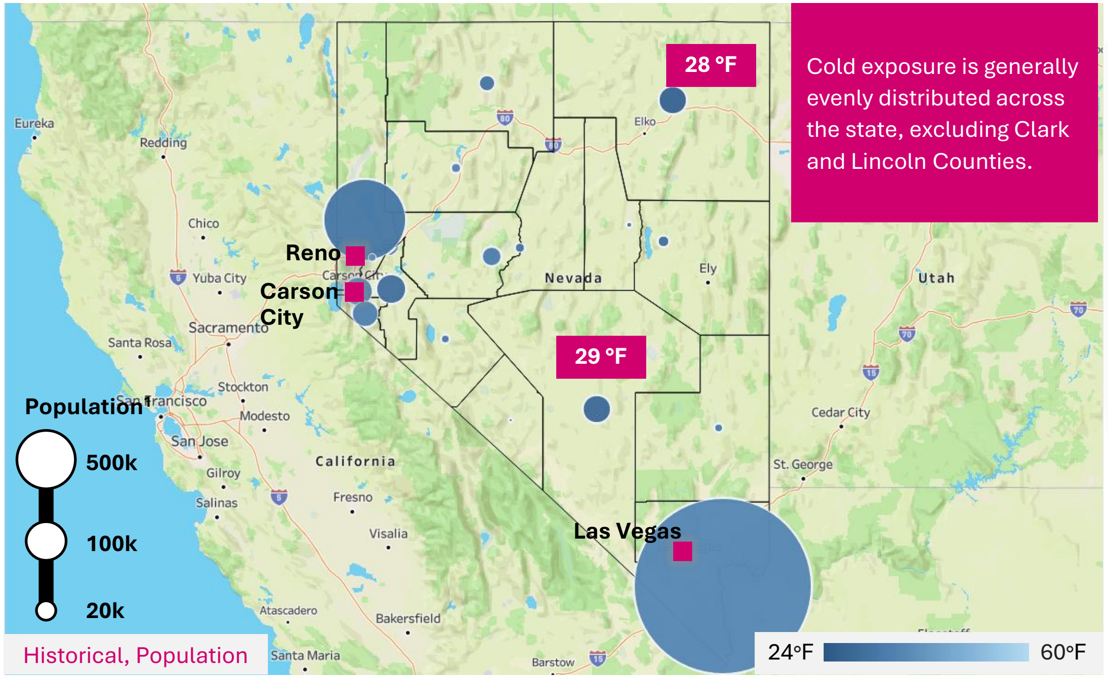
Key Highlights	Analysis
Summer Warming	• **Heat risk increases most drastically in summer**, with a 6 °F increase in the average seasonal max by mid-century, **increasing system utilization and degradation.**
Shorter Shoulder Seasons	• Less pronounced warming in shoulder seasons, although increased autumn maximums could **extend the duration of high system utilization and shorten maintenance windows.**
Extreme Temperatures	• Summer average temperatures above 100 °F by end-century poses a risk of **direct failure to Dx substations and feeder transformers without cooling systems or redundancy.**

Cold

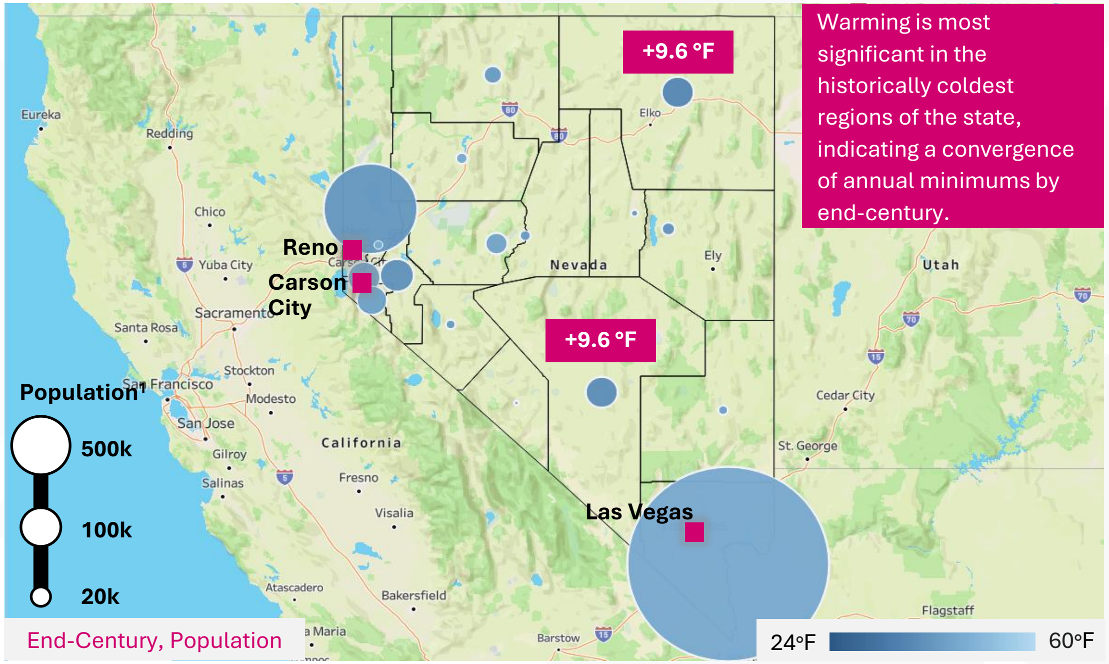
Asset Analysis

NVGOE could continue to fund Dx asset hardening given continued near-freezing annual minimum temperatures and ensure that investment is aligned with geographic cold exposure

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



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



KEY OBSERVATIONS

- Cold exposure is generally evenly distributed throughout the state, but **peak exposure lies in Elko County.**
- Prevalence of proposals including undergrounding, pole/line upgrades seems to address extreme cold exposure, but **NVGOE could consider prioritizing Elko and Nye Counties for future awards.**

KEY OBSERVATIONS

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

Elko County — Elko County is exposed to average annual minimum temperatures of about 37 °F, indicating potential **freezing exposure for Dx assets across the year.**

