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Grid Resilience Reports

New Mexico

Energy & Resources | Networks
11/18/24

Table of contents

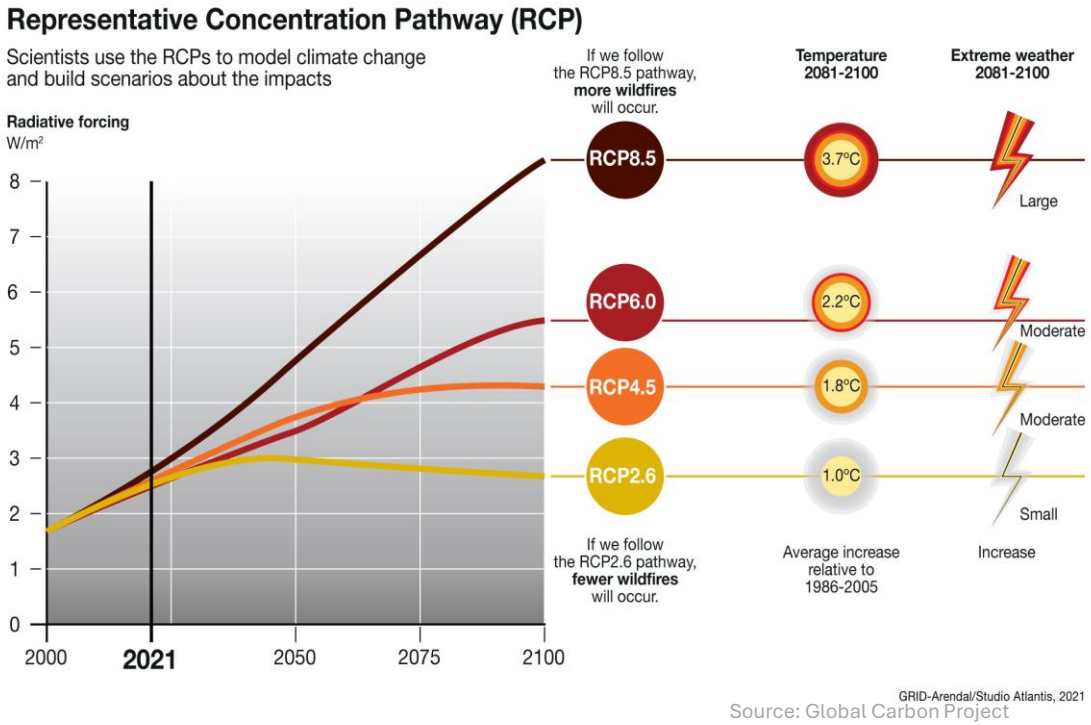
Grid Resilience Reports

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.



Source: Global Carbon Project

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			

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

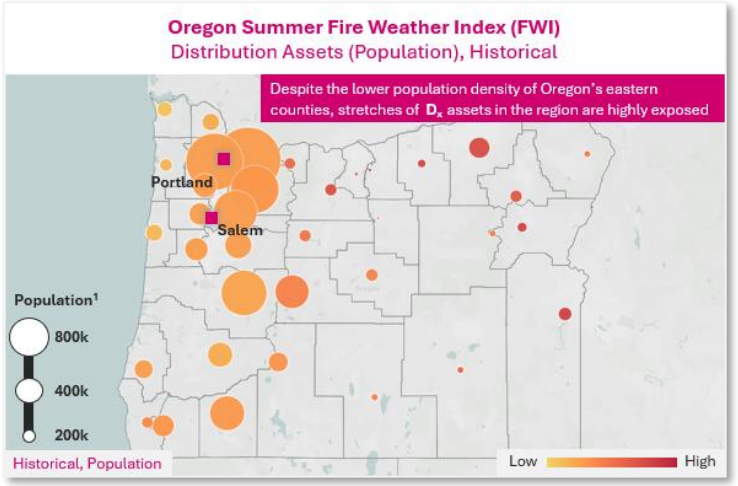
Output: Input metrics applied from a grid cell level to a county level

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)

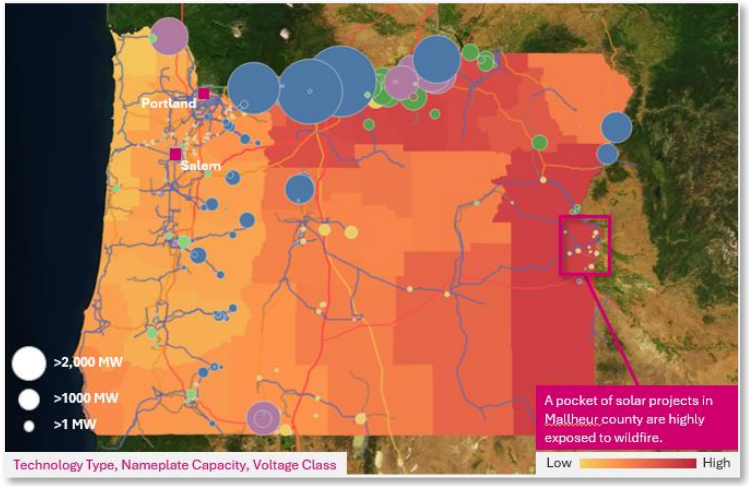
This report is standardized to include 3 different data visualizations that provide insights for Distribution, Transmission, and Generation across 7 extreme weather hazards

1 Distribution Maps



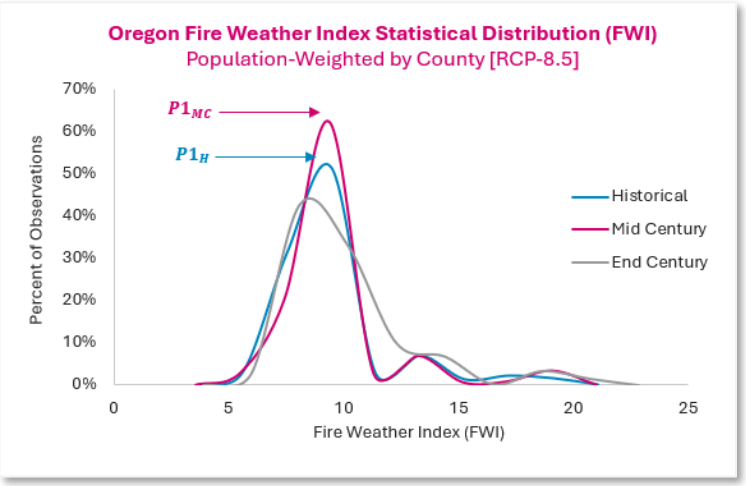
- **Purpose:** Uses population as proxy for volume of distribution assets given that the location of distribution assets is restricted.
- **Interpretation*:** Locate areas of high exposure by identifying counties with coincident large bubbles and dark colors. This indicates a combination of high volume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

Asset Class Overviews

New Mexico

L Low M Moderate H High

EMNRD received many proposals addressing wildfire exposure, but could consider more projects that address heat and cold in the future given significant exposure to these hazards

Key Takeaways

- Consider updated fire response procedures from new data and focus hardening efforts in SW/NW counties that are heavily exposed and highly populated.
- Explore DER opportunities to combat derating from extreme heat events and consider substation upgrades to mitigate the risk of direct asset failure.
- Prioritize T&D hardening in northern counties, especially San Juan County, and investigate new weatherization programs for highly exposed generators.

Hazard	Exposure	Change to Mid-Century	Generation	Transmission & Distribution	AWPI*	Description
FIRE	H	↑	**Consider hardening NG facilities in SW counties and planning for fire response** • Control houses could be damaged or may become difficult to access due to fire. • Consider emergency response planning based on new data from drone programs to decrease restoration times.	**Focus hardening efforts in SW counties and consider Dx pole upgrades or undergrounding** • Sandoval and Dona Ana Counties are heavily exposed to wildfire, posing a threat to a high volume of Dx assets • MV lines in Bernalillo, Sandoval, and Dona Ana Counties could be prioritized for hardening.	M	**Gen:** No proposed awards address generator wildfire exposure, although fire risk for generators is relatively low. **T&D:** Prevalence of drones, planning, and monitoring proposals address fire, but EMNRD could also consider Dx pole upgrades or undergrounding.
HEAT	H	↑	**Explore flexible DER options to offset derating of supply** • DER proliferation would minimize reliance on a band of highly exposed natural gas and solar generators during extreme heat events.	**Consider substation upgrades and more cost-effective Tx hardening methods** • Significant exposure to days >105 °F requires substation upgrades to avoid direct failure. • Reconductoring and GETs could address conductor derating due to extreme heat exposure in the SE and NW.	M	**Gen:** No proposed awards for DERs or generator heat exposure mitigation. **T&D:** Vegetation management proposals address line sag, but EMNRD could also consider substation upgrades given extreme heat exposure and a high likelihood of failure.
COLD	M	↓	**Consider weatherizing coal and natural gas plants to combat cold exposure** • Four Corners Generating Station is exposed to cold, which can cause shutdowns. • Wind farms in the central region of the state face cold exposure that contributes to asset failure and ice throw.	**Prioritize hardening investments in the northern regions of the state** • Annual minimums <32 °F indicate widespread historical freezing exposure in N counties. • Cluster of HV/MV Tx lines in San Juan County are exposed, including import/export lines that would be crucial during extreme weather.	L	**Gen:** No proposed awards address generator cold exposure. **T&D:** No proposed projects address cold exposure, despite continued freezing risk. EMNRD could consider Tx structure reinforcement and Dx pole/cable upgrades.

*** AWPI = Alignment with proposed investment**

L Low M Moderate H High

EMNRD could prioritize substation upgrades in N. counties and pole upgrades in S. counties to address flood and wind exposure, and consider projects to combat curtailment from drought

Key Takeaways

- EMNRD could prioritize substation fortification for low-lying assets in northern counties that are heavily exposed to flooding.
- Consider prioritizing Dx pole upgrades, Tx structure reinforcements, and undergrounding to address wind exposure in southern counties.
- Consider O&M innovation to mitigate the impacts of drought on solar and natural gas production and collect more data about precipitation trends.

Hazard	Exposure	Change to Mid-Century	Generation	Transmission & Distribution	AWPI*	Description
FLOOD	L	↑	**Most supply technologies are not significantly exposed to flood** • A few hydro generators and a large coal plant in northern counties are exposed to moderate flood levels, which can cause plant failure.	**EMNRD could prioritize substation and Dx fortifications in northern counties** • A pocket of HV substations in northern counties are heavily exposed to flooding, which can cause direct failure.	L	**Gen:** Lack of exposure makes gen a lower priority for investment. **T&D:** No projects targeting substations, unaligned with the substation exposure.
WIND	M	→	**Consider encouraging the use of generator components rated for higher wind speeds** • Wind farms in the east are exposed to return values greater than their cutout speeds. • Solar panel racking may be rated below return values.	**EMNRD could prioritize Dx pole upgrades and Tx structure reinforcement in S counties** • High density of Dx assets are exposed to peak state wind exposure in southern counties. • MV/HV Tx lines passing through McKinley, Luna, and Eddy counties are highly exposed.	M	**Gen:** No projects addressing generator exposure. **T&D:** Veg management projects address wind, but pole upgrades and undergrounding could also be considered.
DROUGHT	M	↑	**EMNRD could prioritize O&M innovation for solar and natural gas plants in the SW** • Drought conditions can inhibit natural gas cooling and cause dust buildup on solar panels, decreasing power production.	**Drought exposure does not have a material impact on transmission and distribution assets.**	M	**Gen:** No projects addressing generator exposure. EMNRD could consider using climate-adjusted weather inputs for hydro generation forecasting given changing drought exposure over time.
RAIN	L	→	**EMNRD could seek out additional data to understand future hydroelectric production** • Precipitation is projected to increase in SE counties and decrease in the SW and N.	**Precipitation exposure does not have a material impact on transmission and distribution assets.**	M	**Gen:** No projects addressing generator exposure, but EMNRD could seek out information about upstream conditions and changes to snow patterns.

