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State of the Grid Report

ARIZONA



Energy & Resources | Networks
May 2025

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Executive Summary

High wind speeds and extreme heat are key drivers of severe outages in Arizona, and drive a high volume of interruptions per customer in a cluster of sparsely-populated counties



PROGRAM OBJECTIVE

Help state energy offices and select utilities assess how to use **40101(d) funding** to best strengthen the power grid against extreme weather, by:

- **Assessing** the unique **needs** of each state energy office
- **Analyzing future exposure to extreme weather** in the state, its coincidence with energy assets, and potential impacts
- **Attributing outages to weather events** and commenting on the alignment of utility capital spending with historical exposure
- Outlining a **benefit-cost methodology** to improve asset planning



DELIVERABLE OBJECTIVE

This deliverable seeks to:

- Attribute historical outages in the state to specific weather events and **comment on which events are driving the most customer interruptions in the state**
- Analyze a select utility's capital plan and **assess the alignment between their resilience spending and the weather events driving outages in their service territory**



KEY FINDINGS

Hazard Analysis:

Extreme heat and high winds are key drivers of severe outages* on the Arizona grid

- Windstorms, extreme heat, and summer storms (largely a factor of heat and wind) account for 74% of customer interruptions driven by extreme outages
- Very few extreme outages in the state were not coincident with extreme weather, indicating that weatherization and resilience should continue to be a priority for the state and its utilities
- Sparsely-populated counties with harsh terrain (i.e mountains, deserts) experience the highest volume of interruptions per customer, particularly in Gila and La Paz Counties

Capital Planning Insights:

- PUBLIC-2's capital plan is highly geared towards expanding capacity and serving new customers
- PUBLIC-2 could consider conducting asset-level vulnerability studies to determine whether it is underinvesting in resilience and ensure that it is spending existing resilience investments in the most effective way possible

*A severe outage is defined as one in which >50% of customers in a county are out simultaneously, or at least 30,000 customers in a county experience an outage simultaneously, whichever is less

Despite the importance of wind and wildfire in the West, utilities could bolster their capital alignment with historical & future risk by conducting asset-level vulnerability assessments

STATE OF THE GRID REPORT | FINAL INVESTMENT CONSIDERATIONS



Invest against windstorms: Windstorms are the most widespread and severe cause of extreme outages across WECC in the past 5 years. While utilities are investing some capital against wind risk, the universal elevated exposure requires an increased volume of capital towards mitigations. Given its homogenous exposure, wind upgrades could be pursued as updates to design standards rather than targeted, ad hoc investments like substation upgrades.



Continue existing wildfire mitigations: While wildfire exposure of the past 5 years varies by geography, the cost of ignition remains inordinately high in comparison to other hazards. Therefore, even though ignition probability may be low, the high expected cost, coupled with the expected increase in exposure due to changes in climate, substantiates increased investment in mitigation. Utilities can better justify expensive investments like undergrounding by ensuring upgrades are done on feeders that are exposed to multiple hazards, having a double dividend effect on the investment.



Quantify extreme weather risk in dollars: In order to optimally allocate capital expenditures to buy down the most extreme weather risk for the least amount of dollars, utilities must quantify the cost and benefits of the risk and subsequent investment. The utilities that are most effectively optimizing their plans are implementing asset-level vulnerability assessments, using down downscaled climate projections to predict impacts out to mid-century. Baringa will be expanding on how to conduct such analysis in phase 4 of this project.

ASSET	INVESTMENT	COST	HAZARDS
 POLES & STRUCTURES	Pole Reinforcement	M	3
	Pole Upgrades	M	3
	Dead-End Structures	M	2
	Decreased Span	M	2
	Pole Wrapping	L	1
 CONDUCTORS	Undergrounding	H	4
	Reconductoring	M	4
	Covered Conductors	M	4
	Hardening/Rebuilds	L	1
 SUBSTATIONS	Substation Elevation	H	1
	Control House Remediation	H	1
	Enclosures	H	3
	Reclosers/Switchgear	M	2
	Flood Walls	M	1
	Cooling Mechanisms	M	1
 PLANNING TOOLS	Vegetation Management	H	3
	Dynamic Line Rating (DLR)	L	1
	Wildfire Planning Tools	M	1

Project Approach

Project Overview

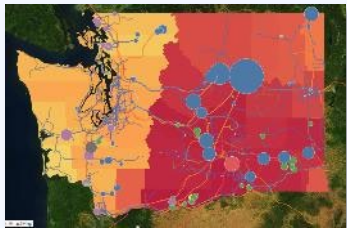
The State of the Grid Report will provide recommendations and insights into most effective **resilience projects, highest risk locations**, and strategies for **improving capital spend efficiency**

1 STATE OF THE GRID REPORT | BENEFITS



Improved understanding of **how extreme weather impacts outage and ignition rates** in your service territory

DELIVERABLE | EXTREME WEATHER ANALYSIS



Analyze 5 years of publicly available extreme weather and outage data to **determine which type of events cause the largest outages and ignitions.**

Comment on expected change in outages and ignitions as a function of climate projections.

2 STATE OF THE GRID REPORT | BENEFITS



Actionable insights to **improve capital effectiveness** that addresses extreme weather risk

DELIVERABLE | INVESTMENT PLAN REVIEW



Review most recent investment plan to determine **effectiveness of normalized capital spend** in mitigating outages and ignitions from extreme weather.

Results will be anonymously compared with other participants to help outline resilience best practices and most effective mitigations.

Baringa is conscious of data privacy and sensitivities and is more than willing to work with your team to address concerns.

Extreme Weather Outage Analysis

Project Overview

Severe outages were mapped to corresponding weather events to better understand which forms of extreme weather are driving customer interruptions and how utilities can respond

DEFINE EXTREME WEATHER EVENTS Purpose: Begin with a definition of extreme weather to focus on the most impactful events. Definition: weather events are considered extreme if they are above the 90th percentile of severity for that state. Data: Western Regional Climate Center (WRCC) Time: 2018 - 2022	FILTER EXTREME OUTAGE EVENTS Purpose: Define extreme outage events to highlight highest cost outages Definition: outage events are considered extreme if: At least 50% OR >30,000 of customers are out in a single county *modified from Oak Ridge National Labs definition Data: EAGLE-I Time: 2018 - 2022	ANALYZE EVENT COINCIDENCE Purpose: Identify the extreme outages that occur at the same time as extreme weather events. Analysis Areas: • WECC Overview • Most Impactful Hazard Analysis • Hazard by Total Interruptions (Pareto Chart) • Spatial Analysis • Historical Ignition Analysis • Hazard Deep Dives	DETERMINE ASSET PLANNING INSIGHTS Purpose: Provide implications for asset planning and funding priorities Example Insights • Historical severe outage locations • Historical extreme ignitions • Historical primary drivers of outages • Distribution of outages across hazards • Design standard implications
KEY WEATHER EVENTS WILDFIRE WINTER STORMS SUMMER STORMS WINDSTORM EXTREME PRECIPITATION RAINSTORM EXTREME HEAT EXTREME COLD FLOOD			

Weather events were mapped to raw data to capture both single hazard and multi-hazard events. Events are considered extreme if the raw data is above the 90th percentile for the state

WEATHER EVENT		PRESENT WEATHER METRICS (Above 90 th percentile)
	EXTREME COLD	Min Temperature
	EXTREME HEAT	Max Temperature
	WILDFIRE*	Fire Weather Index (FWI)
	EXTREME PRECIPITATION	Precipitation

WEATHER EVENT		PRESENT WEATHER METRICS (Above 90 th percentile)
	WIND STORM	Wind
	RAIN STORM	Wind + Precipitation
	SUMMER STORM	Wind + Precipitation + Max Temperature
	WINTER STORM	Wind + Precipitation + Min Temperature
	FLOODING	Surface Runoff

*Outages occurring within two days of a documented wildfire ignition in the county of origin were also attributed to wildfire, overriding other hazard combinations

Mapping outages to weather events more accurately captures the impact of coincident hazards, avoids double counting outages, and allows for flexible event definitions



Coincident Hazards

- **EXPLANATION:** Mapping to events captures unique threats posed to assets from coincident hazards
- **BENEFIT:** Multiple hazards occurring simultaneously can have different impacts on assets than considering each individually (e.g. coincident wind and snow/ice contributes to line galloping, wind and extreme heat could increase probability of vegetation contact given line sag due to heat).



No Double Counting

- **EXPLANATION:** Variable combinations are mapped to specific events
- **BENEFIT:** Ensuring that other hazards are below the 90th percentile isolates the most important hazards. Just looking at one hazards could capture outages that are actually attributable to other hazards.



Flexible Event Definitions

- **EXPLANATION:** Multiple different hazard combinations can be mapped to the same weather event given similar impacts to assets
- **BENEFIT:** Mapping to events allows for historical ignitions and extreme fire weather to be mapped to the same category, as both reflect ignition potential and can be addressed by similar upgrades.