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

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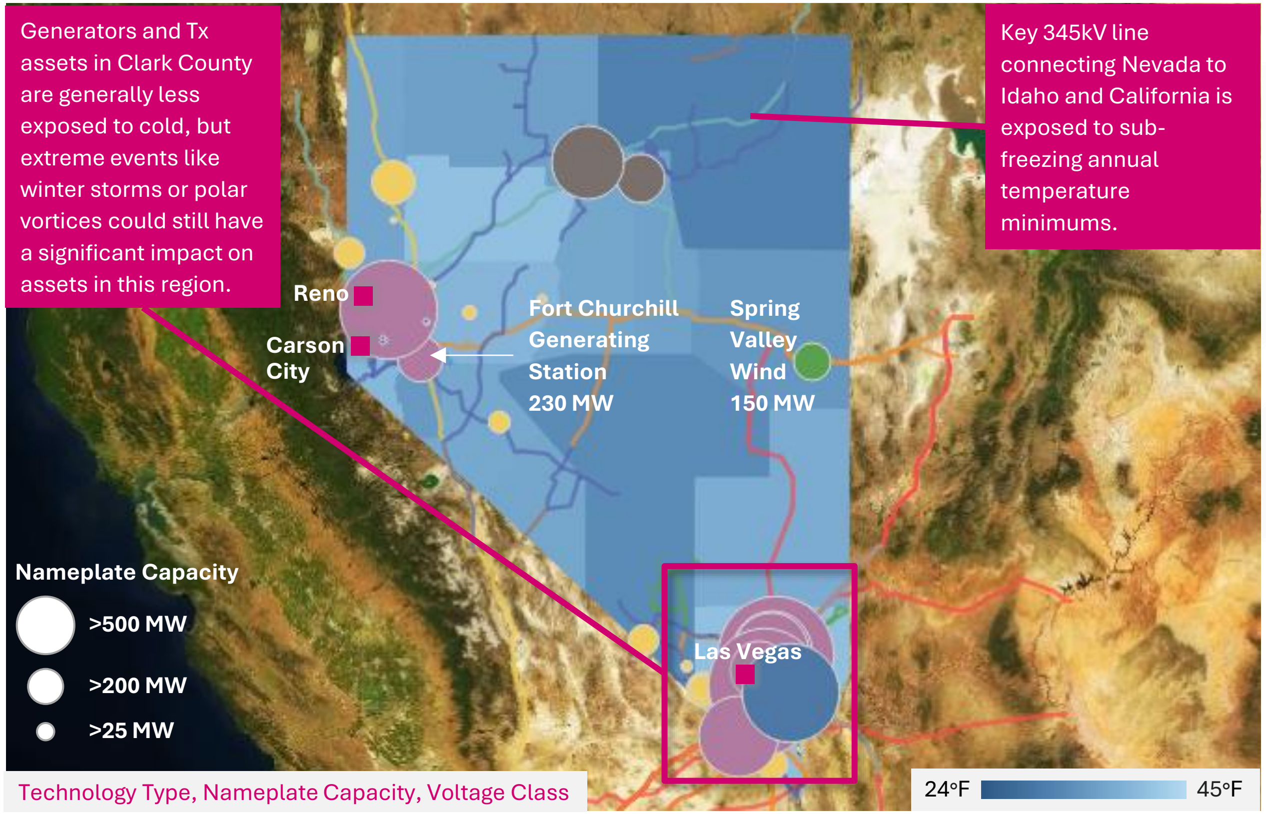
NVGOE could consider resilience upgrades to gas plants and pipeline systems to combat cold exposure, as well as continued transmission hardening addressing freezing

Nevada Average Annual Minimum 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
Transmission	• Despite warming, the **prevalence of near-freezing annual minimums** in many counties contributes to **Tx freezing/icing risk.** • A 345kV line is exposed to annual minimums under 31 °F in Elko County, **posing a threat of direct failure or line galloping when coincident with high wind speeds.** • NVGOE appears to be addressing this issue through pole replacement, undergrounding, and line upgrades, but could **also consider Tx structure reinforcement.**
Natural Gas	• Fort Churchill Generating Station in Lyon County is exposed to average annual minimums of 34°F, which could cause **ignition failure or performance issues.** • **No proposals addressing aging gas infrastructure**, which requires hardening or replacement to mitigate cold exposure.
Wind	• Spring Valley Wind in White Pine County faces cold exposure that contributes to **asset failure and ice throw.**

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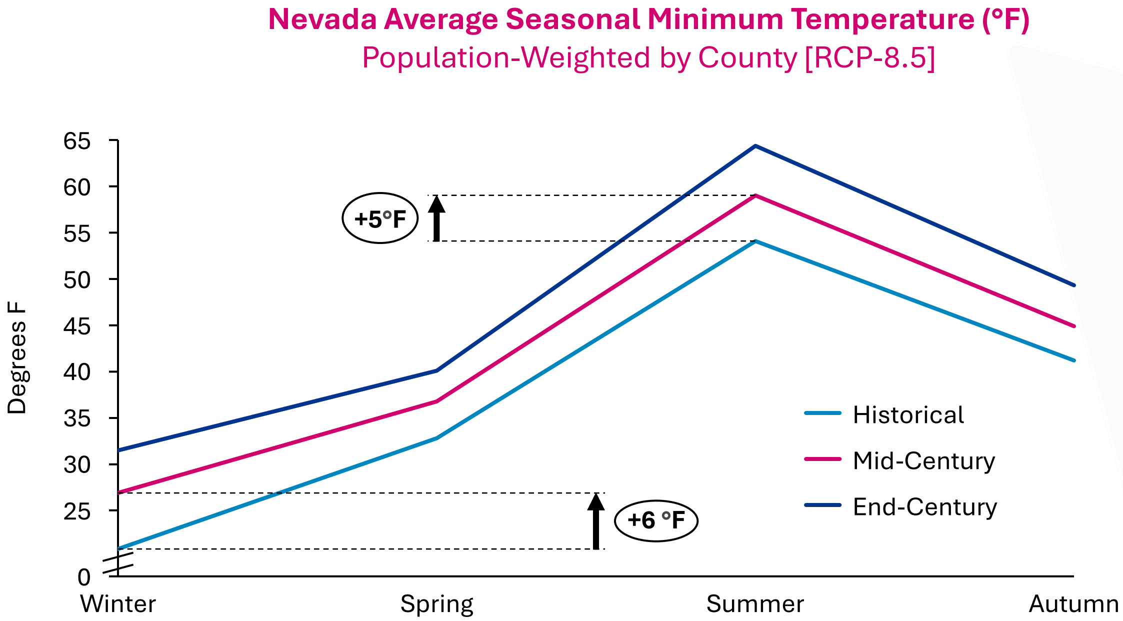
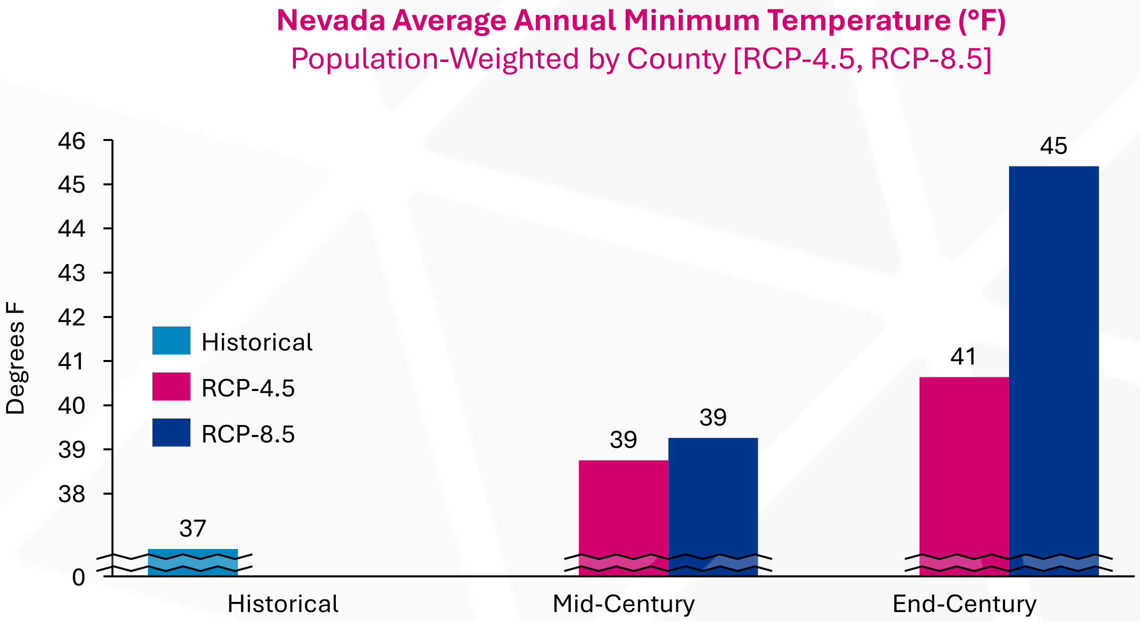
Despite warming, winter minimums remain below freezing, indicating that NVGOE could consider additional adaptations to address cold exposure