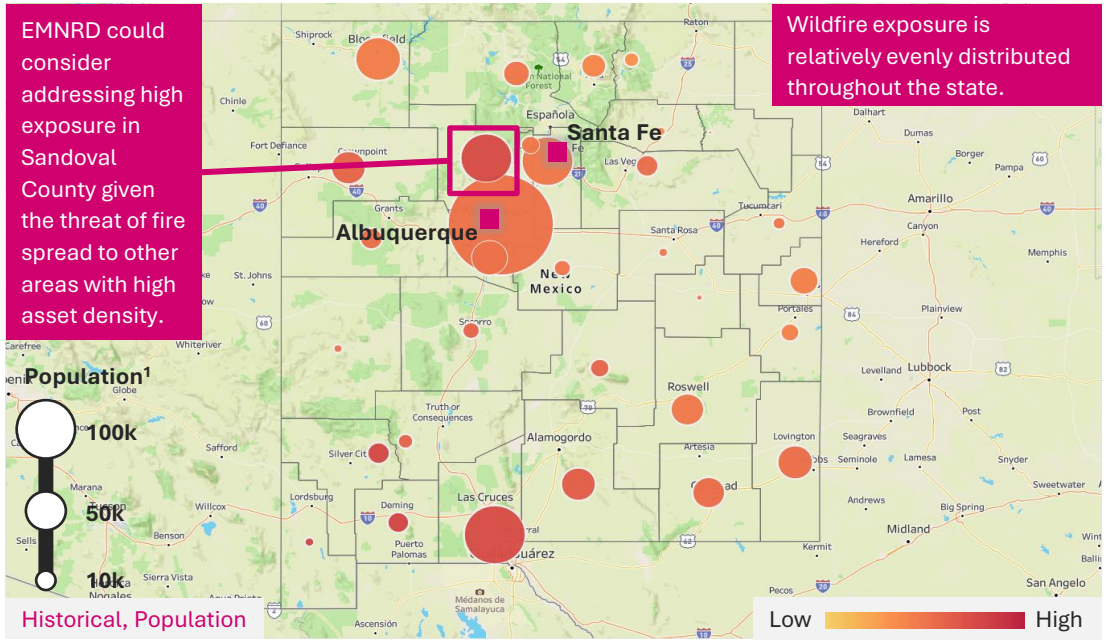
*** AWPI = Alignment with proposed investment**

Wildfire

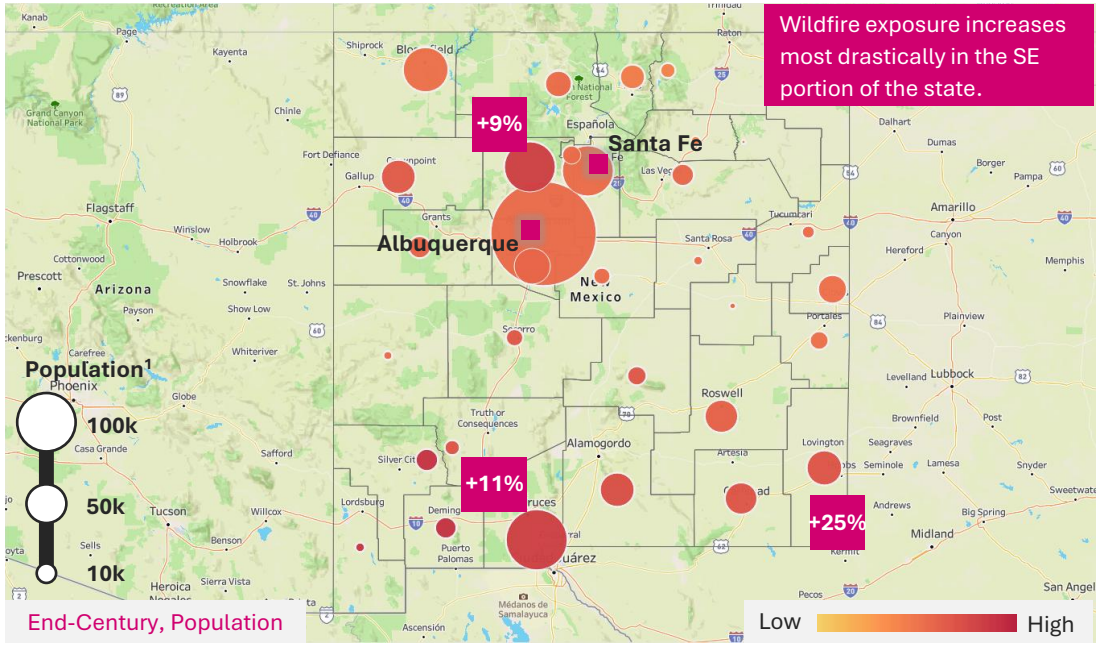
Asset Analysis

EMNRD could continue to fund wildfire mitigation efforts, particularly in the southern regions of the state facing increasing exposure, and highly populated counties in the NW

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



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



KEY OBSERVATIONS

- Fire exposure is relatively evenly distributed throughout the state, although the **SW region is generally most exposed**.
- **Sandoval County** is subject to peak state wildfire exposure, posing a threat to Dx assets within the county and in neighboring **Bernalillo County**.
- Proposals address wildfire exposure through **vegetation management, drone monitoring, and wildfire mitigation planning.**

KEY OBSERVATIONS

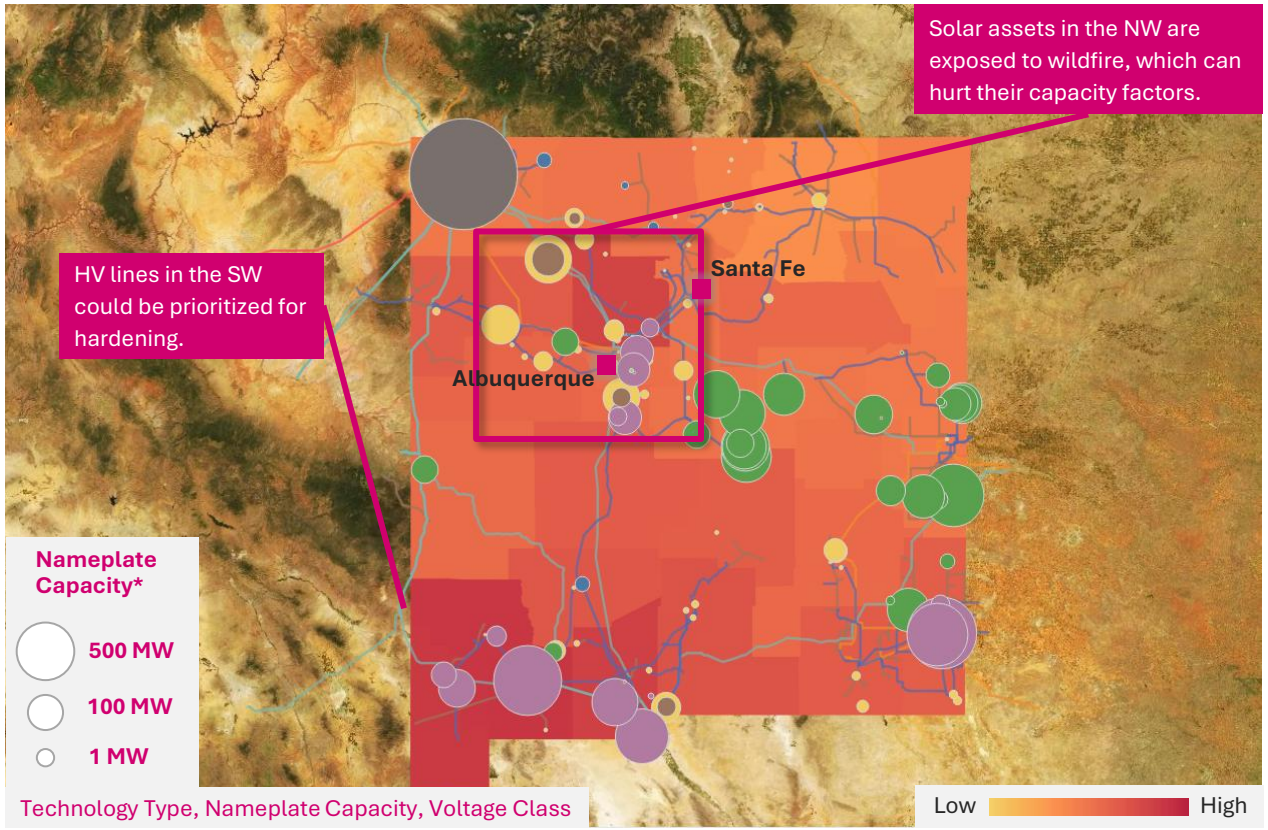
- FWI increases by about 10-25% across the state, demonstrating the importance of utilizing **forward-looking climate projections for state-wide fire mitigation planning.**

Dona Ana County — 2nd most populous county is exposed to high levels of FWI (~40 by end-century), indicating a priority area for future wildfire mitigation projects.

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

EMNRD could consider prioritizing hardening for Tx and natural gas operational facilities in SW counties, and explore methods to combat solar derating from soot and ash

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



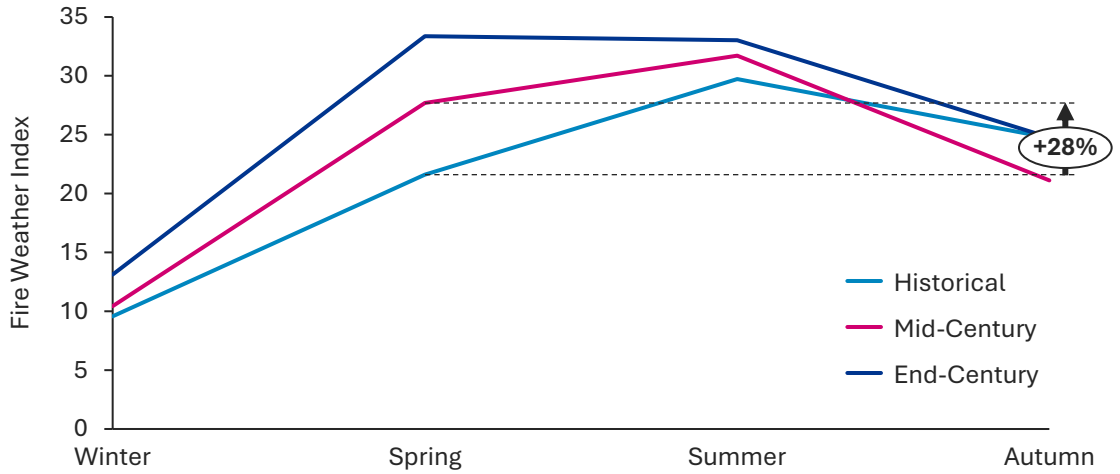
Source: ClimRR, US Census Bureau, City and Town Population Totals

Key Highlights	Analysis
Transmission	• High density of **345kV+ lines in SW counties connecting natural gas assets to demand centers are heavily exposed** and could be prioritized for investment. • Crucial **transmission juncture in Bernalillo County borders high exposure regions,** posing a threat to unfortified Tx assets. • EMNRD could consider **undergrounding and pole wrapping** projects to address exposure.
Restoration	• Wildfire causes **ingress/egress issues** through destruction of roads and transportation, slowing restoration times for all assets. • Wildfire poses a threat to **control houses and other operational infrastructure** for natural gas plants, which are highly exposed in the SW.
Renewables	• Soot and ash from burns **decrease capacity factors for solar assets by decreasing solar irradiance.** • **Very few proposed projects address generator exposure,** indicating an overlooked resilience topic area for the state.