Outages were classified as “severe” if more than 50% of customers OR more 30,000 customers in a given county are out at a single point in time

1 OUTAGE EVENT HANDLING



Define outage events to analyze coincidence with weather events and avoid double counting

METHODOLOGY

- 1 In a new column, assign “y” if “Customers Out” entry >0 in the data row, “n” if “Customers Out” = 0
- 2 Assign a unique event number to each string of consecutive “y” entries, separated by at least one “n” entry
- 3 For each unique event, keep the row with the maximum “Customers Out” value

DATASET | EAGLE-I



Comprehensive outage dataset from 2014-2022 created through a partnership between Oak Ridge National Lab and the U.S. DOE



Data is collected from utility’s public outage maps and provides 92% coverage of US and Territories

2 SEVERE OUTAGE CLASSIFICATION



Define “severe” outages in order to determine which weather events are coincident with the costliest outages in the state

DEFINITION

At least 50% of customers out in a given county

OR

At least 30,000 customers out in a given county

*whichever is less

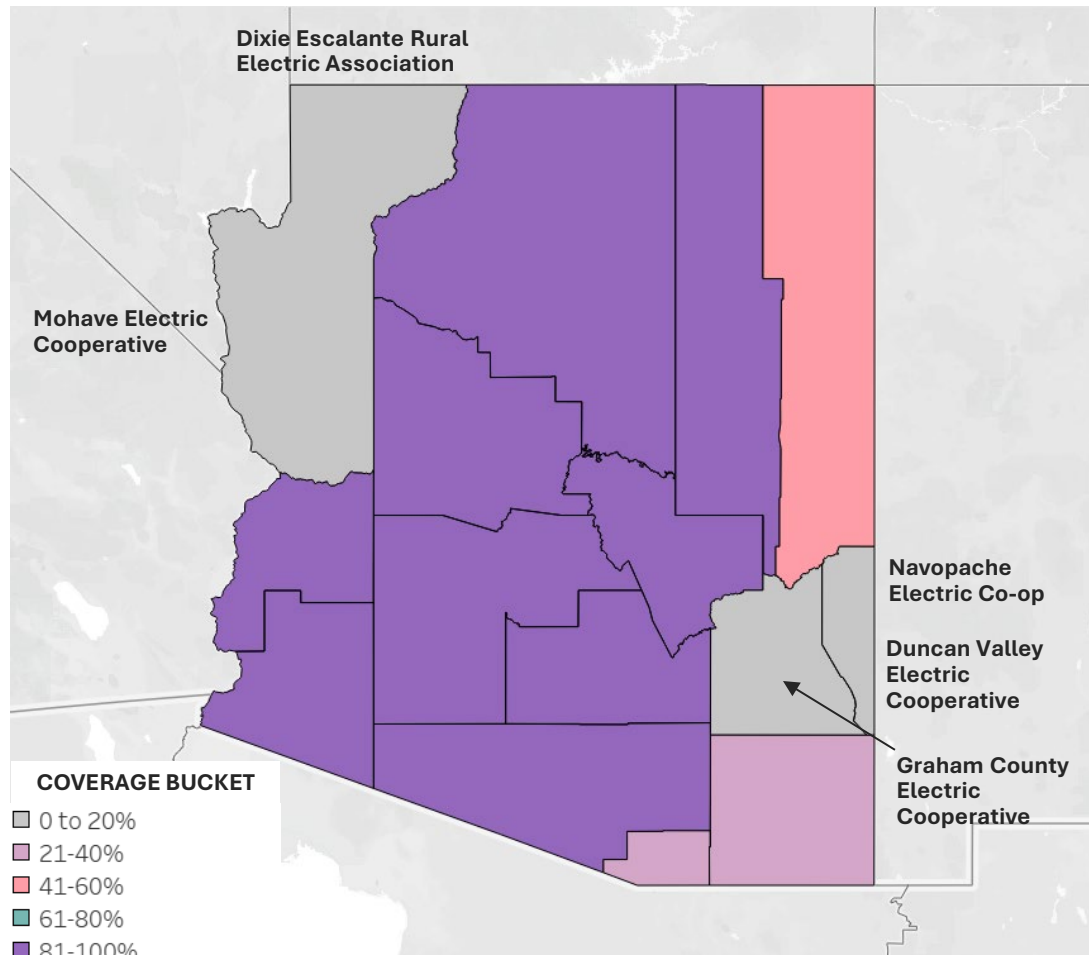
SEVERE OUTAGES | JUSTIFICATION

Draws on ORNL’s “Analysis of Historical Power Outages in the United States and the National Risk Index,” in which the researchers determined the 30,000 customer metric as a conservative threshold to isolate extreme, weather-cause events

While ORNL uses a 15% customer outage threshold, we have increased it to 50% for this analysis to focus our insights on how to address the costliest and most severe outages in the state

The EAGLE-I dataset provides coverage for 91% of AZ customers, but is missing data from cooperatives in the NW and SE corners of the state

EAGLE-I CUSTOMER COVERAGE (%) (AZ, 2018-2022)



*Relative to other counties within the state

INSIGHTS

Outage data generally has better fidelity in the central portion of the state

- These counties likely have better outage coverage given their higher populations and service from IOUs
- Rural cooperatives throughout the state generally have the worst outage coverage in the EAGLE-I dataset

Counties with sparse outage coverage only account for 9% of customers within the state

- Over 91% of customers in the state are covered in the EAGLE-I dataset
- Insights surrounding the volume of customer interruptions in the state will be aligned with real world exposure

Additional consideration could be given to the hazards faced by counties without outage data

- The weather events driving outages in counties without data will be underrepresented in this analysis
- While this may not have a large impact on the distribution of the volume of customer interruptions, it could significantly change the distribution of the count of outages associate with different hazards

KEY HAZARDS IN UNDERCOVERED AREAS (FROM GRR)*

- SE Counties: Extreme Cold,
- Mohave County: Wind, Extreme Heat, Wildfire

WECC Summary

Windstorms are often the primary driver of customer interruptions in WECC, especially among smaller counties, but heat, wildfire, and rainstorms drive many interruptions along the coast

INSIGHTS

Windstorms are the most common primary driver of customer interruptions across WECC

- This is especially true among states in the eastern portion of the region such as Montana, Wyoming, and Colorado
- Wind is frequently the primary driver for counties with relatively fewer customer interruptions, indicating that it has an outsize impact on rural communities with radial networks and more overhead line mileage

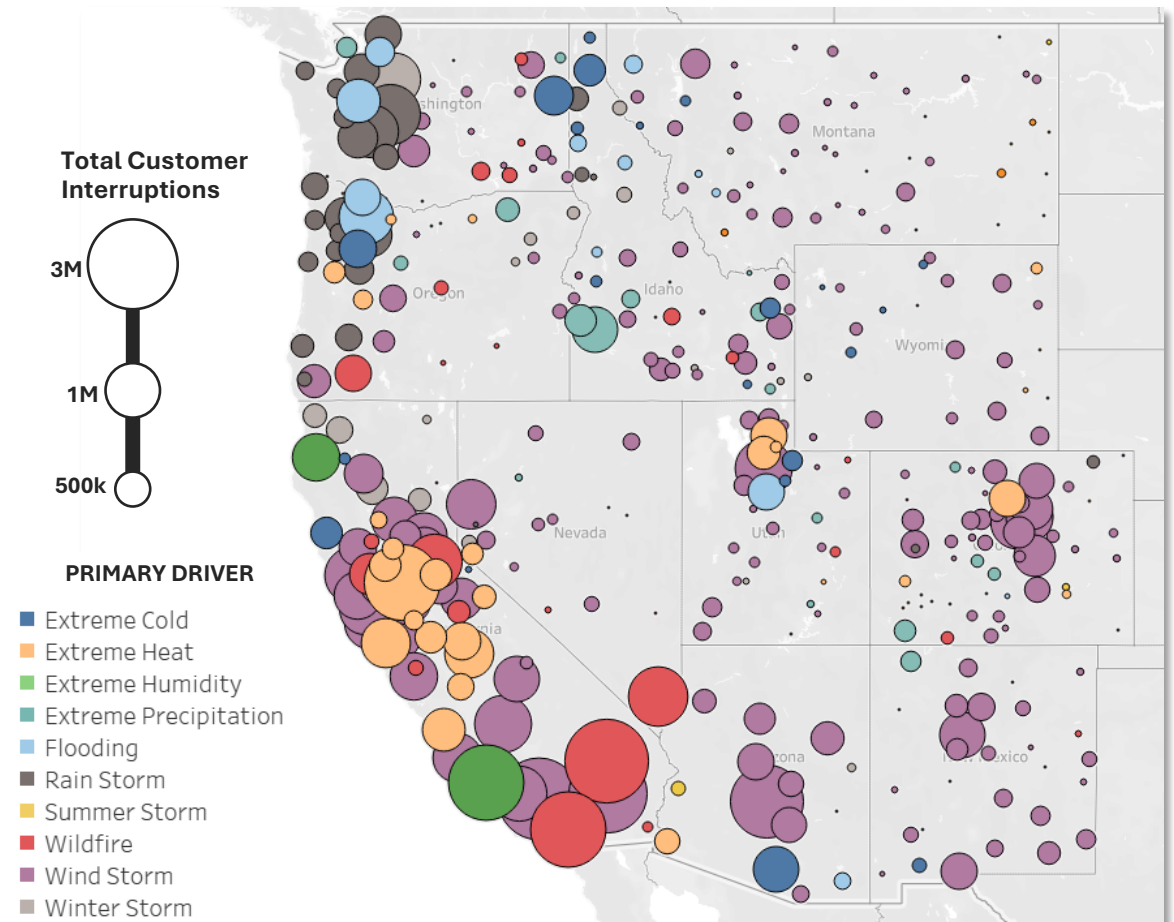
A higher volume of total customer interruptions is generally concentrated along the coast

