Storms are coming

The power of predictive analytics for storm response, restoration, and outage communications

Kyle Decker, Director, Data Science

Melanie Wemple, Director, Data Science

Jesse Woods, Vice President of Strategic Accounts, Data Science

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We understand utilities because we've made them our business for more than 35 years.

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Applying predictive data science to help electric and gas utilities make data-driven decisions that improve their bottom line and increase customer satisfaction

Solution Services

Advancing business and technology solutions that strategically enhance operations for utilities

Weather's impact on reliability, customers

Weather and outages

- Largest driver of customer interruptions
- Account for 50% to 60% of US power interruptions

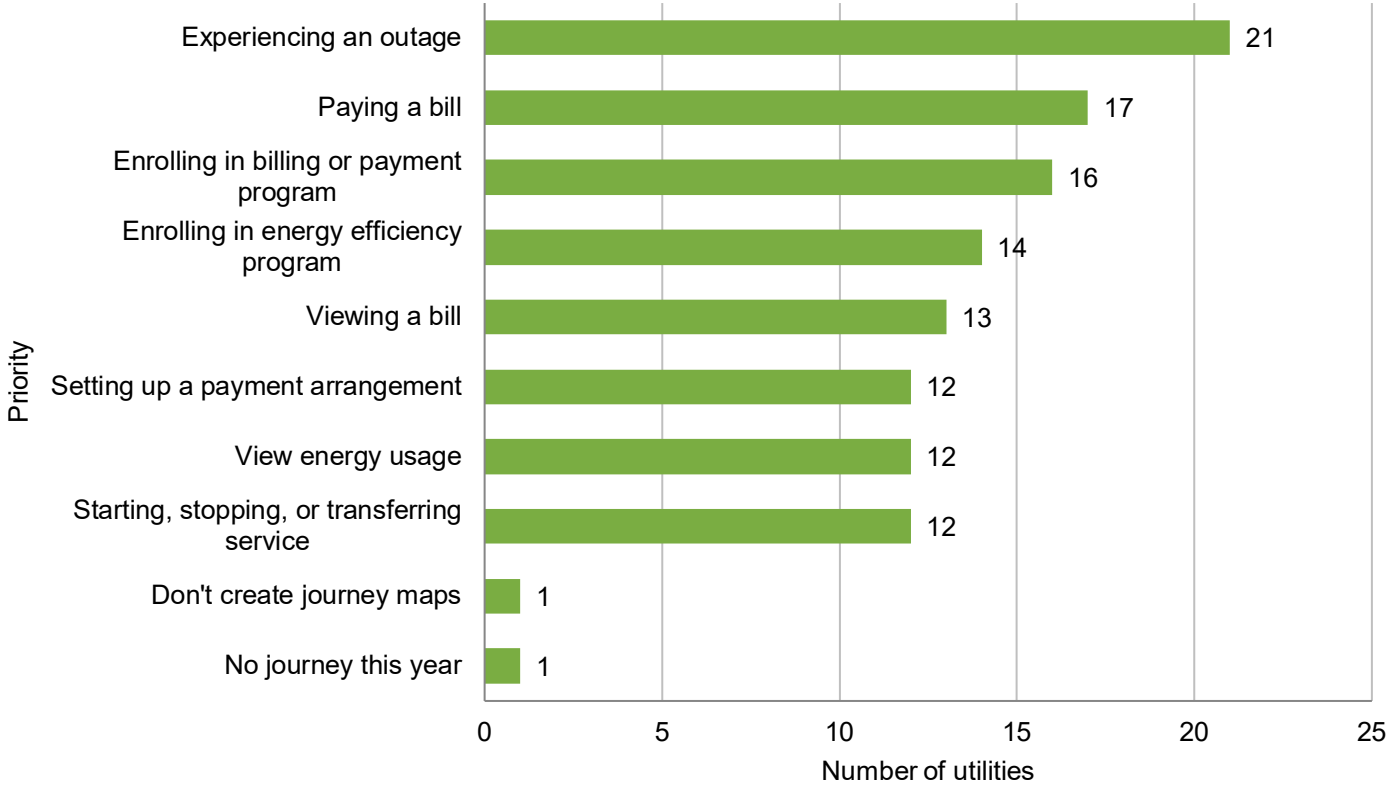
Key drivers of customer satisfaction

- Outage frequency and duration
- Timeliness, accuracy, and convenience of information during an outage

Foundations of improved reliability and customer experience

- Understanding historic impacts of weather
- Accurately predicting and accounting for future impacts