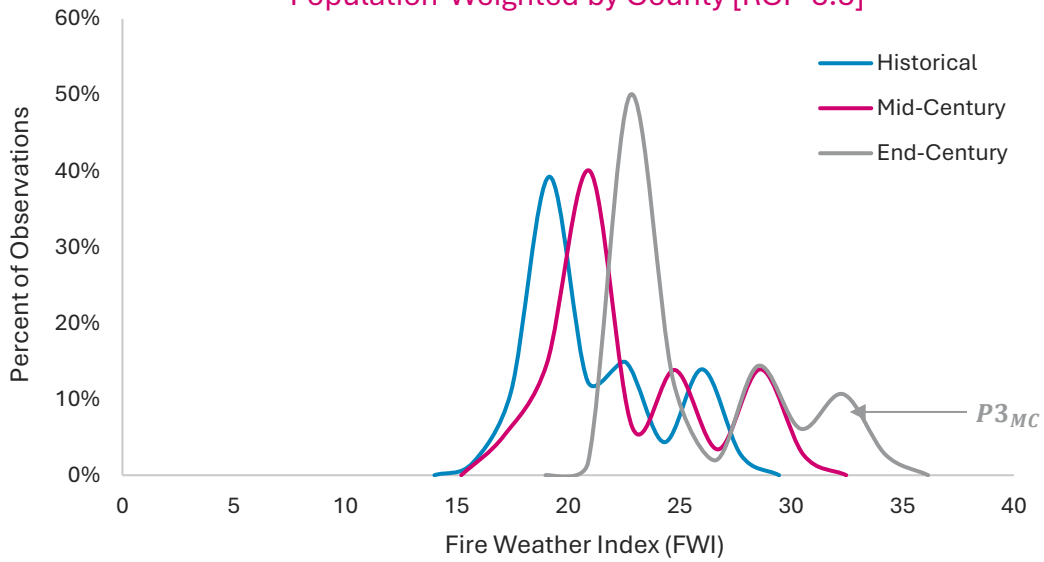
*Generator nameplate capacities may exceed those shown in the legend

Spring fire exposure will become more severe over time, increasing the duration of the fire season and shortening the window for scheduled maintenance

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



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



KEY OBSERVATIONS

- Spring FWI increase 28% by mid-century, indicating a **lengthening of the wildfire season combined with an increase in severity.**
- Stagnant or declining exposure in autumn indicates that the **fire season will shift earlier in the calendar year.**
- Relatively constant FWI levels in autumn and winter indicate that **scheduled maintenance and fire mitigation upgrades could be planned for these seasons of lower exposure.**

KEY OBSERVATIONS

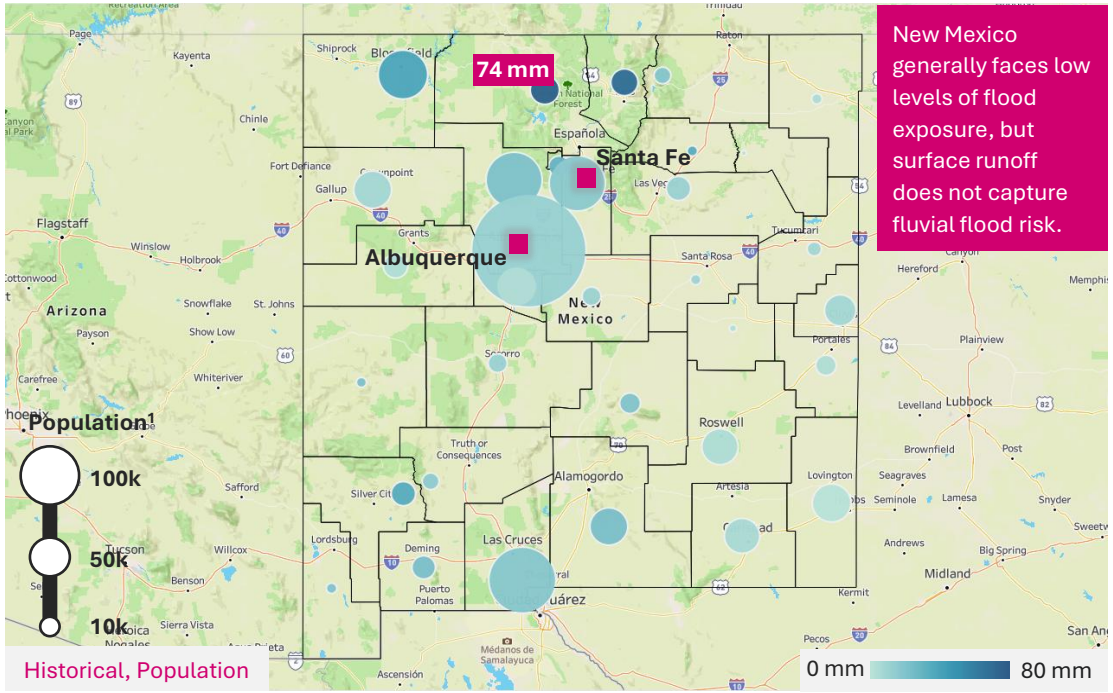
- Rightward shift of the curve by indicates that **wildfire exposure will become more severe over time.**
- The tri-modal shape of the curve represents **three regions of the state that face distinct levels of fire risk** given differences in climate zones.
- Peak 3 (P3) shifting right by end-century indicates that **fire exposure will increase by about 10 FWI points in the most exposed regions** (about 10% of the state population).

Flood

Asset Analysis

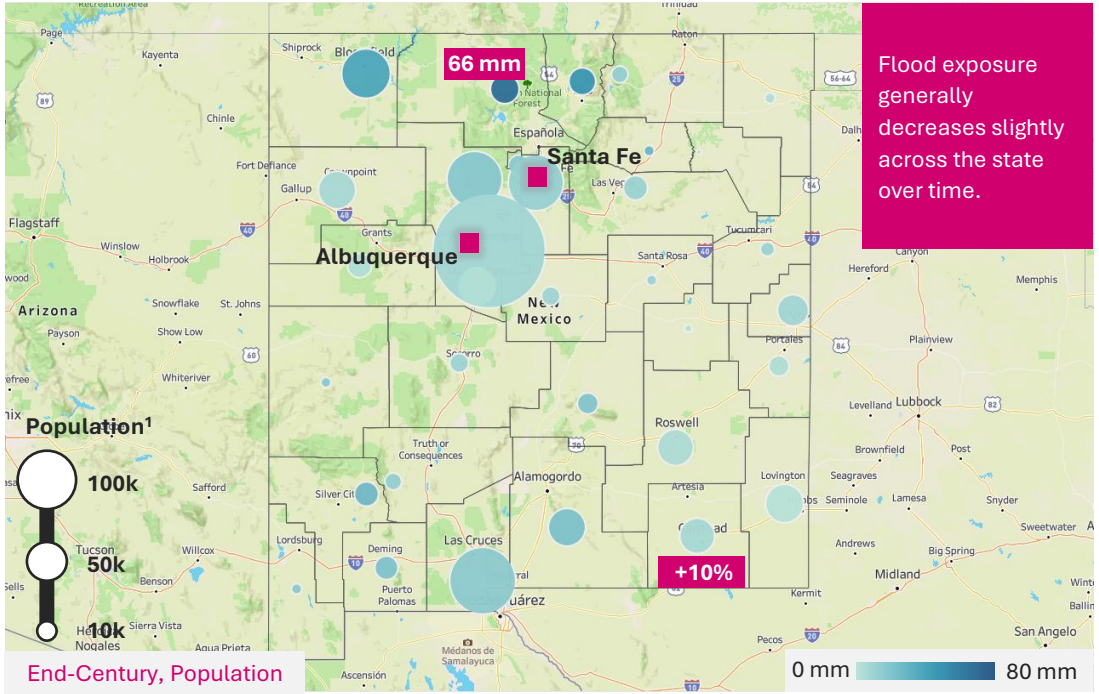
Despite generally low flood exposure across the state, EMNRD could prioritize upgrades for low-lying Dx substations in Rio Arriba County

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



Historical, Population

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



End-Century, Population

KEY OBSERVATIONS

- Most flood exposure lies in the **north-central counties** given higher precipitation levels, but **state-wide flood levels are relatively low** compared to other states in WECC.
- **Undergrounding could be considered across most counties** given the low levels of flood exposure posed to buried lines and infrastructure.

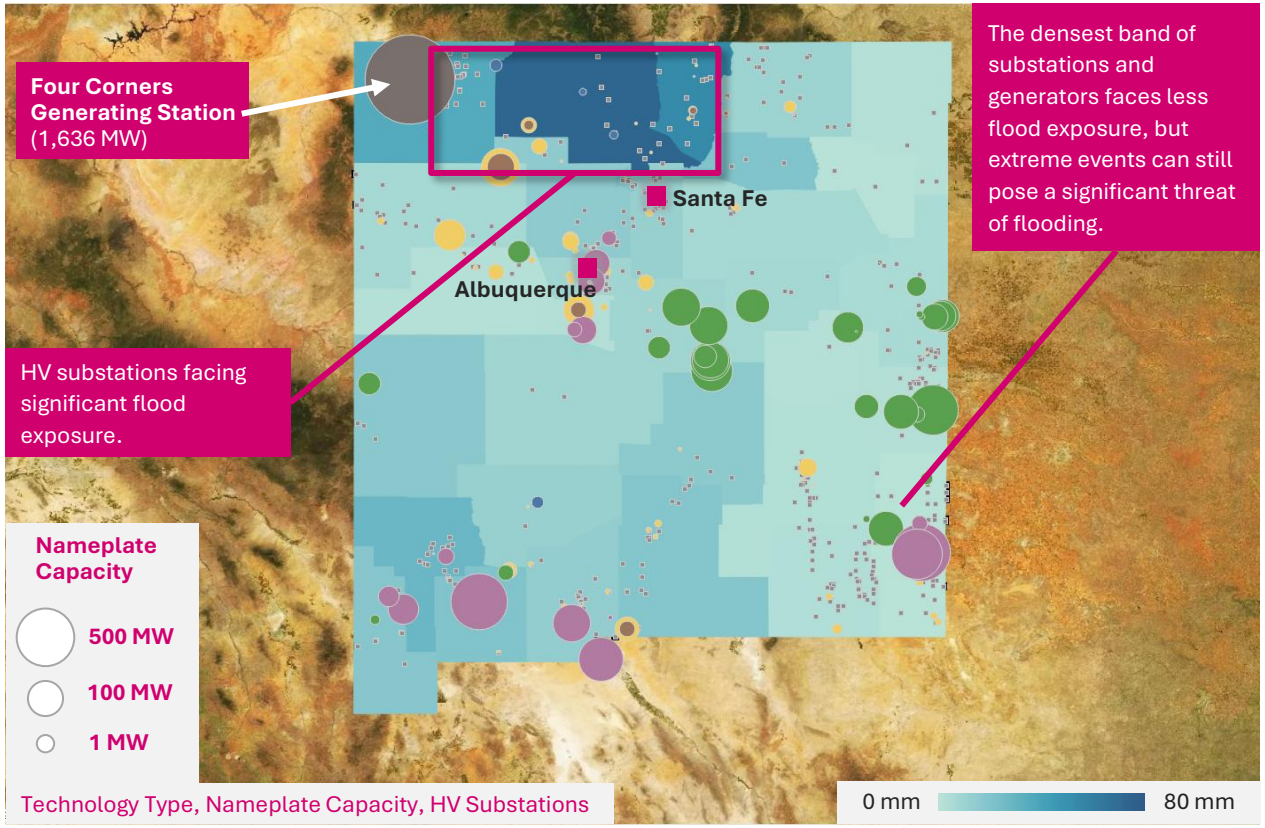
KEY OBSERVATIONS

- EMNRD may want to consider upgrades for low-lying substations in north-central counties despite a small decrease in flood exposure over time.
  - **Rio Arriba County** Rio Arriba County faces peak state-wide flood exposure, making it a **priority area for Dx substation upgrades.**

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

EMNRD could prioritize the fortification of high voltage substations in north-central counties given the high density of assets facing significant exposure and their high cost of failure

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



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

Key Highlights	Analysis
Substation	• VIC runoff captures pluvial flood exposure (caused by intense precipitation), but HV substations can also be exposed to fluvial flooding if located in flood plain or riverbank without necessary protections. • High density of **HV substations in San Juan, Rio Arriba, and Taos 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	• A handful of small hydroelectric plants in Rio Arriba County are significantly exposed to flood, which can contribute to **dam overtopping/failure and pose a threat to control houses.** • The Four Corners Generating Station is exposed to flood, jeopardizing control house and plant substation equipment.