- More populous counties in CA, WA, and OR drive a higher volume of customer interruptions
- Coastal states demonstrate a wider range of primary driving hazards, including wildfire, extreme heat, flooding, and rainstorms

Extreme heat and wildfire are primary drivers of customer interruptions even in northern counties of the state

- While the northern portions of the state generally face less heat and wildfire exposure, these hazards are still driving customer interruptions because grid infrastructure could be less prepared for these events
- Per Baringa's Grid Resilience Reports, heat and wildfire exposure is projected to increase across the region out to mid- and end-century, potentially justifying hardening in historically less-exposed regions where this change will be most dramatic

PRIMARY DRIVER OF CUSTOMER INTERRUPTIONS BY COUNTY
(WECC, 2018-2022)



State Summary

Arizona



High winds and extreme heat account for the majority of customer interruptions during extreme outage events, but wildfires often cause more severe outages at the county level

HAZARD INSIGHTS

Summer storms drive a substantial number of customer interruptions on the Arizona grid

- Weather events with concurrent >90th percentile wind gust speeds, maximum temperatures, and precipitation drive about 30% of customer interruptions resulting from extreme outages
- The high volume of interruptions from windstorms and extreme heat indicate that these two components of summer storms could be prioritized for additional investment, as precipitation is less likely to be the key outage driver
- The AZ GRR projects increasing heat exposure out to mid- and end-century, further justifying additional investment to address this hazard

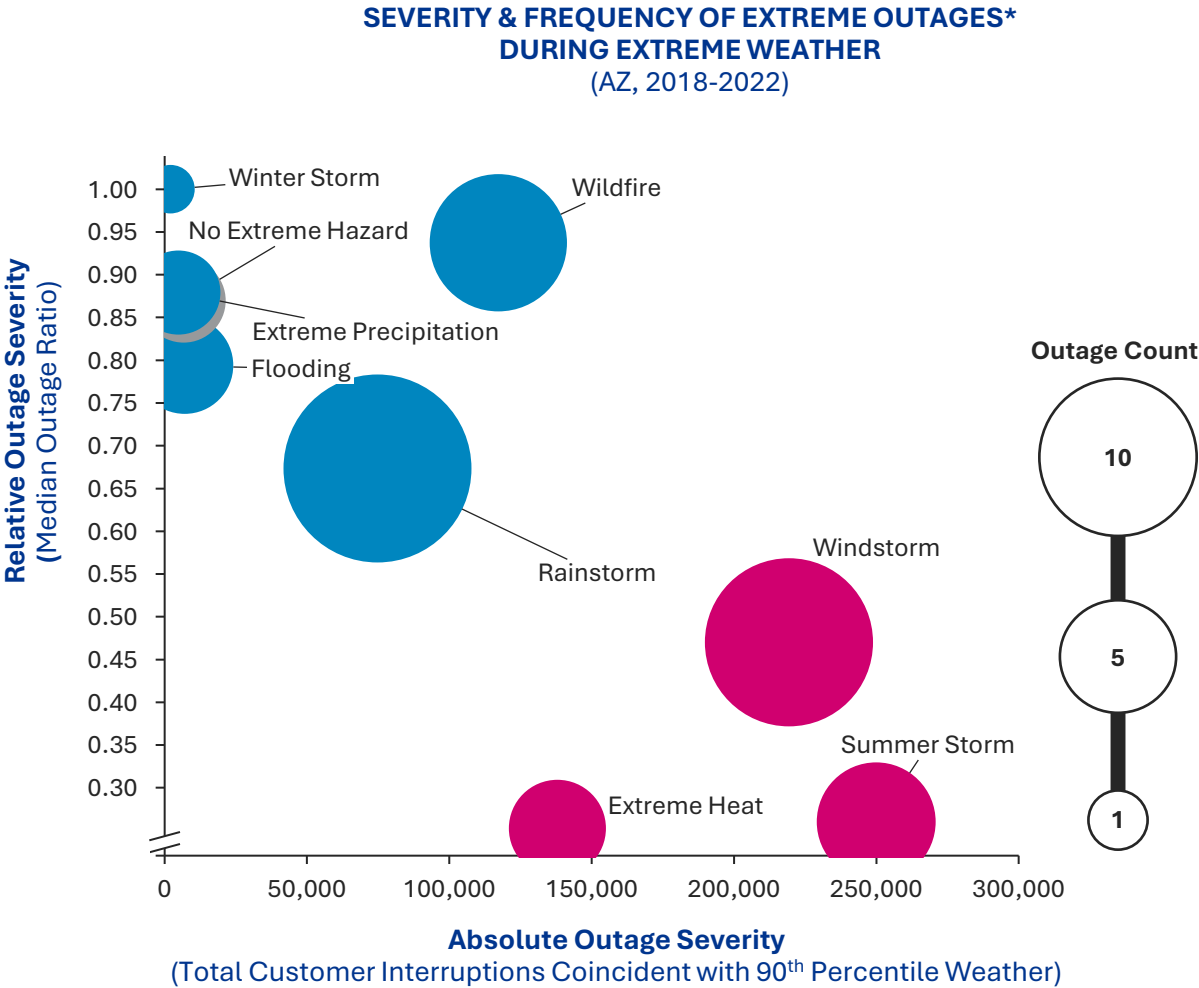
Extreme heat and summer storms are concentrated in highly populated counties

- The high volume of customer interruptions from these events combined with low event counts and median outage ratios indicates that they typically occur in more populated counties, such as Maricopa County
- Wildfire events could be monitored given their high median outage ratio, indicating that they often drive outages impacting the majority of a county

MOST IMPACTFUL HAZARDS		FUTURE OUTLOOK**	EVENT COUNT	MED. OUTAGE RATIO	TOTAL CUST. INTS.	AVG. CUST. INTS. / EVENT
	Summer Storm	↑ FURTHER RESEARCH NEEDED ↑	6	.26	249,956	41,659
	Windstorm		12	.47	219,306	18,275
	Extreme Heat		4	.25	137,963	34,491

*A severe outage is defined as one in which >50% of customers in a county are out simultaneously, or at least 30,000 customers in a county experience an outage simultaneously, whichever is less

**Future outlook for the hazard severity based on Baringa's Grid Resilience Report, completed as part of phase 2 of this analysis (Insert link to the GRR here)



The majority of customer interruptions are concentrated among a few key weather events, including summer storms, windstorms, and extreme heat

OUTAGE INSIGHTS

Customer interruptions resulting from severe outages are highly concentrated among a few key weather events

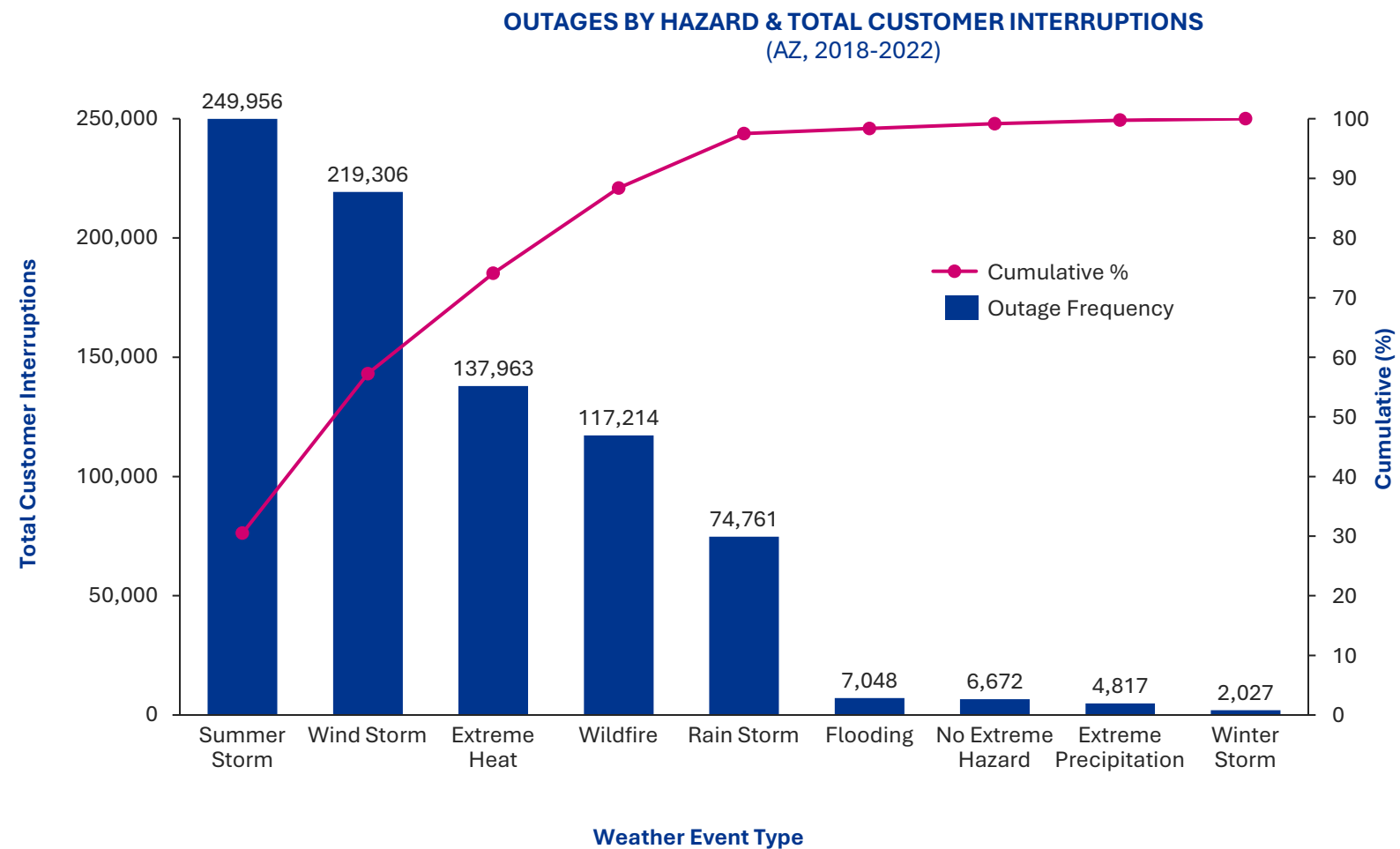
- The top 3 weather events (summer storms, windstorms, and extreme heat) account for about 74% of all customer interruptions from extreme outages
- The top 5 events account for 97% of such interruptions, justifying a statewide resilience focus on this group of weather events