KEY OBSERVATIONS

- Significant winter warming (+6 °F by mid-century) will decrease overall heating load, but the **impact on electricity demand ultimately depends on the speed of heating electrification.**
- End-century winter minimums remain below 32 °F, indicating that **freezing and icing exposure persists despite warming.**
- Proposed projects address cold exposure through weatherization and pole upgrades, but **NVGOE could also consider asset enclosures.**

KEY OBSERVATIONS

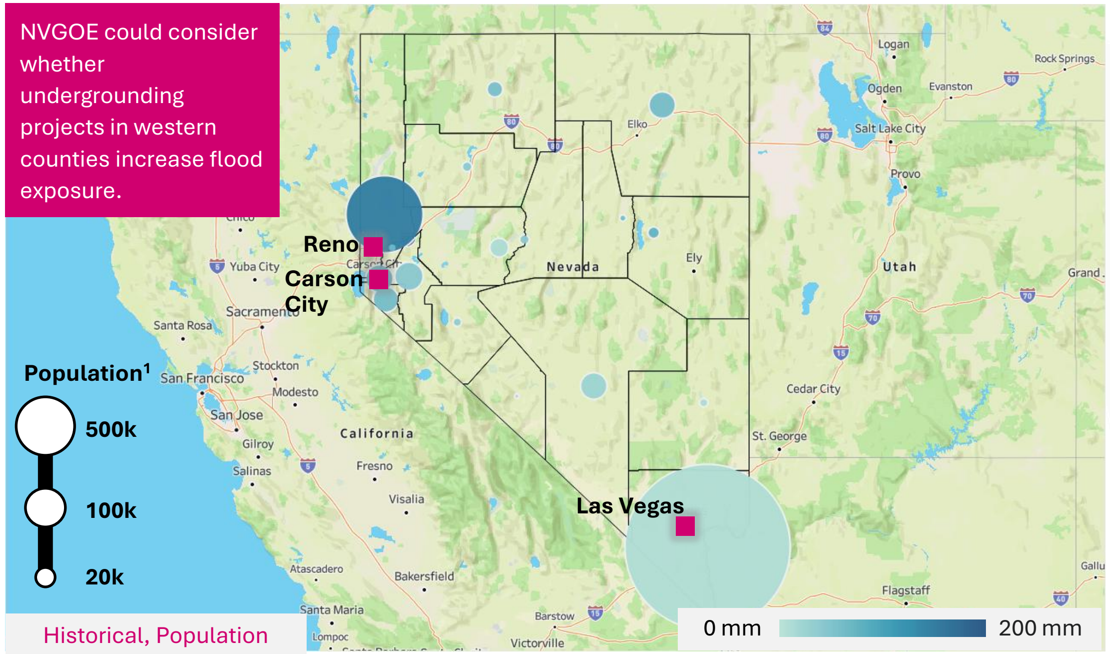
- ~5% increase in average annual temperature minimums by mid-century indicates a reduction in heating load.
- Diverging temperature projections by end-century demonstrates projection uncertainty and the importance of continued monitoring.
- Regarding extreme cold, global climate models do not resolve for extreme cold events like polar vortexes, so **assets could still face similar levels of exposure to cold-related failures.**

Flood

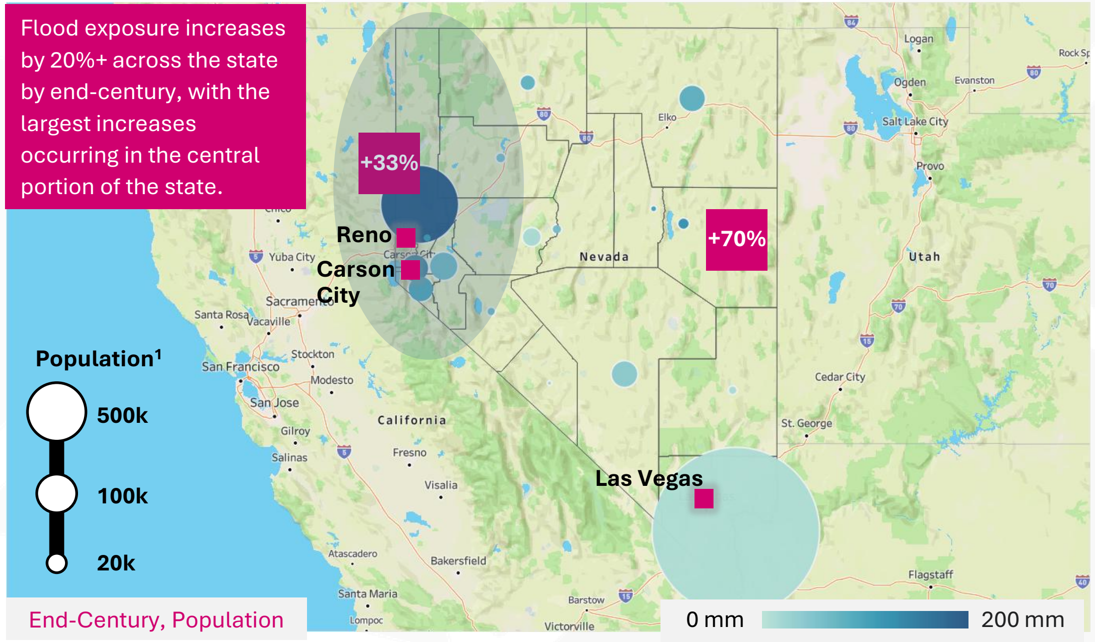
Asset Analysis

NVGOE could consider funding projects to fortify substations in western counties given the high volume of assets exposed to increasingly severe flooding

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



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



KEY OBSERVATIONS

- Most flood exposure lies in the **western counties** given their higher precipitation levels and proximity to bodies of water.
- Lower elevation of NW counties **increases the likelihood of unfortified Dx substation flooding.**
- Currently no proposed projects explicitly address flood exposure.