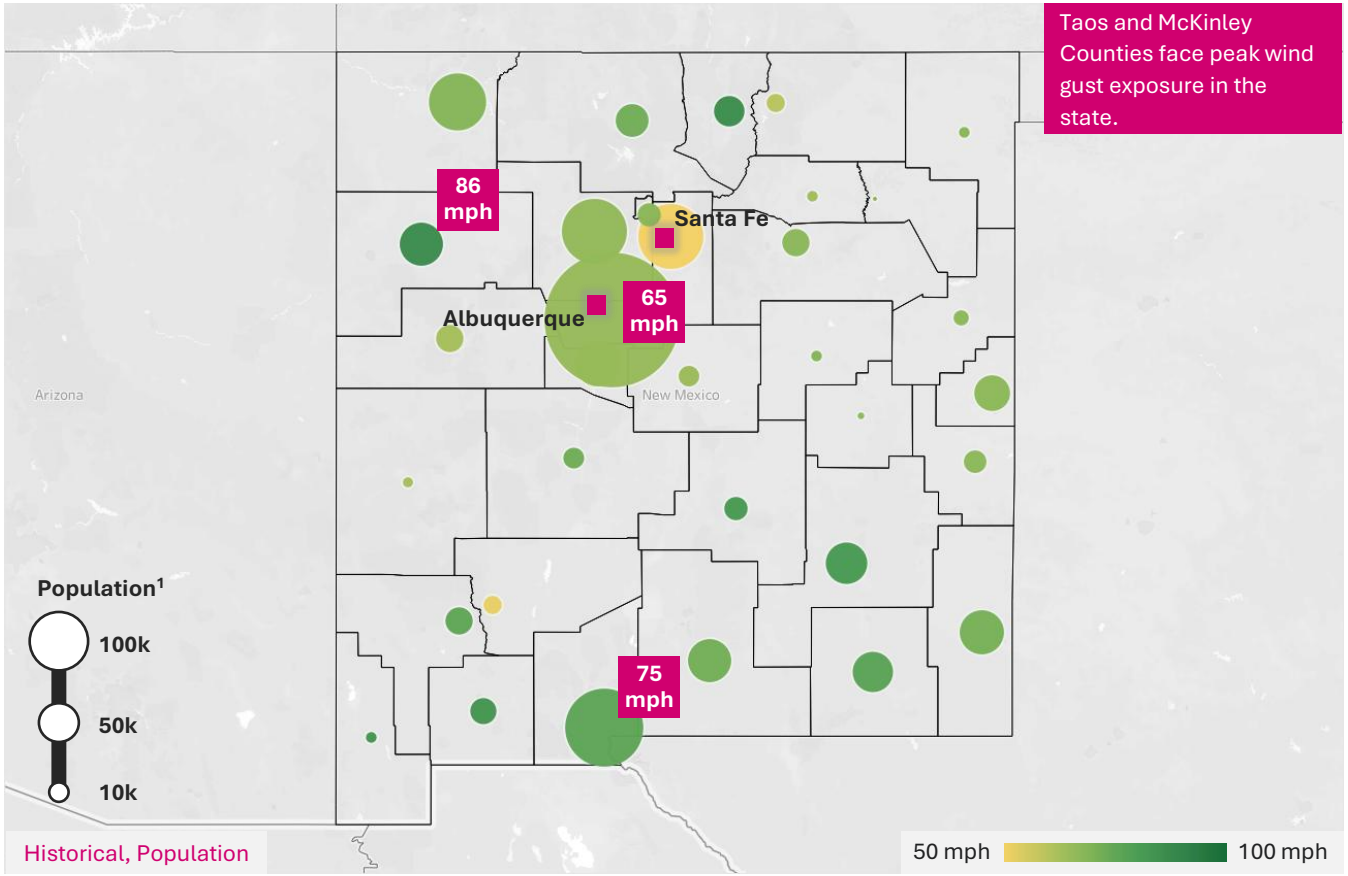
*Generator nameplate capacities may exceed those shown in the legend

Wind

Asset Analysis

EMNRD could encourage utilities to adopt upgraded wind design standards and consider Dx pole upgrade projects for highly-exposed southern counties

New Mexico 100-year Wind Speed (mph)
Historical



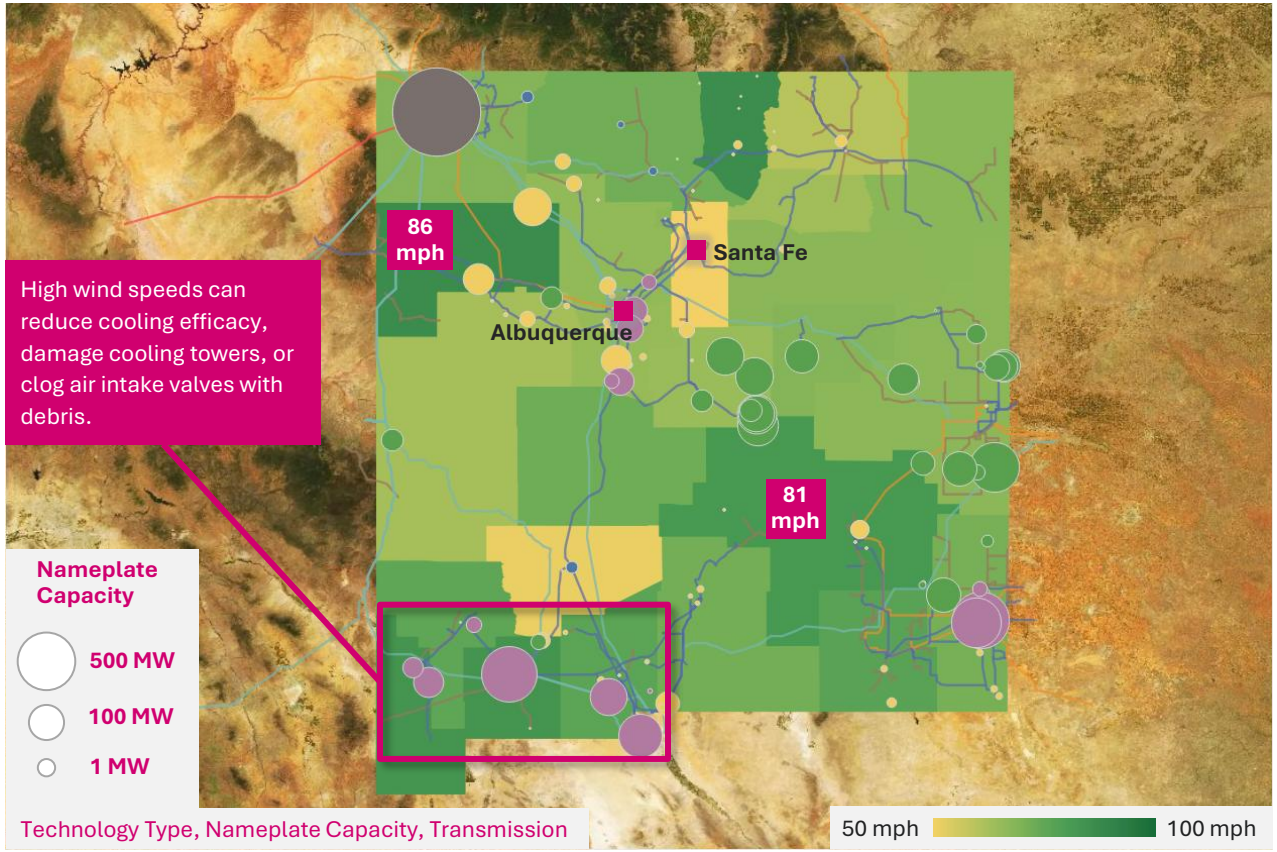
Key Highlights	Analysis
Distribution	• Given weak climate signals, wind speeds are derived using historical data and do not vary at high spatial resolution. • Rather than targeted investments, wind exposure could be addressed through **upgraded design standards** across a utility service territory.
McKinley County	• McKinley County has a population of over 65k and 100-year return value of 86 mph, **indicating a high exposure area for Dx assets**.
Southern Counties	• **Southern counties generally exhibit high wind gust speeds**, exposing a high volume of Dx assets. • EMNRD's vegetation management projects generally address wind exposure, but **pole upgrades could also be considered in high exposure regions.** • High wind speeds combined with high wildfire exposure could contribute to **fire spread in this region of the state.**

Source: DRI, EIA860, HIFLD

EMNRD could consider reinforcing Tx structures for MV/HV lines and encourage the procurement of wind turbines with higher cutout speeds to avoid curtailment

New Mexico 100-year Wind Speed (mph)

Historical



Source: DRI, EIA860, HIFLD, EIA State Energy Profile

Key Highlights	Analysis
Transmission	• Multiple MV-HV Tx lines pass through McKinley, Luna, and Eddy Counties, where they are exposed to high wind return values. • EMNRD could consider **reinforcing Tx structures** or **undergrounding lines** to complement ongoing vegetation management projects addressing exposure.
Wind	• Wind farms cutout speeds can vary between 45-70mph, indicating that in high wind speed events, these turbines stop producing. • Wind farms throughout the state are exposed to 100-year return values greater than 60 mph, posing a **significant threat of curtailment to an asset class that accounts for 38% of state electricity generation.**
Solar	• Solar plants in McKinley and Chaves counties are exposed to relatively high extreme wind gust levels. • Depending on OEM, solar panels can be rated to 90 mph, **indicating potential need for rack reinforcement and vegetation management.**

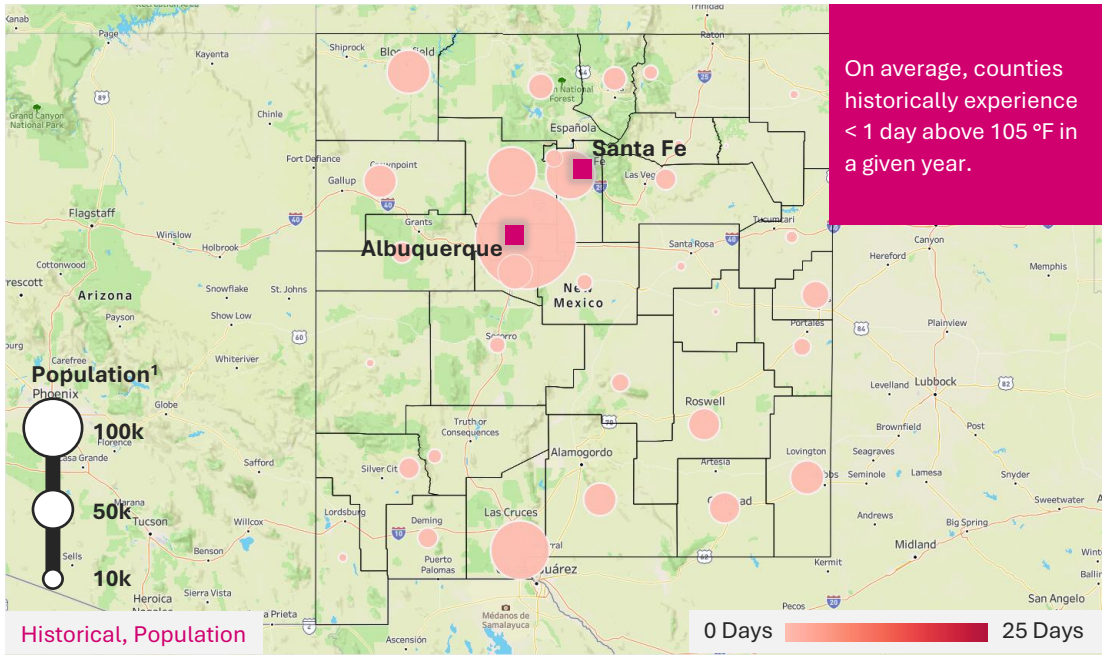
*Generator nameplate capacities may exceed those shown in the legend