Extreme weather drives a high percentage of extreme outages in the state

- About 1% of extreme outages were not coincident with at least one extreme weather variable, a much lower percentage than other states in WECC
- Indicates that extreme weather drives an outsized portion of severe outages in AZ and system hardening/weatherization should be a priority

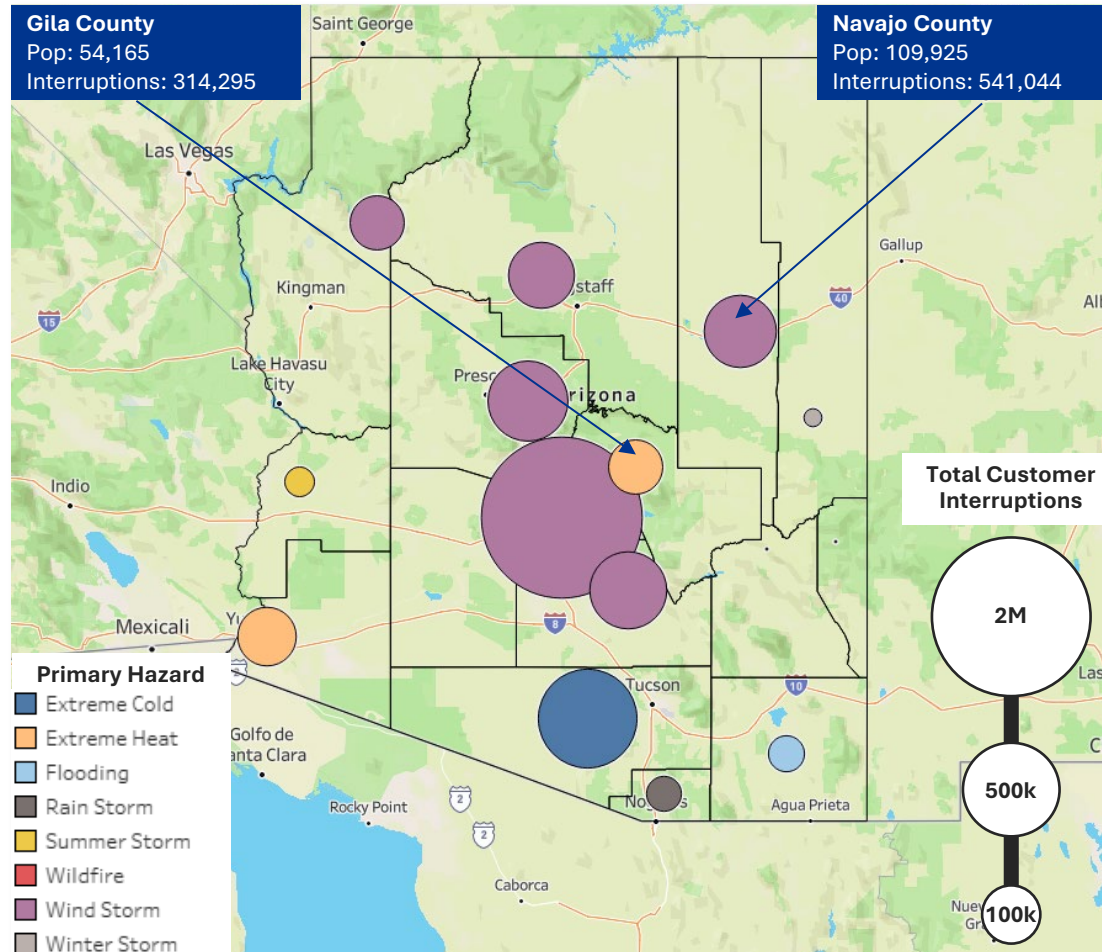
Utilities could consider which events impact their climate zone

- Variable climate across the state indicates that local analysis is needed to determine the highest priority events at the utility level
- Conducting asset-level vulnerability studies with forward-looking climate data is critical to maintaining spend alignment through changing weather patterns



Wind and flood drive an outsized number of customer interruptions in NW counties, accounting for population, while S counties experience fewer interruptions than expected

PRIMARY DRIVER OF CUSTOMER INTERRUPTIONS BY COUNTY (AZ, 2018-2022)



INSIGHTS

Windstorms are the most common primary driver of customer interruptions across Arizona counties, especially in the north-central region

- Windstorms drive a high volume of interruptions across highly populated counties in the central region of the state

Summer storms are more likely to result in extreme outages than other hazards

- Despite leading in customer interruptions from severe events, summer storm's minimal representation on this map indicates that a larger share of its total customer interruptions are derived from extreme outages compared to other hazards

Extreme cold drives outages in Pima County

- While Pima County does not face significant cold exposure, the high volume of cold-related outages indicates that the grid may not be properly equipped to deal with this hazard, warranting further investigation

Gila and Navajo Counties experience a high volume of outages relative to population

- Indicates that the grid is generally less reliable in these regions of the state, as they face close to state-average extreme weather exposure
- Navopache Electric Co-op has service territory in both of these counties and could be prioritized for assistance

PRIMARY DRIVER METHODOLOGY

1. Map weather variable combinations to event definitions (see slide 15)
2. Count the number of total customer interruptions at the county level (> 0 customers out) coincident with 90th percentile or greater weather variables for each of the combinations associated with a weather event
3. Deem the event with the most coincident interruptions as the "primary driver"

Sparsely-populated counties with significant climate exposure tend to experience the greatest number of customer interruptions per capita

- Counties with more customer interruptions per customer tend to be among the least populated in the state, as they likely have a large volume of overhead, radial distribution infrastructure that is particularly vulnerable
- Gila and La Paz counties contain large swathes of mountain ranges and deserts respectively, potentially contributing to elevated outage levels

Extreme heat generally drives outages across the least reliable sections of the Arizona grid

- Extreme heat was found to be the primary driver of outages in Gila and La Paz Counties (see slide 24)
- Extreme heat exposure in these counties is projected to intensify out to mid- and end-century, per Baringa's Grid Resilience Report, further justifying investment