KEY OBSERVATIONS

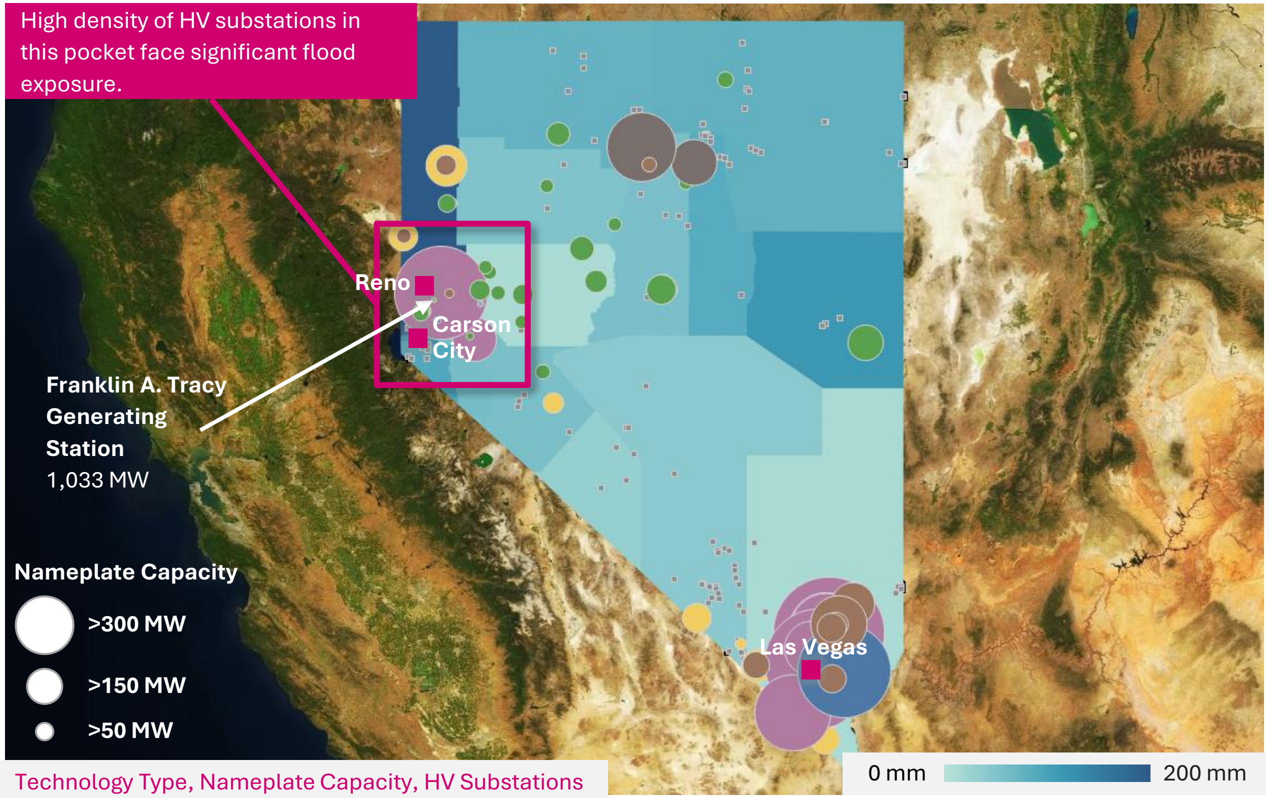
- NVGOE could consider funding projects to fortify low-lying Dx substations in western counties given increased exposure and high volume of assets.

Washoe County — **Washoe County is highly populated and faces peak state flood exposure**, posing a substantial threat to a high density of substations and distribution poles.

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

NVGOE could prioritize substation fortification for Washoe and Douglas Counties as well as Carson City given their high density of HV substations and high levels of flood exposure

Nevada Average Annual Surface Runoff (mm/year)
Generators, Mid-Century [SSP5-8.5]



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

Key Highlights	Analysis
Substation	• High voltage substations will be exposed to pluvial flooding if located in flood plain or riverbank without necessary protections. • High density of **HV substations in Washoe and Douglas Counties are heavily exposed to flood risk**, marking a priority for future hardening projects.
Restoration	• Flooding causes **ingress/egress complications** by washing out access roads, contributing to restoration issues. • Flooding can **affect on-site buildings or facilities**, making it more difficult to maintain adequate staffing for oversight and restoration.
Generators	• Solar and battery facilities in Washoe County are significantly exposed to flooding, which can inundate critical electronics and cause failure. • Franklin A. Tracy Generating Station in Storey County is exposed to flood, which can cause auxiliary equipment to fail and damage control houses.

Source: ClimRR, EIA860, HIFLD

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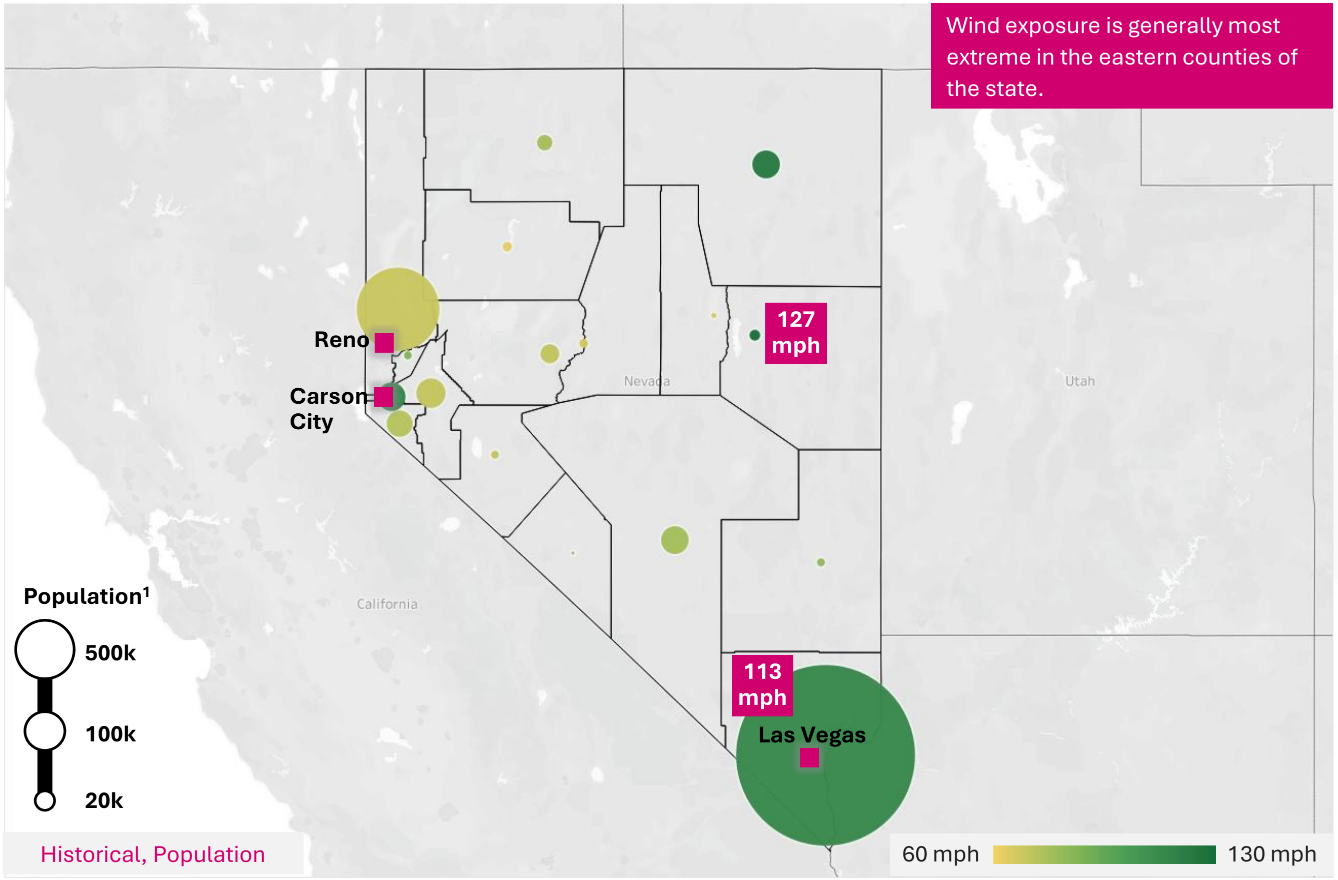
Wind