Extreme Heat

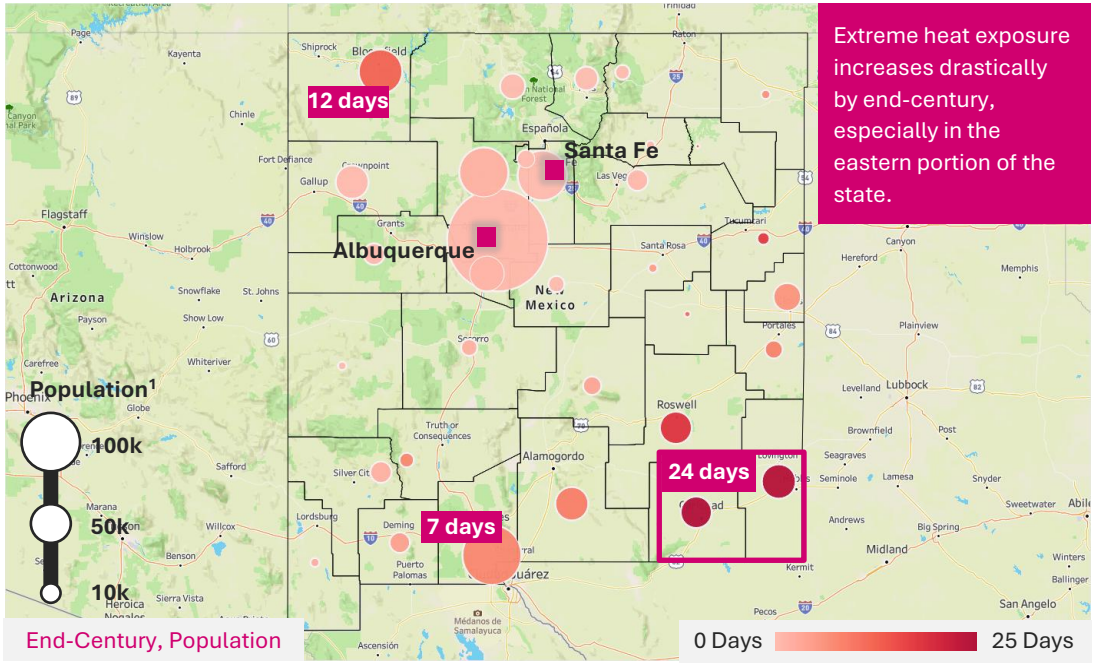
Asset Analysis

Escalating extreme heat exposure suggests that EMNRD could prioritize substation and Dx line upgrades such as reconductoring to address derating, degradation, and risk of failure

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



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



KEY OBSERVATIONS

- Currently T_x and D_x assets have **little 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

- SE counties are expected to face **about 24+ days >105 °F annually, causing high asset utilization, derating, and potential substation failure. Veg management proposals** address line contact exposure.

Dona Ana County Populous county facing 7 days of extreme heat exposure by end-century, potentially justifying substation and Dx line upgrades to mitigate potential failure and derating.

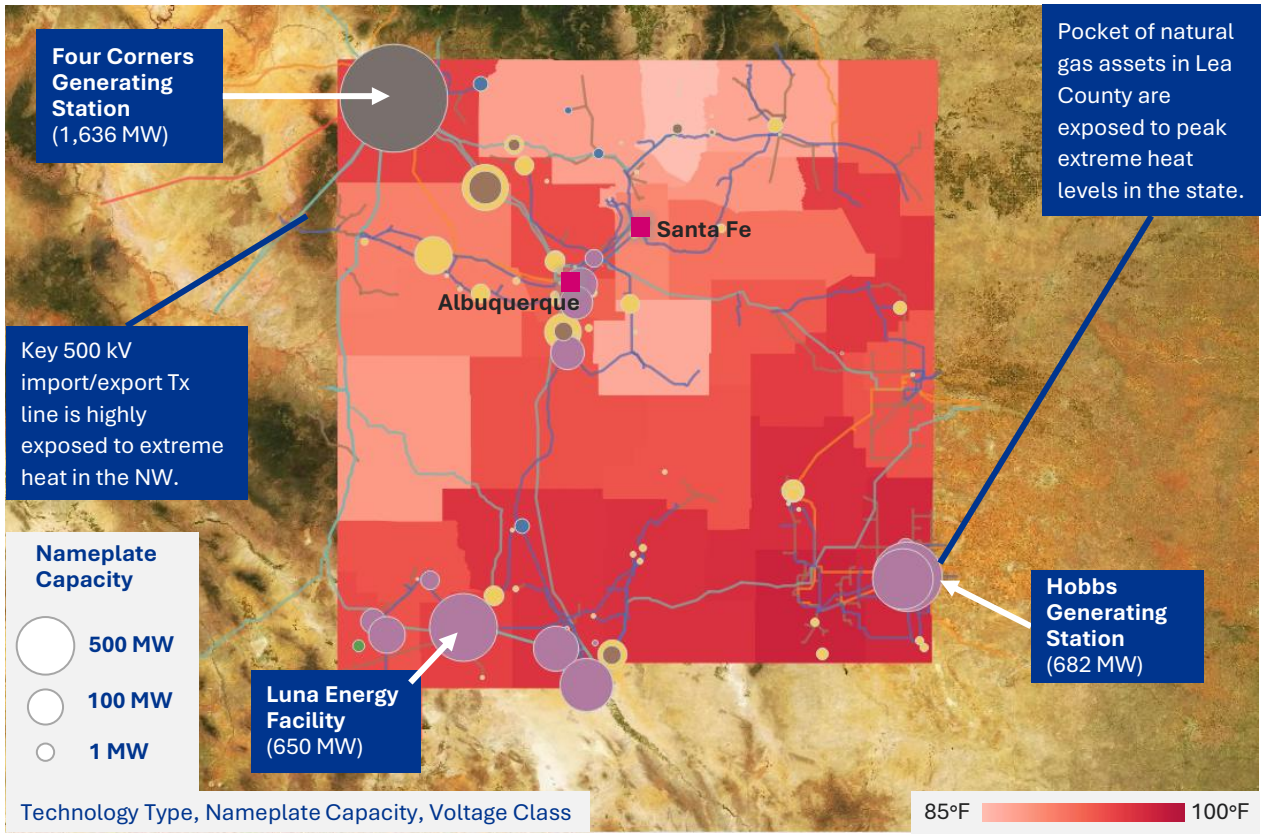
[1]Population bubbles are continuous and therefore labels are approximate. [2]EPRI Climate READi

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

EMNRD could consider funding cooling upgrades for large thermoelectric generators and projects to combat line derating such as line upgrades, GETs, or DER buildout

New Mexico 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, US Census Bureau, City and Town Population Totals

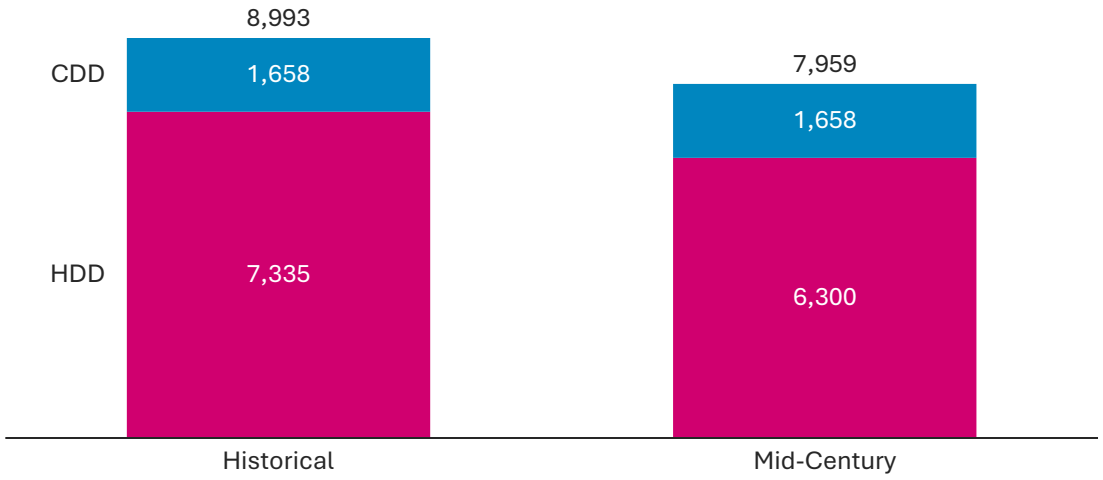
Key Highlights	Analysis
Thermoelectric	• Thermoelectric generators that rely on water-based cooling methods will **experience production derates** as extreme heat raises average water temperatures. • EMNRD could prioritize upgrades for highly exposed thermoelectric generators with large nameplate capacities.
Solar	• Solar assets throughout the state are significantly exposed to extreme heat, contributing to **production derating** at temperatures above 77°F.
Transmission	• Many MV/HV lines are highly exposed to extreme heat in the SE and NW, which can cause capacity derates and line sag. • Veg management proposals partially address line sag, but EMNRD could consider **other adaptations to combat line derating such as reconductoring or grid-enhancing technologies (GETs).**

*Generator nameplate capacities may exceed those shown in the legend

Extreme heat days will become more common in New Mexico, contributing to higher levels of asset utilization, accelerated degradation, and potential capacity violations

New Mexico Average Annual Cooling & Heating Degree Days (CDD & HDD)

Population-Weighted by County [RCP-8.5]

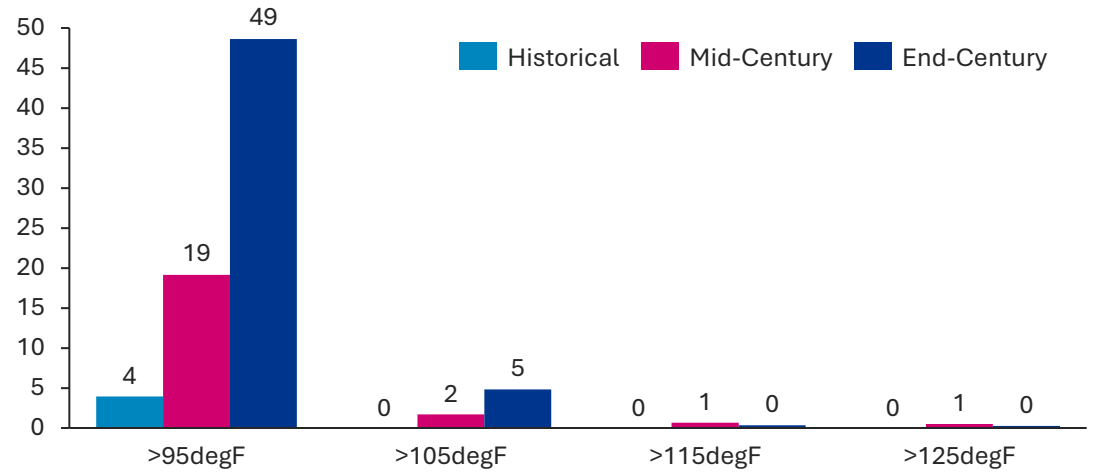


KEY OBSERVATIONS

- Between historical and mid-century, **the ratio of CDD to HDD increases,** with the share of average number of CDD jumping from about 22% to 26%.
- This results in **increased summer asset utilization and degradation**, but **impacts to winter utilization remain unclear** depending on heating electrification trends.
- Larger gap between HDD values than CDD values indicates that heating load will be more significantly impacted than cooling load.