IOUs serve both the most reliable and least reliable counties in the state

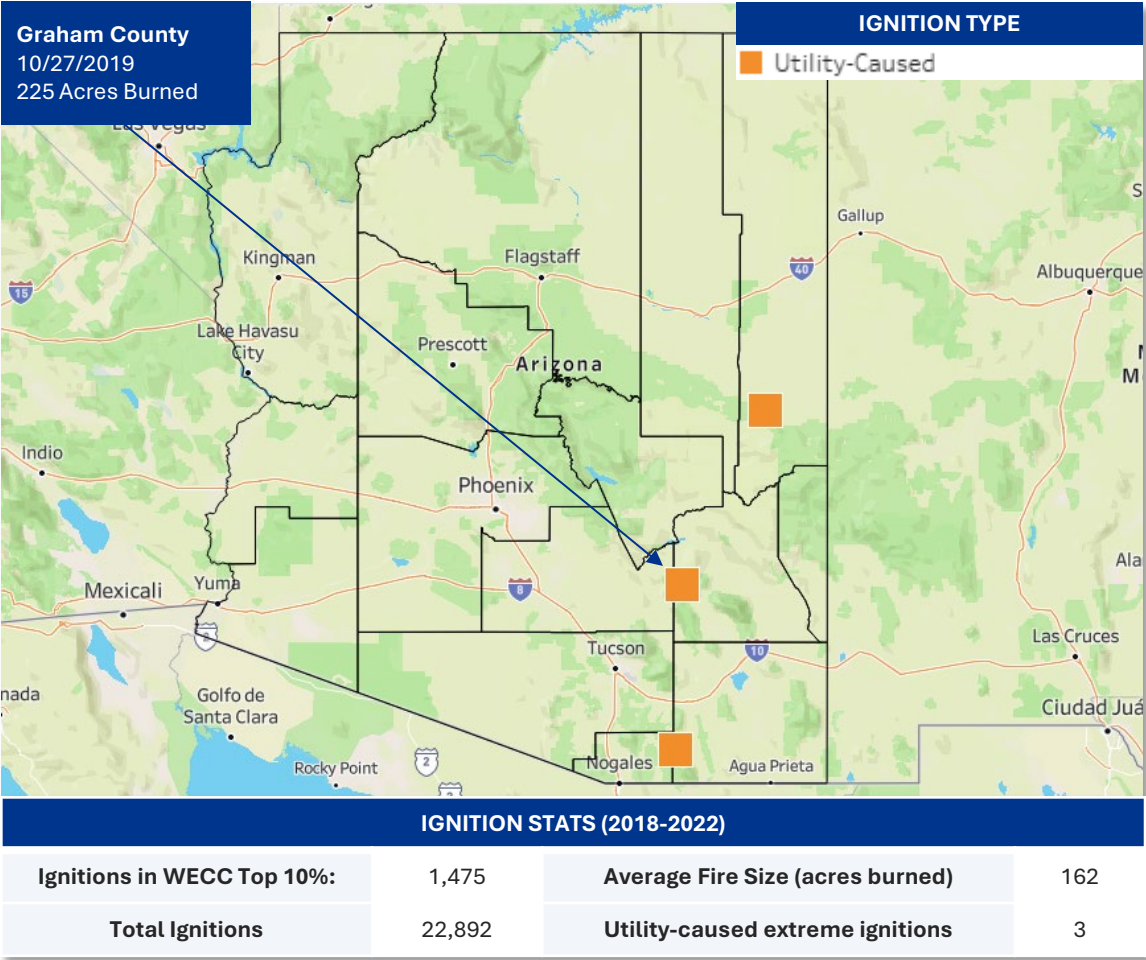
- Arizona Public Service's territory includes Maricopa County, which has the lowest volume of interruptions/customer, as well parts of La Paz and Gila Counties, which exhibit the highest volume of interruptions per capita
- This indicates that population density and climate exposure are better indicators of reliability than utility type, although a clearer correlation with utility type may become apparent with improved outage data

METHODOLOGY

1. Calculate the total number of customer interruptions that occur in a particular county, ensuring outage events are not double counted
2. Divide this number by EAGLE-I's "covered customers" metric for the county

While utility-caused ignitions are concentrated in cooperative service territories in the southeastern portion of the state, Arizona had the fewest utility-caused ignitions in WECC

UTILITY-CAUSED, TOP 10% IGNITIONS BY ACRES BURNED (AZ, 2018-2022)



INSIGHTS

- Utility-caused ignitions are concentrated in southeastern portion of the state, specifically in the service territories of cooperatives
- This diverges from Baringa’s Arizona Grid Resilience Report, which found the western portion of the state to be most highly exposed to wildfire
 - Utility-caused ignitions are likely concentrated in this region as it is sparsely populated, indicating there could be a high volume of aging overhead distribution infrastructure that is inspected/maintained infrequently
 - The ignitions are also consolidated in cooperative service territories, which face less stringent wildfire regulation, own more assets per customer, and may have fewer resources for wildfire mitigation
- Arizona has relatively fewer utility-caused ignitions compared to other states in WECC
- Arizona’s three recorded utility-caused ignitions are the lowest in WECC from 2018-2022, far below the average of 16
 - Arizona’s high levels of wildfire exposure make this state more significant

IGNITIONS METHODOLOGY

- Historical ignition data was collected from the FPA-FOD and the WFIGS Interagency Fire Perimeter Database
- We filtered out the **top 10% of ignitions by fire size across states in WECC**
- The map at left depicts these top 10% ignitions that also listed **“Power generation/transmission/distribution” as their NWCG cause code**
- The red boxes denote top 10% utility-caused ignitions that were also coincident with a severe outage in the ignition county within 2 days of the discovery date

Extreme outages are generally attributable to higher wind speeds, but a high coincidence of outages with low wind speeds indicates vegetation contact could be driving many outages

UNDERSTANDING THE DATA

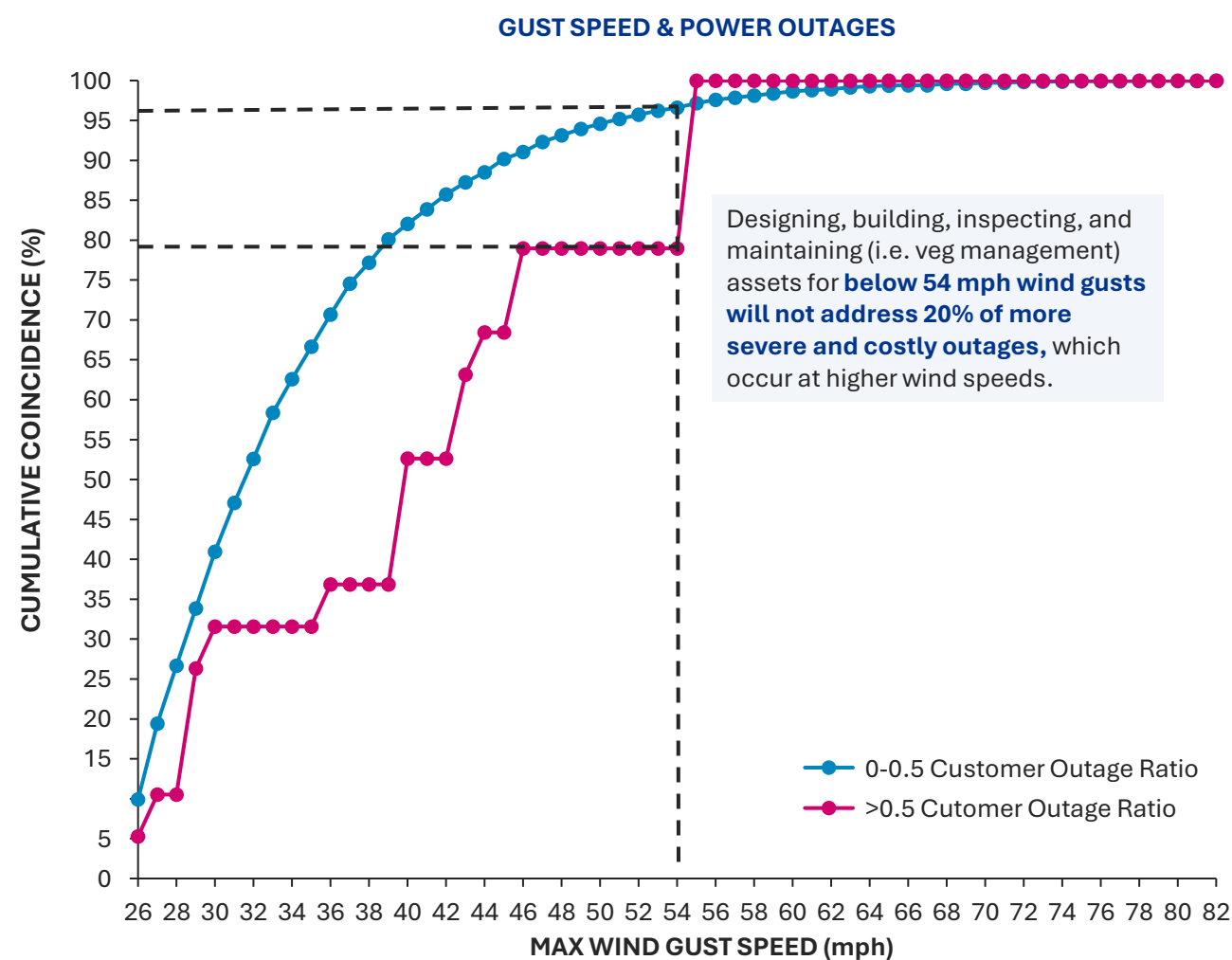
Extreme outages (>50% of customers out) are more likely to be coincident with high wind gusts than non-extreme outages

- About 20% of extreme outages are attributable to wind speeds above 54 mph, compared to just 5% of non-extreme outages
- Below 30 mph the outage curves are relatively aligned, indicating the severity of outages occurring at these wind speeds is likely more sensitive to vegetation density than to wind speed directly

ASSET PLANNING INSIGHTS

Prioritizing vegetation management and active inspection could address a significant portion of wind-driven outages

- Almost 80% of extreme outages and 95% of non-extreme outages occur below 50 mph wind speeds, which are more likely attributable to vegetation contact or aging equipment rather than direct failure
- Outages are coincident with wind speeds up to 81 mph, which could serve as an important threshold for planning and design
- **Low-Cost:** Pole Reinforcement (Trussing, Guy Cables, Concrete Base, etc.), Pole Material Upgrades, Decreased Spans, Vegetation Management
- **High-Cost:** Undergrounding



Designing and inspecting assets above the 99th percentile summer storm, particularly the wind and precipitation thresholds, could be necessary to address the most extreme outages

UNDERSTANDING THE DATA

Extreme outages (>50% of customers out) are more likely to be coincident with more severe summer storms