Asset Analysis

NVGOE is addressing wind exposure through pole upgrades, vegetation management, and undergrounding, but they could improve prioritization based on geographic exposure

Nevada 100-year Wind Speed (mph)
Historical

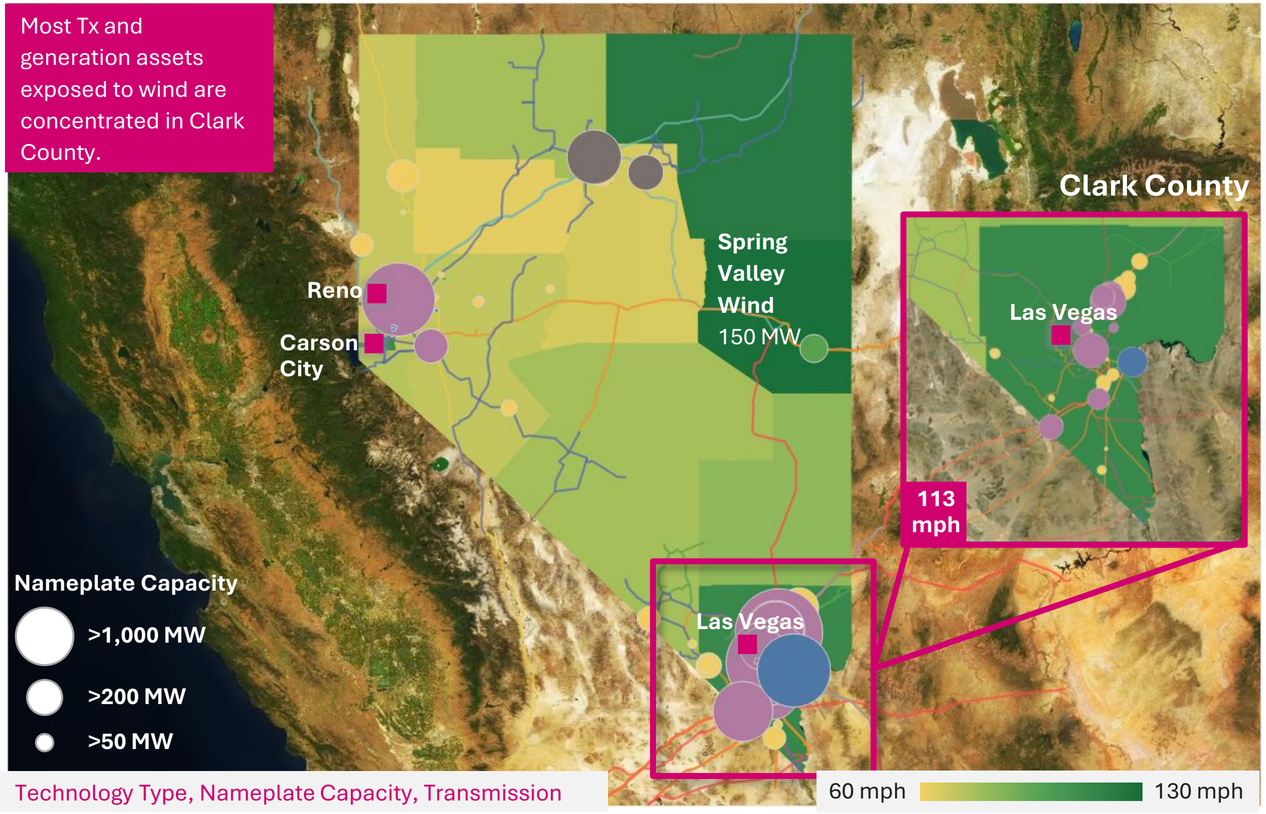


Key Highlights	Analysis
Distribution	• Given weak climate signals, wind speeds are derived using historical data and do not vary at high spatial resolution. • Rather than targeted investments, wind exposure should be addressed through **upgraded design standards** across a utility service territory.
Clark County	• Clark County has a population of approximately 2.3M and 100-year return value of 113 mph, **indicating a high exposure area for Dx assets**. • Coincident fire exposure poses a threat of significant fire spread in the county.
White Pine County	• **White Pine County** has the highest return value of 127mph, indicating high failure likelihood lower class poles. • Although there might be less volume of Dx infrastructure, **remote customers are at significant risk of prolonged outages,** especially if they are served by long, radial Dx lines.