New Mexico Average Annual Days Exceeding Daily Max Heat Index Thresholds

Population-Weighted by County [RCP-8.5]

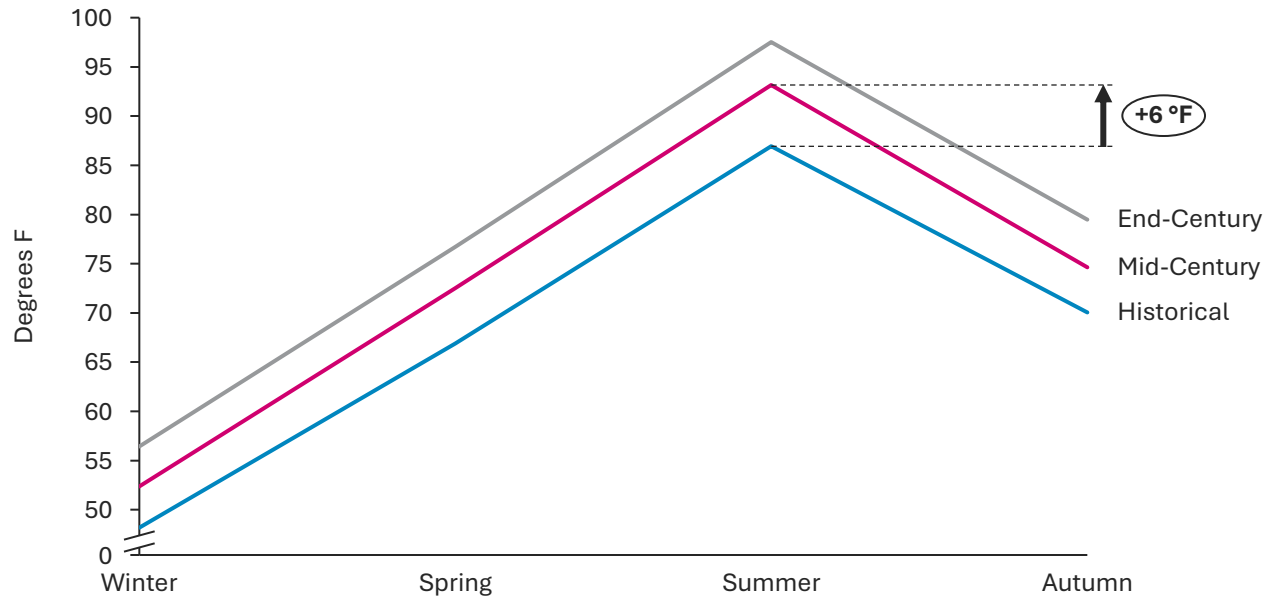


KEY OBSERVATIONS

- >4x increase in days with heat index >95°F by mid-century represents an increase in cooling demand, manifesting in **higher levels of asset utilization and accelerated asset degradation.**
- Increase in days > 105°F by mid and end-century poses a **substantial risk to distribution substations**, which can fail after two consecutive days above 104 °F without sufficient cooling infrastructure, indicating a crucial focus area for EMNRD in future funding allocation processes.

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

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



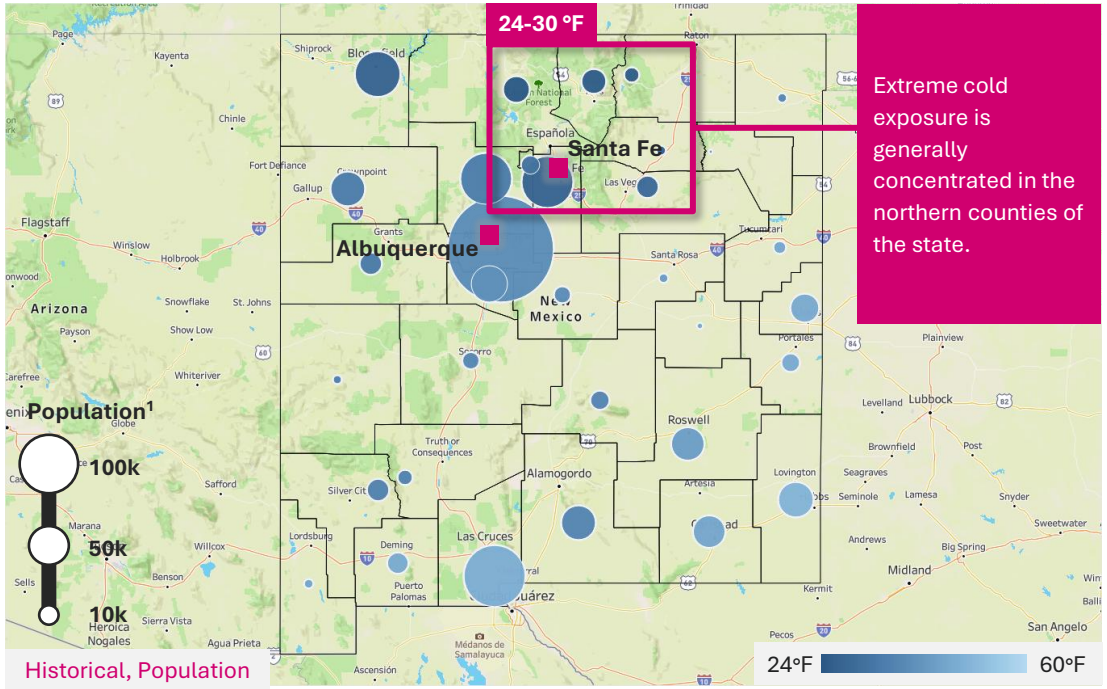
Key Highlights	Analysis
Summer Warming	• **Heat risk increases most drastically in summer**, with a 6 °F increase in the average seasonal max by mid-century, **increasing system utilization and degradation.**
Shorter Shoulder Seasons	• There is generally less pronounced warming in shoulder seasons, although increased autumn maximums could **extend the duration of high system utilization and shorten maintenance windows.**

Extreme Cold

Asset Analysis

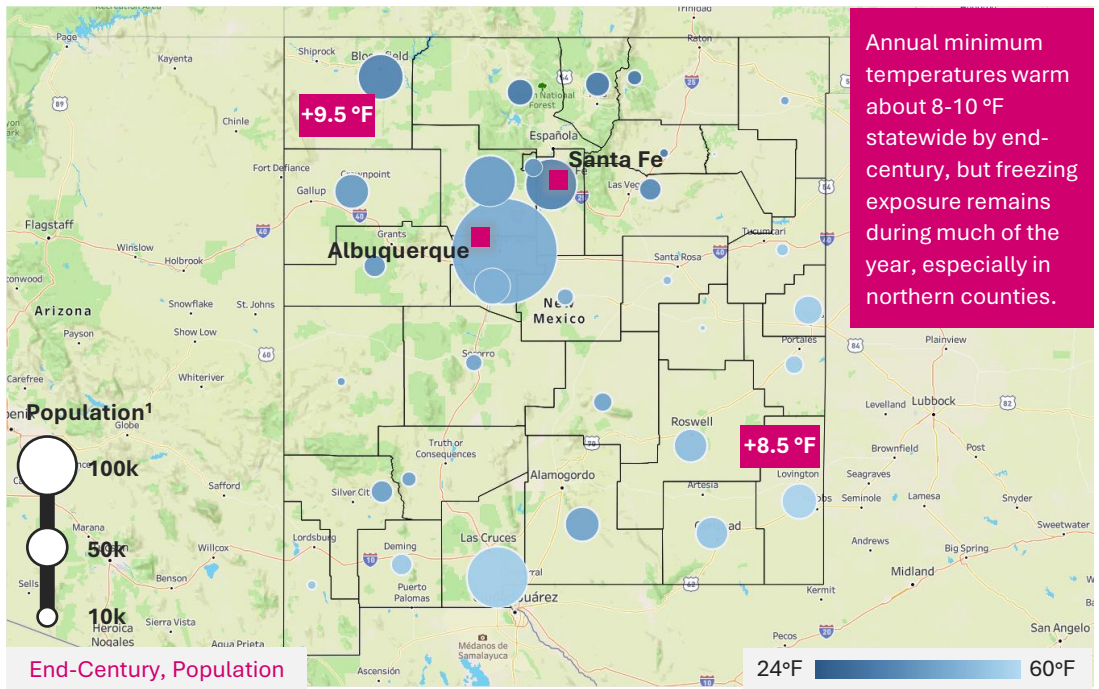
EMNRD could consider undergrounding or Dx pole upgrades to address extreme cold exposure that persists despite warming, especially in northern counties

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



Historical, Population

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



End-Century, Population

KEY OBSERVATIONS

- Extreme cold is concentrated in the **northern regions** of NM.
- Annual minimums are below 32 °F across many northern counties in the state, indicating **widespread historical freezing exposure.**
- Few current proposals appear to address cold exposure; EMNRD could consider pole upgrades as a low-cost way to improve mechanical loading.

KEY OBSERVATIONS

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

Santa Fe County

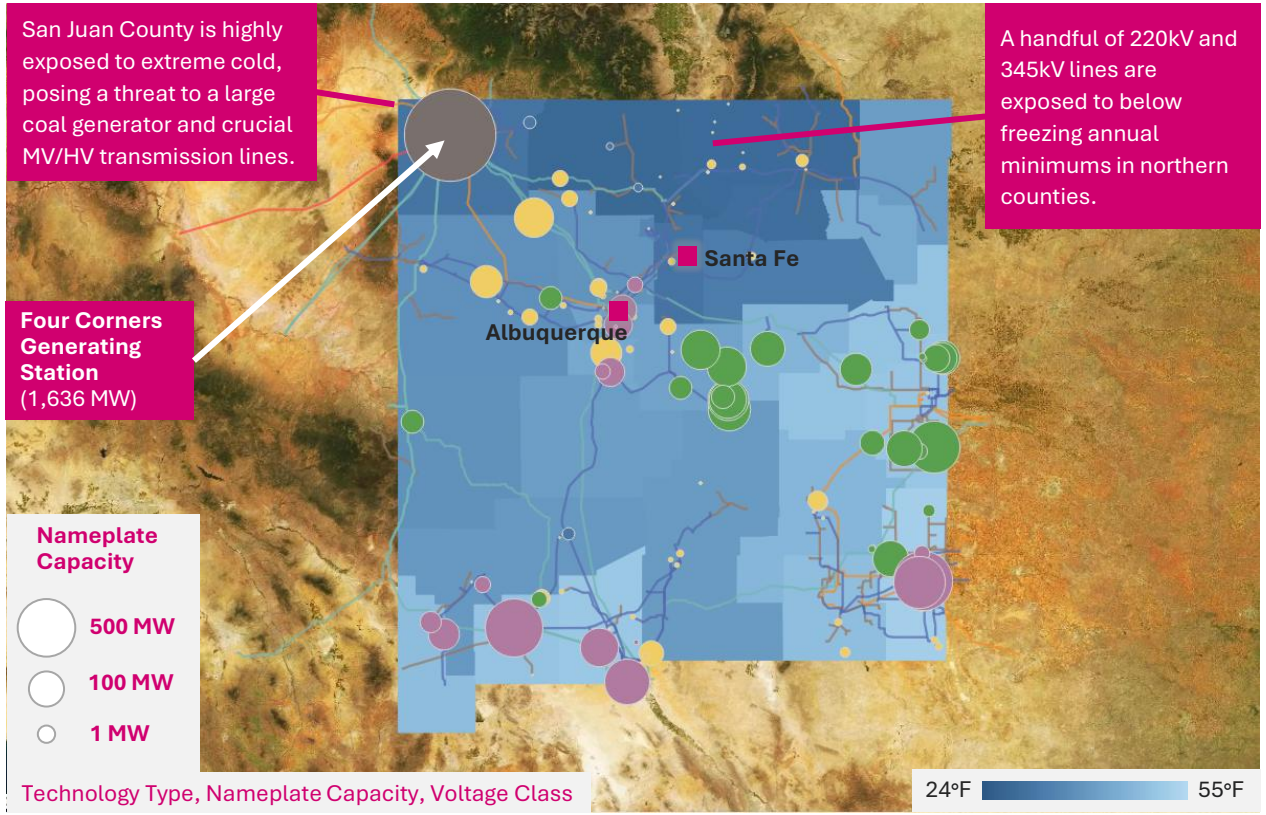
By end-century, Santa Fe County will be exposed to annual minimum temperatures of 37 °F, indicting potential **icing exposure for much of the year.**