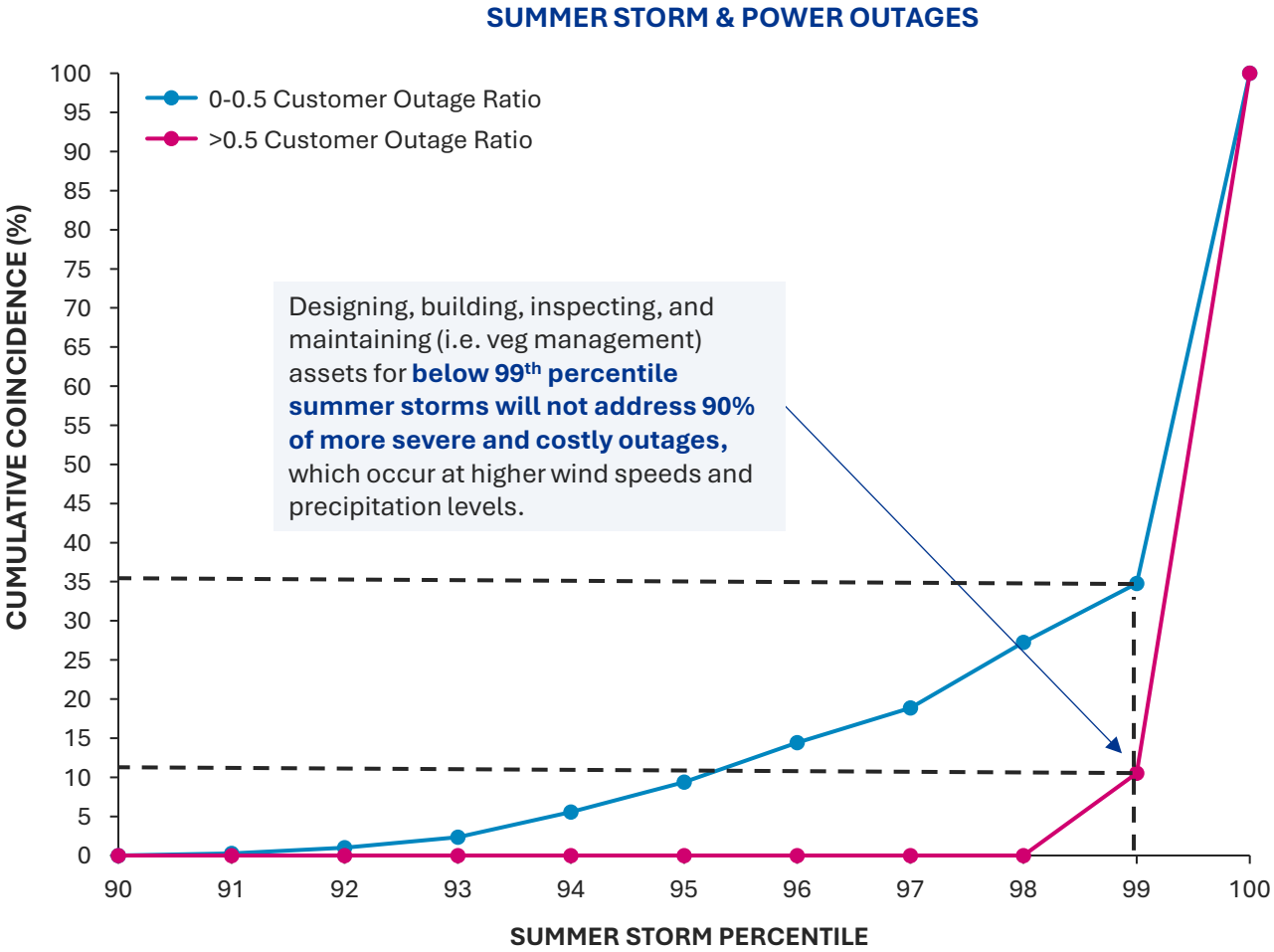
- Almost 90% of extreme outages are coincident with rainstorms in the 99th percentile or greater, compared to about 65% of non-extreme outages
- Precipitation and wind are the largest drivers of this gap at the 99th percentile, indicating that failures causing extreme outages are likely the result of lightning strikes or vegetation contact

ASSET PLANNING INSIGHTS

Targeted vegetation management could address a majority of wind-caused outages, but upgrades addressing lightning strikes may also be necessary to prevent extreme outages from monsoon thunderstorms

- Low-Cost:** Pole Reinforcement (Trussing, Guy Cables, Concrete Base, etc.), Pole Material Upgrades, Decreased Spans, Vegetation Management, Lightning Arresters/Grounding
- High-Cost:** Undergrounding

HAZARD	PRECIP	GUST SPEED	MAX TEMP
99TH PERCENTILE	0.04 (in.)	42 (mph)	102 °F



Extreme outages do not demonstrate an increasing sensitivity to temperature, but significant statewide exposure could justify continued investment to address outages of all severities

UNDERSTANDING THE DATA

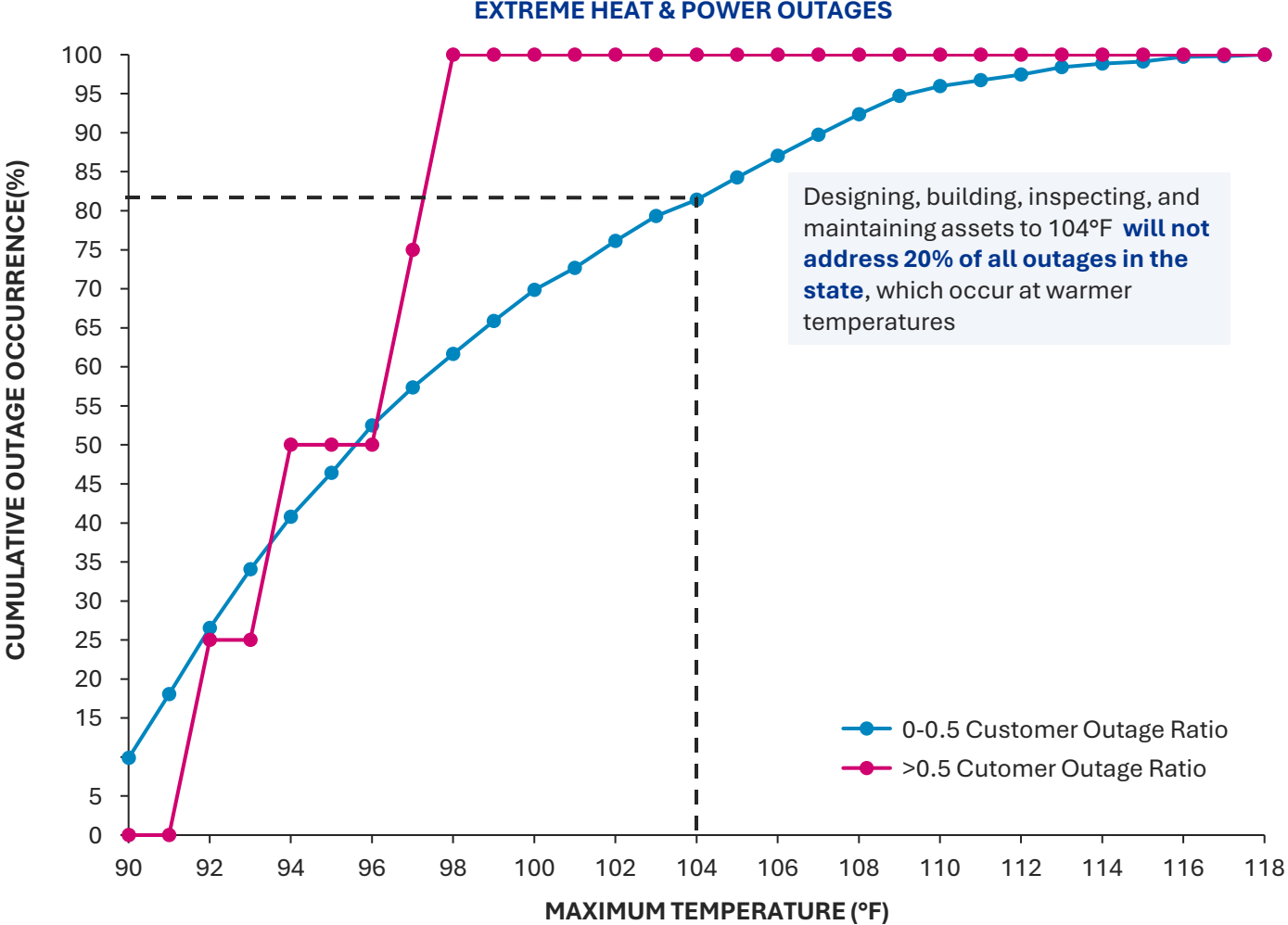
Non-extreme outages are generally more responsive to heat than extreme outages

- Part of this is the result of a small sample size of extreme outages caused by heat (4), which may not accurately reflect the typical distribution
- Extreme outages appear more sensitive to extreme heat during summer storm events, but even then, it is less impactful than wind and precipitation, corroborating this trend

ASSET PLANNING INSIGHTS

Escalating extreme heat risk could justify additional investment to address outages of all severities