Source: DRI, EIA860, HIFLD

HV transmission lines in Clark County could be prioritized for mitigation investment given their critical import/export capacity with neighboring supply centers

Nevada 100-year Wind Speed (mph)
Historical



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

Source: DRI, EIA860, HIFLD

Key Highlights	Analysis
Transmission	• A cluster of MV-HV transmission lines in the Clark County are exposed to high historical wind speeds. • These lines tie Nevada to California, Arizona, and Utah, and are critical for **import/export capability** during extreme weather events. NVGOE could focus on reinforcing Tx structures to mitigate risk.
Solar	• Many solar farms in Clark County are historically exposed to wind speeds are 113 mph at the 100-year return period. • Depending on OEM, solar panels are only rated to 90mph, **indicating need for rack reinforcement and vegetation management.**
Wind	• Wind farms cutout speeds can vary between 45-70mph, indicating that in high wind speed events, there the turbines stop producing. • Spring Valley Wind in White Pine County is exposed to 100-year return period values far greater than the cutout threshold, impacting **critical supply for remote customers.**

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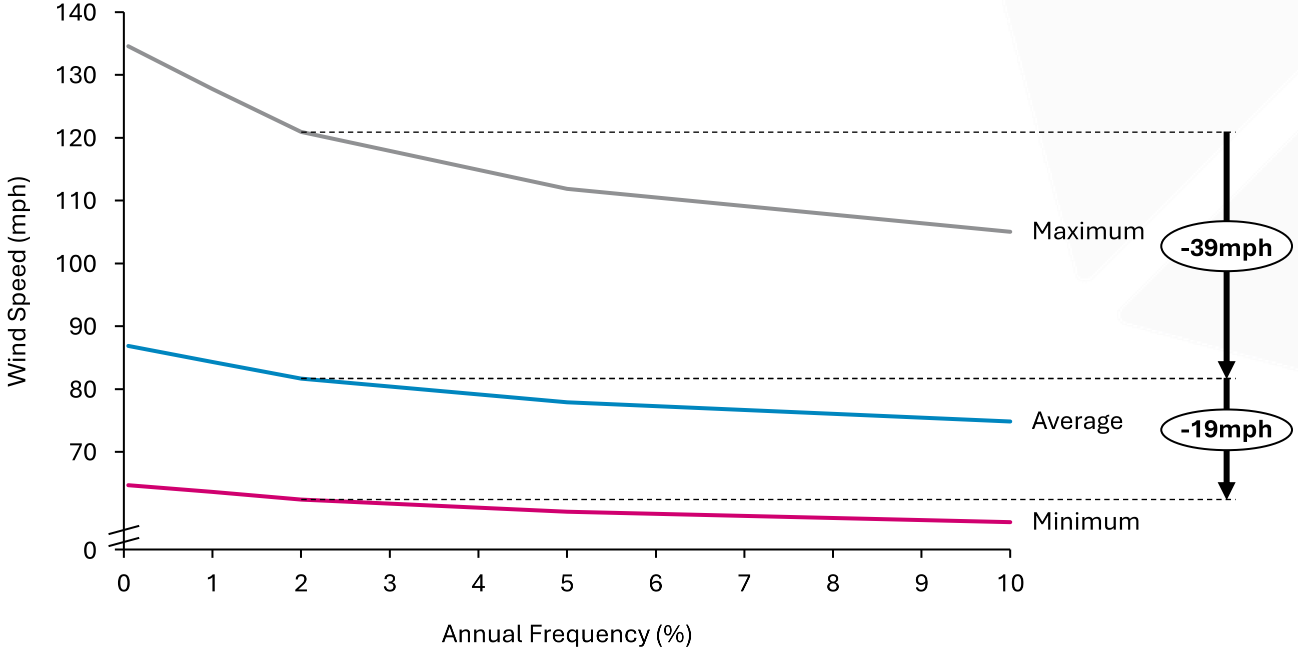
Baringa

Historically, there is a 1% chance that the average wind speed seen across Nevada counties is ~85mph annually.

Nevada 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 Nevada counties is ~85mph annually. • The 10% annual likelihood drops to 75mph, indicating high system wind speeds are common across counties.
Volatility Across Counties	• There is a wide band between the maximum and minimum counties around the mean. • This indicates that wind adaptations should be focused on a county basis rather than over large service territories.

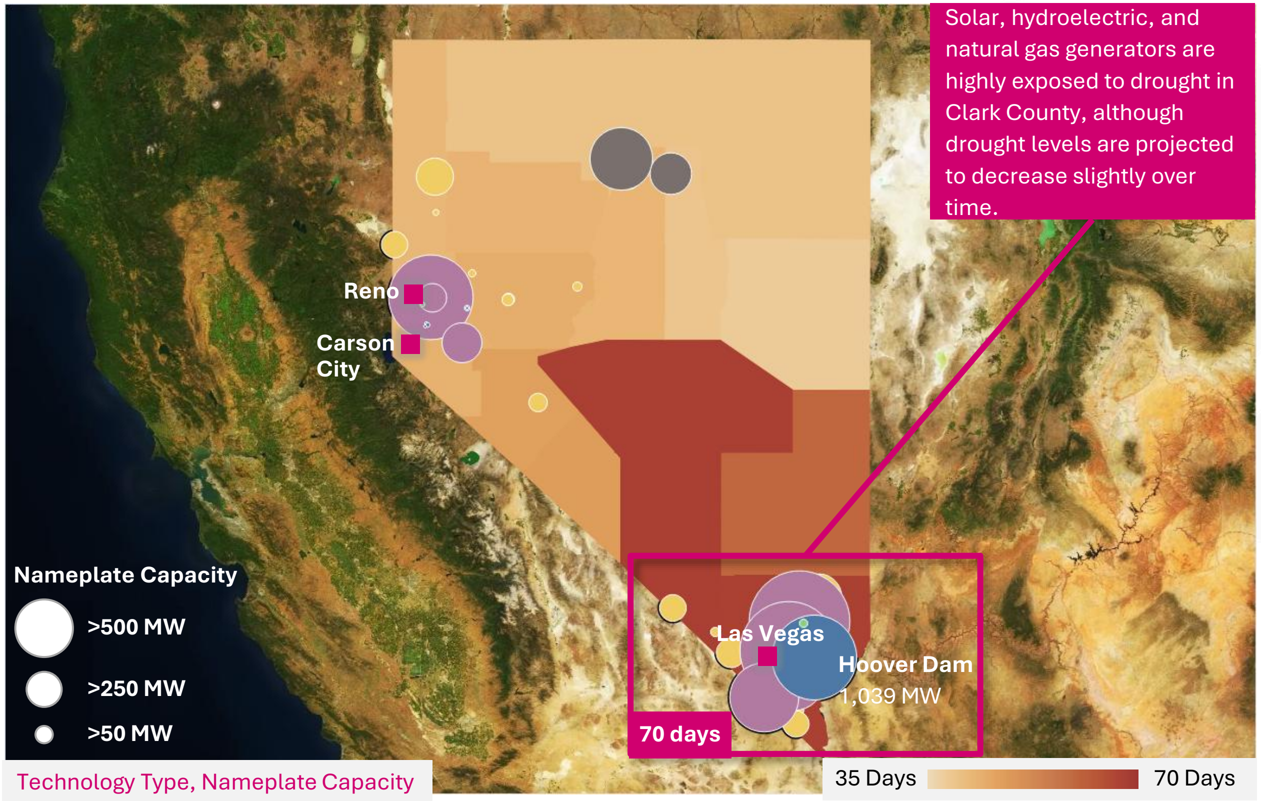
DRI

Drought

Asset Analysis

Drought exposure increases could justify increased data collection for hydroelectric production forecasting and innovative cleaning/cooling solutions for solar and natural gas