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

EMNRD could consider resilience upgrades to the Four Corners Generating Station to combat cold exposure, as well as Tx hardening addressing freezing, such as structure reinforcement

New Mexico Average Annual Minimum Temperature (°F)

Generators, Mid-Century [RCP-8.5]



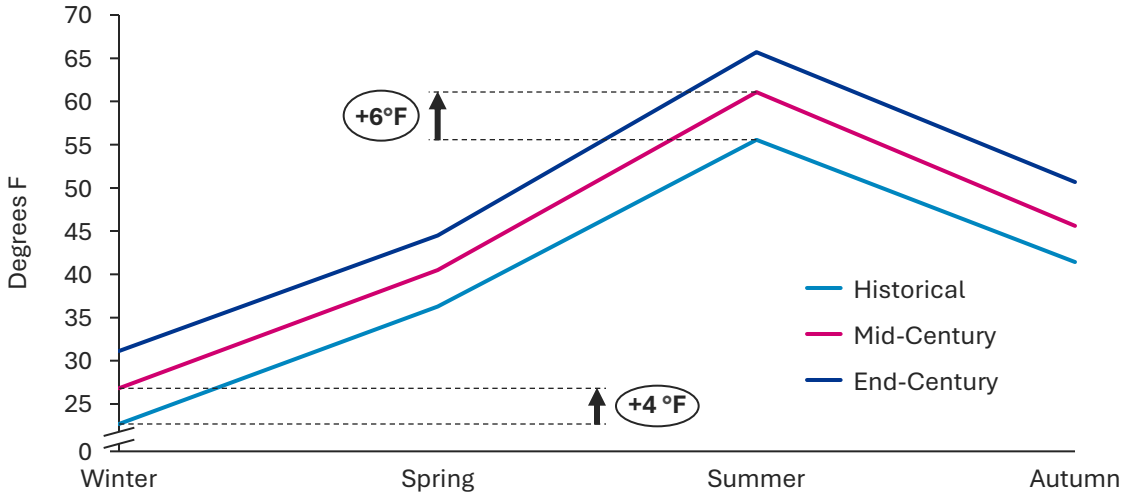
Key Highlights	Analysis
Coal	• Four Corners Generating Station is exposed to average annual minimum temperatures of 31 °F. • Freezing temperatures can cause **plant startup challenges and freeze coal stockpiles.** Adaptation investments could be explored given the region's reliance on this resource's high nameplate capacity.
Wind	• Wind plants in Torrance, Catron, and McKinley Counties face cold exposure that contributes to **asset failure and ice throw.**
Freezing/Icing	• Despite warming, the **prevalence of near-freezing annual minimums** in many counties contributes to **Tx freezing/icing risk** that can cause asset failure. • The cluster of lines in San Juan County are highly exposed, **including HV import/export lines that would be crucial during extreme weather events.**

*Generator nameplate capacities may exceed those shown in the legend

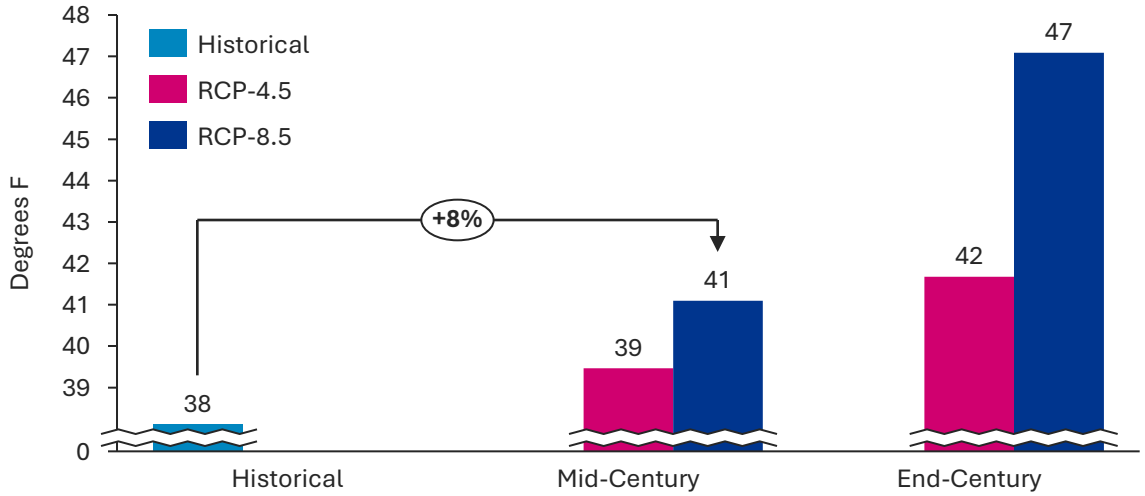
Source: ClimRR, US Census Bureau, City and Town Population Totals

Despite warming over time, winter temperature minimums remain below 32 °F, indicating that EMNRD could consider pole and cable upgrade projects to address freezing exposure

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



New Mexico 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) will decrease overall heating load, but the **impact on electricity demand ultimately depends on the speed of heating electrification.**
- Mid-century and end-century winter minimums remain below 32 °F, indicating that **freezing and icing exposure persists despite warming.**
- EMNRD did not receive proposals addressing this continued exposure to freezing, but they could **consider Dx cable and pole upgrades.**

KEY OBSERVATIONS

- 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.**

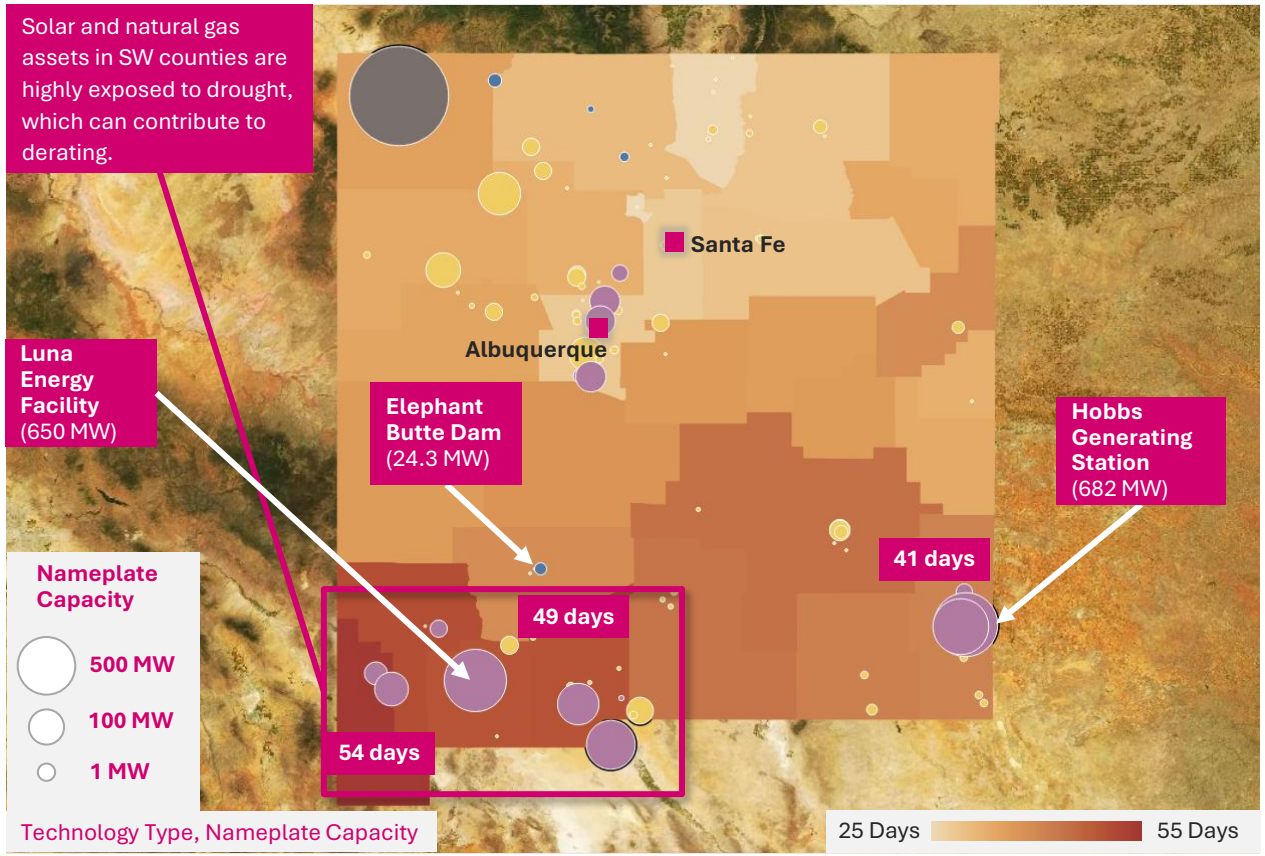
Drought

Asset Analysis

EMNRD could prioritize O&M innovation for solar and natural gas plants in the SW, and consider using climate-adjusted weather inputs for hydroelectric generation forecasting

New Mexico Consecutive Days No Precipitation

Generators, Mid-Century [RCP5-8.5]



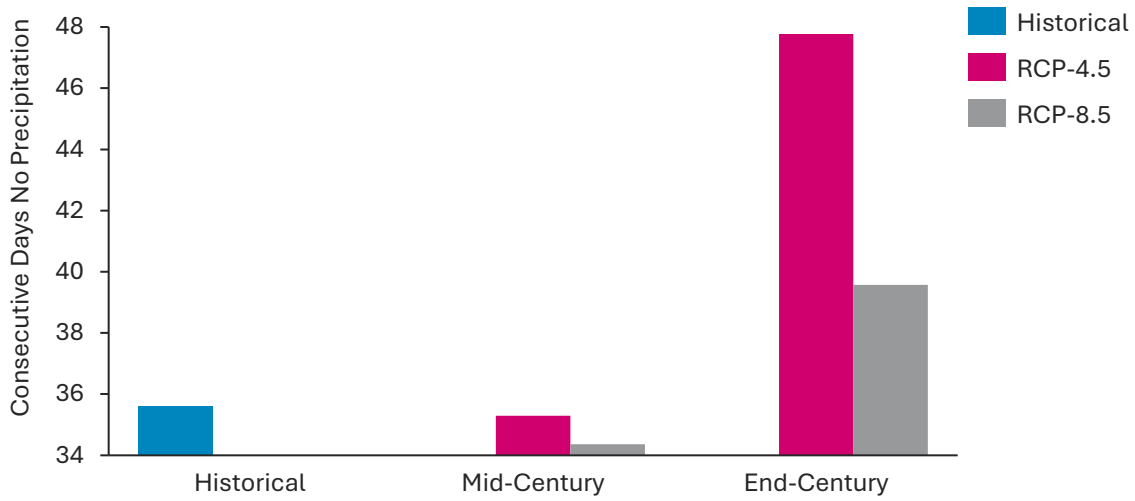
Key Highlights	Analysis
Natural Gas	• Large **natural gas plants in southern counties** are highly exposed to drought. • Lack of water availability can **reduce natural gas cooling ability**, resulting in power production curtailments. • In arid conditions, **air intakes for CCGTs and CTs can clog and degrade** due to dust and sand particles, decreasing efficiency and longevity of generator.
Solar	• Drought conditions cause dust buildup on solar panels, hurting capacity factors. • In areas that also have high wildfire exposure (like the SW), **panel cleaning projects address two hazards simultaneously.**
Hydroelectric	• **Drought exposure is generally projected to increase** over time throughout the state, particularly in the SW. • **Elephant Butte Dam** in Sierra County will face **a 34% increase** in drought exposure by end-century, likely decreasing electricity production.