- About 20% of all outages occur above 104 °F , which is an important threshold given substation transformers and other critical equipment can fail when exposed to two consecutive days above this temperature¹
- In addition to driving equipment failure, extreme heat can contribute to capacity violations due to increased load and heat-related line sag can cause vegetation contact
- **Low-Cost:** Monitoring and sensors, demand response, vegetation management
- **High-Cost:** Undergrounding, backup power systems, capacity and transformer upgrades



Utility Capital Plan Review

Project Overview

Background & Approach

We have a total of 12 utilities across WECC participating in this analysis, 5 public power, 5 cooperatives, 2 investor-owned utilities

STATE	UQID
California	PUBLIC-1
Arizona	PUBLIC-2
Washington	PUBLIC-3
Nevada	PUBLIC-4
Washington	PUBLIC-5

STATE	UQID
Colorado	COOP-1
New Mexico	COOP-2
Oregon	COOP-3
Utah	COOP-4
Wyoming	COOP-5

STATE	UQID
Montana	IOU-1
New Mexico	IOU-2

Severe outages were mapped to corresponding weather events to better understand which forms of extreme weather are driving customer interruptions and how utilities can respond



ANALYZE 2024 UTILITY CAPITAL PLANS

Purpose: Review projects listed in capital plans and categorize into standardized buckets of utility spending



MAP RESILIENCE INVESTMENTS TO HAZARDS

Purpose: Determine which types of investments mitigate or adapt the utility network to certain extreme weather events



ASSESS INVESTMENTS-EXPOSURE ALIGNMENT

Purpose: Normalize spend across relevant utility metrics and determine the degree to which capital allocation aligns with historical extreme weather exposure

CAPITAL PLAN	
Project	\$(k)
Undergrounding	900
Reconductoring	75
Substation Upgrade	500

TECHNOLOGY, PREDICTION, IMAGING

ASSESSMENT & REPAIR

SYSTEM UPGRADES

... additional spend categories in slide 34

Individual projects in utility capital plans are mapped to standardized buckets in order to compare spend between utilities

TECHNOLOGY, PREDICTION, IMAGING

ASSESSMENT & REPAIR

SYSTEM UPGRADES

... additional spend categories in slide 34

WILDFIRE

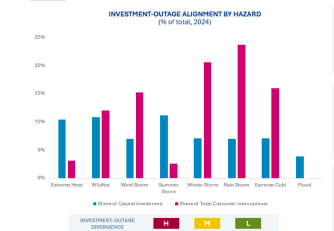
EXTREME HEAT

MAPPED TO 9 SEPARATE EVENTS

Project categories are ascribed a value as to generally how effective they are at addressing each extreme weather variable.

UTILITY INVESTMENT-OUTAGE ALIGNMENT | COOP-3

While COOP-3 has high coverage of extreme heat events, there is an opportunity to explore targeted resilience investments that address asset failures due to wind and precipitation.



INVESTMENT-OUTAGE ALIGNMENT BY HAZARD (% of total, 2024)

Legend: Blue = Capital Investment, Red = Total Customer Interruptions

Legend: Blue = Public Power, Green = Cooperative, Red = IOU

Legend: Green = L, Yellow = M, Red = H

INVESTMENT-OUTAGE DIVERGENCE

INVESTMENT-OUTAGE DIVERGENCE: L M H

The level of capital spend addressing each weather event is compared to the share of customer interruptions it drives

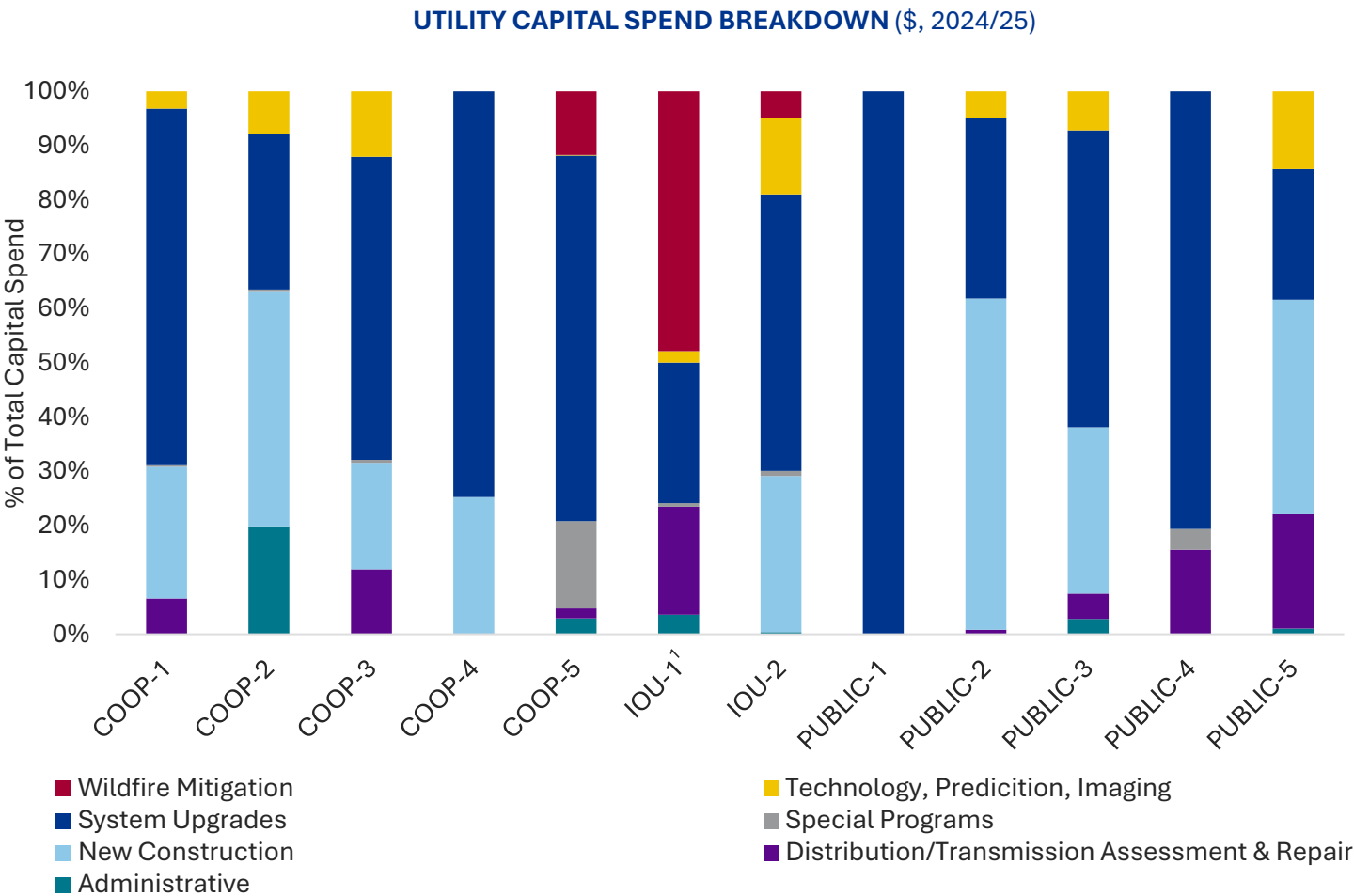


Individual projects and line items within the capital plans were mapped to larger buckets to allow for standardized comparison across utilities

CATEGORY	DEFINITION	SUBCATEGORIES
 TECHNOLOGY, PREDICTION, IMAGING	Investments in analysis and tools that improve asset management, asset planning, and operational efficiencies.	Modeling, Remote Sensing, Mapping
 ASSESSMENT & REPAIR	Investments needed to repair or replace damaged or end-of-life distribution equipment like-for-like.	Like-for-like equipment replacement
 SPECIAL PROGRAMS	Investments needed for non-traditional capital and other unique projects.	Demand Response/VPP, Wildfire Training Environmental/Ecological Protection
 SYSTEM UPGRADES	Investments in existing assets that improve the capacity, reliability, resilience, etc. of the system.	Transformer Capacity Upgrades, Pole Replacement/Reinforcement, Reconductoring Undergrounding, Voltage/Phase Upgrades
 NEW CONSTRUCTION	Investments in brand new assets and equipment.	New Lines, New Substations, New Customer Interconnection
 ADMINISTRATIVE	Investments in supporting infrastructure and processes for capital planning and operations.	Fleet, Building Remodeling, Travel, Education, Salaries
 WILDFIRE MITIGATION	Investments in system upgrades, adaptations, mitigations, that lower the likelihood of wildfire ignition and prevent damage to assets.	Investments that explicitly address wildfire risk in the capital plan.