Nevada Consecutive Days No Precipitation
Generators, Mid-Century [RCP5-8.5]



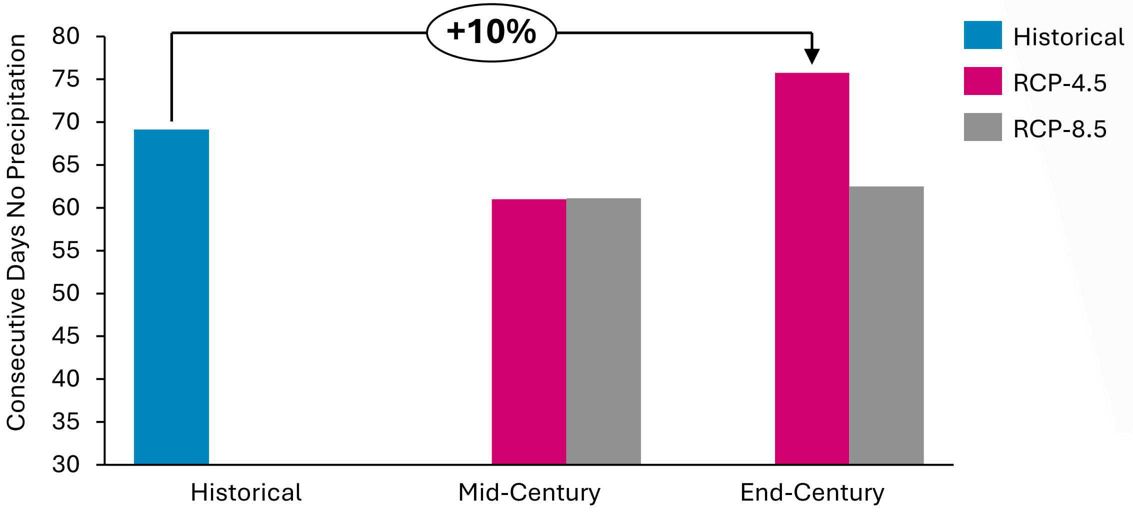
Onshore Wind	Coal Plant	Hydroelectric	Nuclear	Solar Photovoltaic
Biomass	Natural Gas Plant	Pumped Storage	Batteries	Other

Key Highlights	Analysis
Hydroelectric	• **The Hoover Dam in Clark County is exposed to peak statewide drought levels,** which could decrease electricity production. • While drought exposure is projected to decrease slightly in the county over time, **asset owners and grid operators could consider upstream conditions and water demand trends** which also influence production levels.
Natural Gas	• In arid conditions, **air intakes for CCGTs and CTs can clog and degrade** due to dust and sand particles, decreasing efficiency and longevity of generator. • Lack of water availability can **reduce natural gas cooling ability**, resulting in power production curtailments.
Renewables	• Drought conditions cause dust buildup on solar panels, hurting capacity factors. • In areas that also have high wildfire exposure, **panel cleaning projects address two hazards simultaneously.**

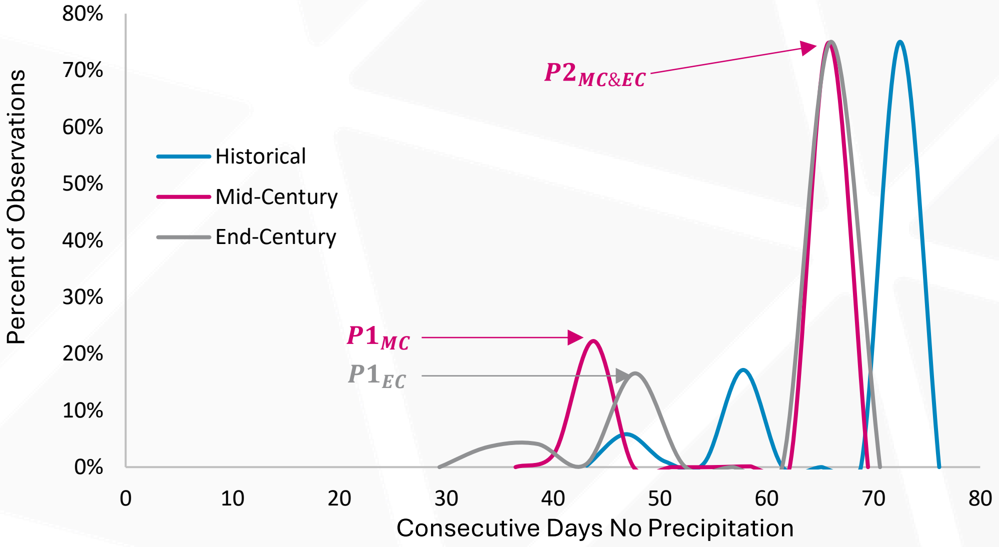
Source: ClimRR, EIA860, HIFLD

Drought exposure is projected to decrease slightly under most warming scenarios and time horizons, but NVGOE could continue to monitor exposure given variation in projections

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



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



KEY OBSERVATIONS

- **Drought exposure increases by ~10% by end-century** (under RCP 4.5), contributing to potential asset cooling failures and decreased hydroelectric production.
- Lower drought exposure for RCP-8.5 than RCP-4.5 by end-century demonstrates that **drought risk does not scale linearly with temperature** increase and could be monitored closely over time, especially by hydroelectric asset owners.
- ***Average metrics may not capture extreme events.***