*Generator nameplate capacities may exceed those shown in the legend

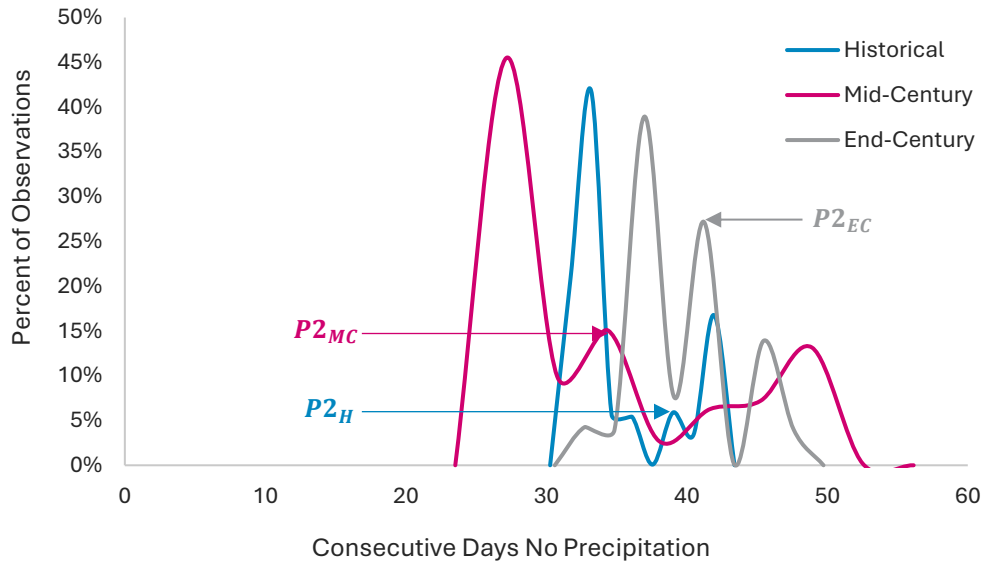
Source: ClimRR, US Census Bureau, City and Town Population Totals

Average drought exposure peaks mid-century under RCP-8.5, but a pocket of more severe exposure emerges by end-century, marking a potential area for future investment

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



New Mexico Average Consecutive Days w/ No Precipitation Statistical Distribution
Population-Weighted by County [RCP-8.5]



KEY OBSERVATIONS

- **Drought exposure increases by ~11% by end-century** (under RCP 8.5), contributing to potential asset cooling issues and reduced hydro output.
- Decreasing drought exposure by mid-century compared to increased exposure by end-century indicates that **drought risk does not scale linearly with temperature** increase and could be monitored closely over time, especially by hydroelectric asset owners.

KEY OBSERVATIONS

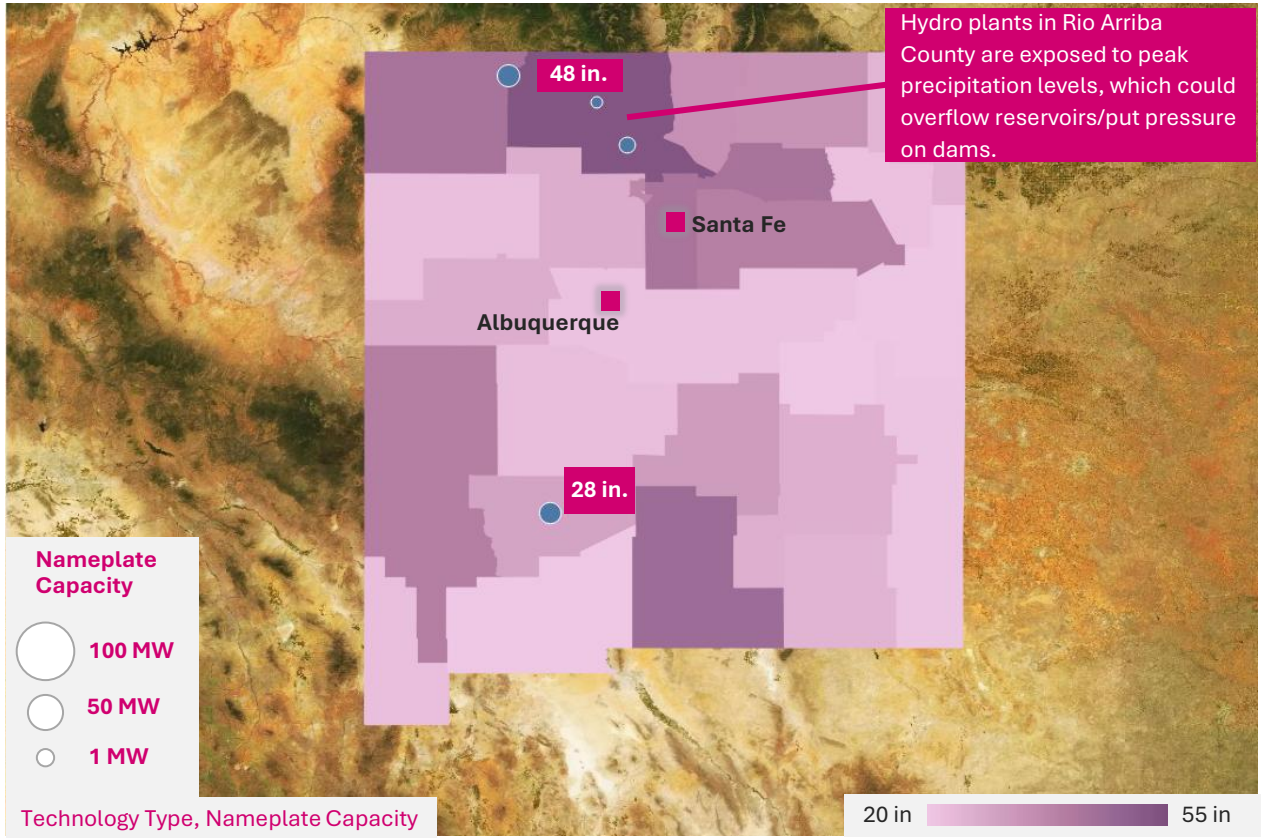
- The mid-century curve's shape indicates that the dispersion of **drought exposure widens over time,** with high-exposure regions (i.e. SE counties) experiencing even more severe droughts.
- The rightward shift of the end-century curve compared to historical demonstrates **increasingly severe drought exposure by end-century.**
- Tri-modal curve indicates three regions of drought risk, while the increase in P2 indicates **a wider region exposed to moderate drought levels.**

Precipitation

Asset Analysis

While precipitation levels remain relatively constant over time, EMNRD could consider how upstream conditions and changing snow patterns will impact hydroelectric production

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



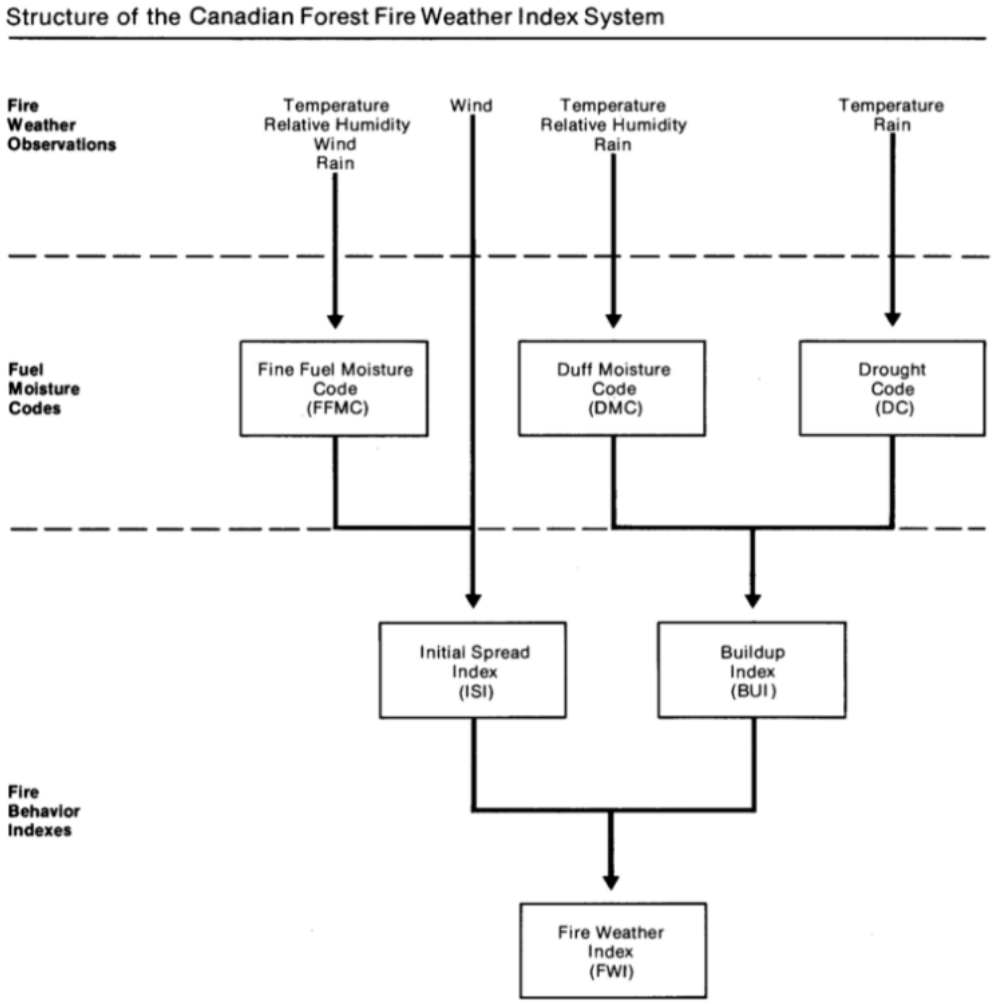
Key Highlights	Analysis
Trends	• Precipitation levels remain relatively constant throughout the state to end-century. • Precipitation is projected to **increase in SE counties** and **decrease throughout the SW and northern regions** of the state.
Upstream Coordination	• **Upstream precipitation and drought** will have significant impacts on hydro production. • EMNRD could **establish a relationship with CEO and WAPA** to share information about precipitation conditions and hydro output along the Rio Grande 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.**

*Generator nameplate capacities may exceed those shown in the legend

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

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