Capital Plan Review

Cooperatives’ and public power entities’ highest categories include system upgrades and new construction, while IOUs generally spend more on wildfire mitigation



ALL UTILITIES

- System upgrades make up a significant portion of capital spending across all utility types, indicating that resilience is a key focus area
- Many utilities are also spending substantially on new construction, increasing capacity to serve new customers and large loads
 - This corroborates recent data showing new transmission and distribution expenditures driving the bulk of utility spending increases in recent rate cases

COOPS

- Cooperatives typically prioritize system upgrades in their capital allocation, demonstrating a prevalence of aging equipment and focus on resilience

PUBLIC POWER

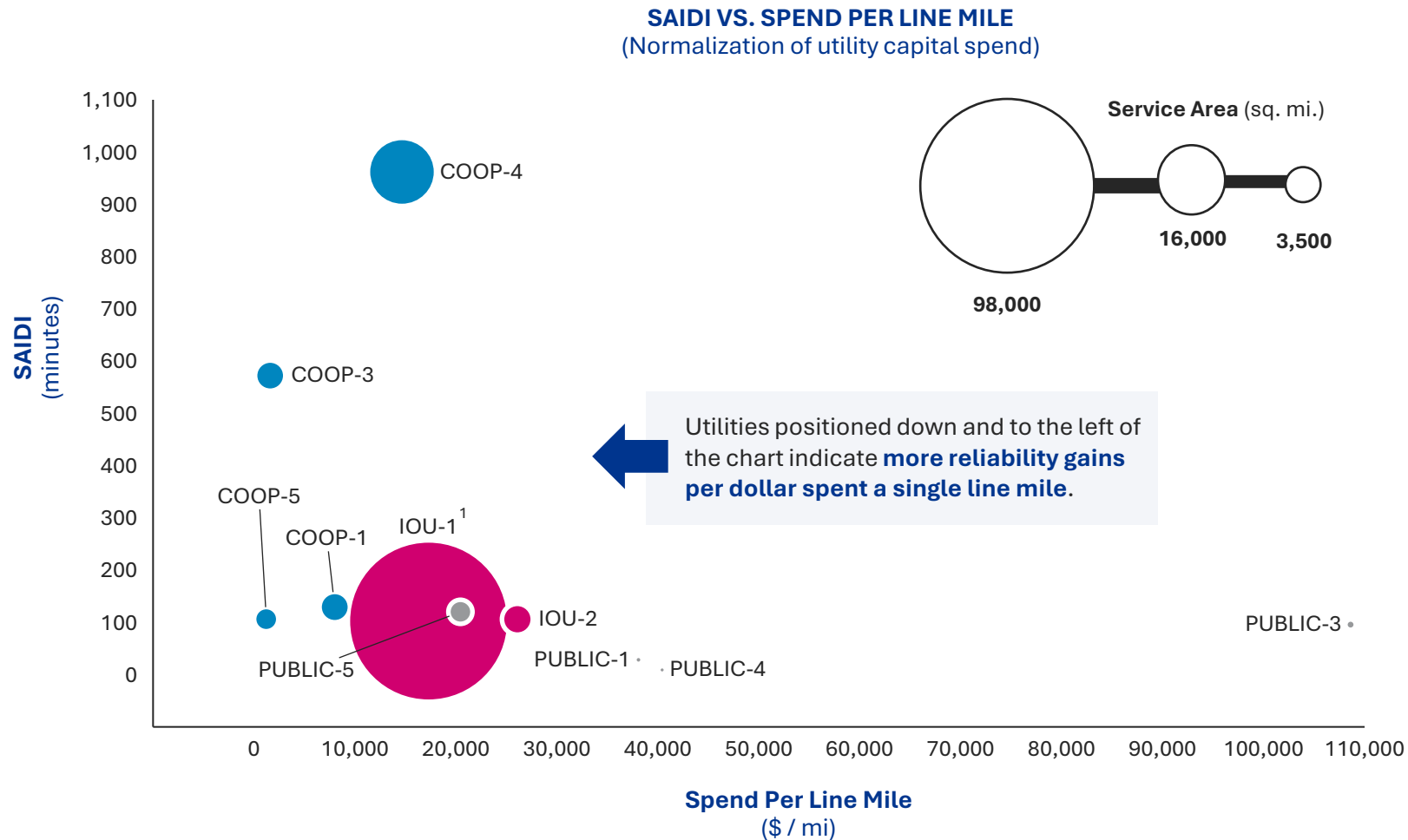
- Public power entities spend significant sums on both system upgrades and new construction and often have extensive undergrounding programs

IOUs

- Generally spend more on wildfire mitigation given the commonplace requirement to file Wildfire Mitigation Plans (WMPs) with the PUCs

1 IOU-1 provided their Wildfire Mitigation Plan rather than their exhaustive capital plan, resulting in a high percentage of wildfire mitigation spending

Cooperatives spend less per line mile, while public power entities are generally more reliable; IOUs fall somewhere in between these two utility types on the spend vs. reliability matrix



INSIGHTS

COOPS

- Cooperatives typically spend less per line mile, indicating lower overall spend given their medium-sized service territories
- Wide range of reliability could be driven by different levels of spend effectiveness or extreme weather exposure

PUBLIC POWER

- Public power entities have higher reliability given their smaller territories and higher percentage of underground equipment
- Less area and more expensive upgrades indicate high spend per line mile, though entities that are outliers could be spending less effectively

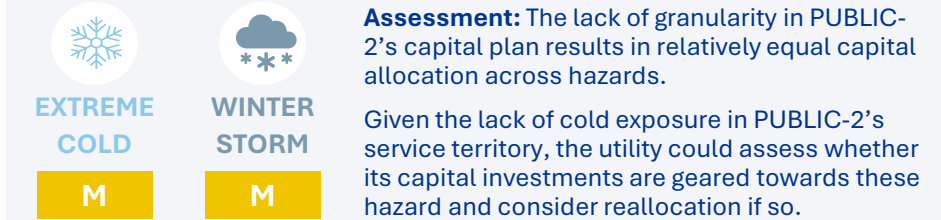
IOUs

- IOUs see both high reliability and relatively low spend per mile
- Being subject to strict oversight from a state regulator could improve IOUs' reliability and spend effectiveness
- Given their larger service territories and customer counts, IOUs could benefit from economies of scale that increase spend effectiveness (i.e. admin, procurement, etc.)

¹ An estimate of IOU-1's total capital spend was considered in this view, not just Wildfire Mitigation Plan spending

Utility Investment-Outage Alignment

HIGH COVERAGE HAZARDS



Assessment: PUBLIC-2's high percentage of undergrounded lines could result in actual exposure to summer storms and high winds being less than the level indicated by outage data.

Despite this prevalence of undergrounding, PUBLIC-2 could assess whether its “overhead distribution upgrades” category is appropriately tailored to windstorms and summer storms given they drive over 50% of customer interruptions in the surrounding area.

Assessment: PUBLIC-2 exhibits relatively less alignment between capital investment and climate exposure compared to other utilities in WECC. A high percentage investment going towards serving new customers and a lack of detail in the public-facing capital plan dilutes resilience spend and contributes to the significant misalignment.

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Utility Benchmark Analysis

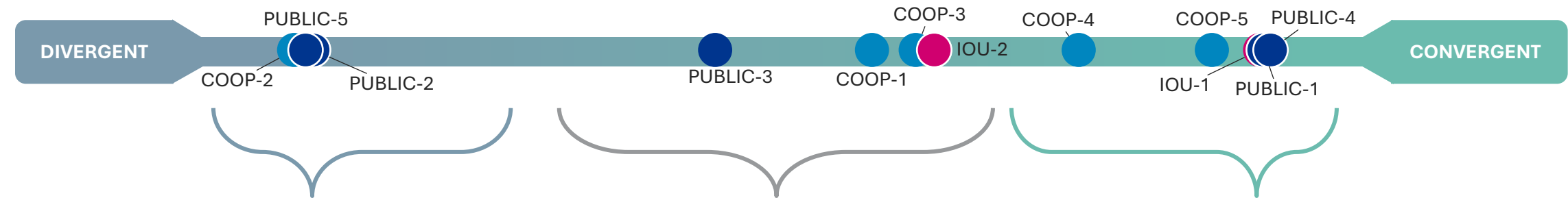
Utilities with convergent coverage are investing in upgrades that address hazards that have been historically responsible for the most severe outages in their service territory

RANKING OVERALL UTILITY COVERAGE OF EXTREME WEATHER EXPOSURE GIVEN CAPITAL INVESTMENTS

Utility Comparison Chart

Utilities that are **DIVERGENT** see a lower proportion of their capital plan cover the hazards that historically drive outages

Utilities that are **CONVERGENT** see a higher proportion of their capital plan cover the hazards that historically drive outages



REALLOCATION OPPORTUNITIES

Planning Considerations:

- Consider tradeoffs between resilience upgrades and other investments like new construction replacements
- Explore targeted investments to address hazards that historically drive outages
- Conduct asset-level risk assessment using future extreme weather data

UNCERTAIN COVERAGE

Planning Considerations:

- Investigate whether the share of customer interruptions from non-severe outages is better aligned with investment
- Conduct asset-level risk assessment using future extreme weather data to help clarify future exposure and prioritize resilience investments

INVESTMENT EXPANSION

Planning Considerations:

- Continue investment strategy to address the most pertinent hazards and prioritize resilience investments
- Pursue asset-level risk assessment to determine if current investments will continue to mitigate potential changes in most concerning hazards

Utilities in WECC generally underinvest in windstorms given their widespread severity over utility service territories. Wildfire remains a highlight hazard for continued investment.

RANKING OVERALL UTILITY COVERAGE OF EXTREME WEATHER EXPOSURE GIVEN CAPITAL INVESTMENTS

Hazard Comparison Chart