KEY OBSERVATIONS

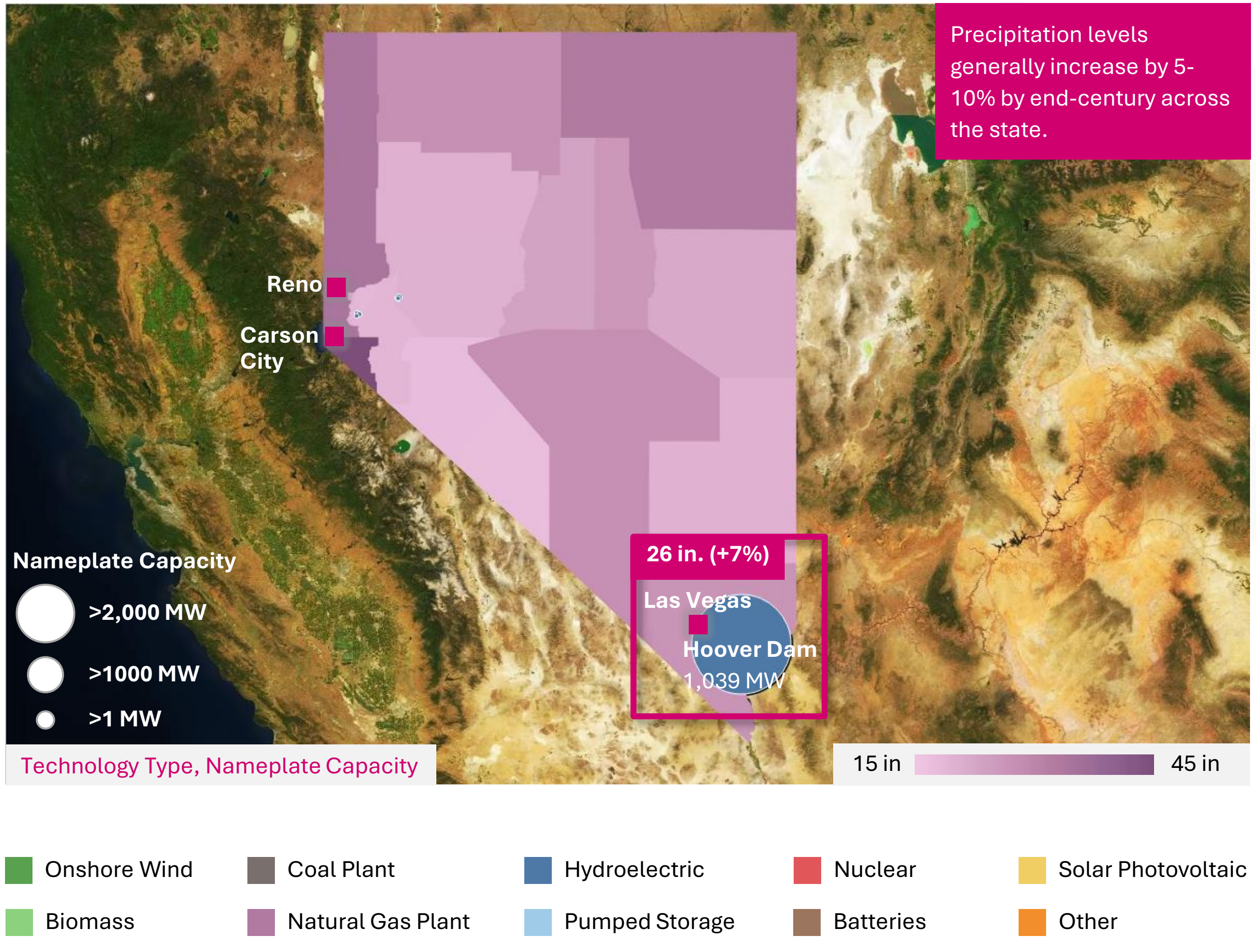
- The leftward shift of the curve over time indicates a **mild decrease in drought exposure across the state under RCP 8.5.**
- The shift from a tri-modal to bi-modal distribution indicates a **convergence of exposure into two climate zones by mid-century.**
- The larger leftward shift of P1 than P2 indicates **drought exposure decreases more significantly in rural regions than Clark County.**
- Given variations in drought exposure over different warming scenarios, **NVGOE could continue to monitor the trajectory of drought over time.**

Precipitation

Asset Analysis

NVGOE could consider the impacts of precipitation timing, upstream conditions, and changing snow patterns to better forecast electricity production from the Hoover Dam

Nevada Annual Max Precipitation (in)
Generators, Mid-Century [RCP5-8.5]



Key Highlights	Analysis
Timing	• Timing of precipitation has an important impact of hydro output. • Extreme rainfall events may overflow reservoirs and put more pressure on dams, increasing risk of failure. • Projections of increased annual precipitation indicate that **extreme precipitation events may become more likely over time.**
Upstream Coordination	• **Upstream precipitation and drought** will have significant impacts on hydro production. • NVGOE could **establish a relationship with SEOs from AZ, CO, and UT** to share information about precipitation conditions and hydro output along the Colorado River.
Changes to Snow Patterns	• While precipitation levels remain relatively constant to mid-century, precipitation type and timing is likely to change and could be monitored. • Grid operators could **consider the impacts of less snow and earlier snow melt when conducting long-term planning.**

Source: ClimRR, EIA860, HIFLD

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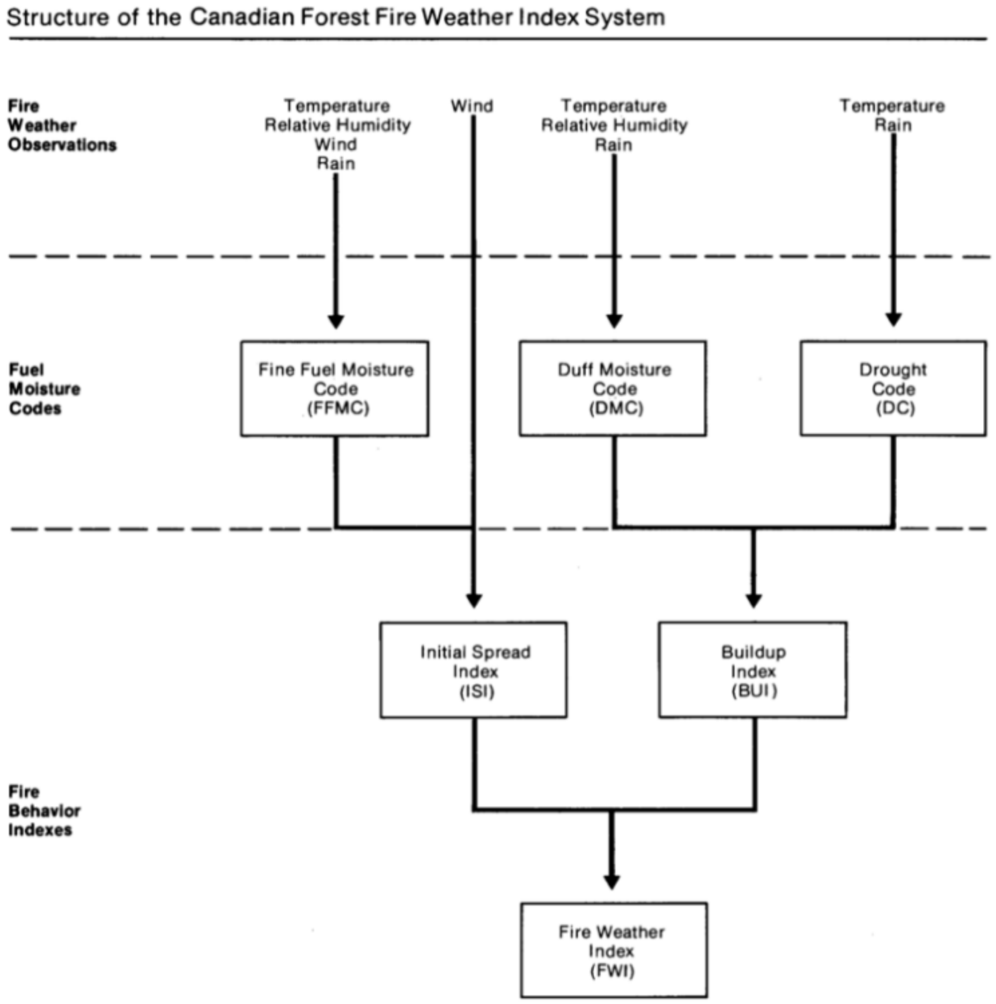
Appendix

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