Outage customer experience (CX) is top utility priority in 2023

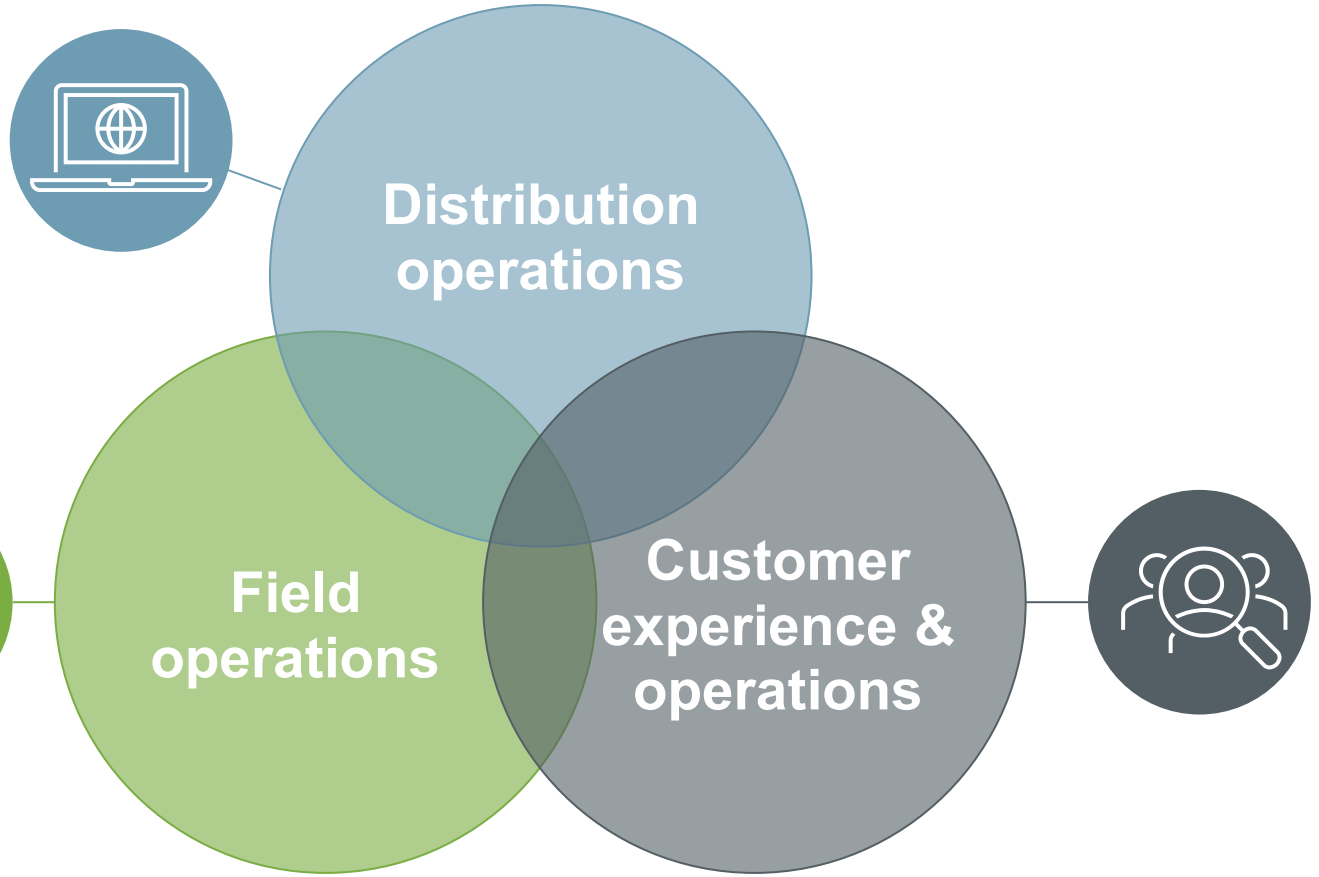


© E Source (2022 Customer Experience Survey). **Base:** n = 32 utilities. **Question S3_6:** Which customer journeys is your utility focused on improving in the coming year? Select all that apply. **Note:** We feature only the top eight journeys in this chart.

Utility CX, distribution, and field operations departments often work separately, though improving reliability, decreasing outages, and increasing customer satisfaction are shared objectives.

Our experience crosses utility enterprise

Development and application of data science models to streamline outage prediction systems, optimize crew allocation and scheduling, and prioritize vegetation management and undergrounding

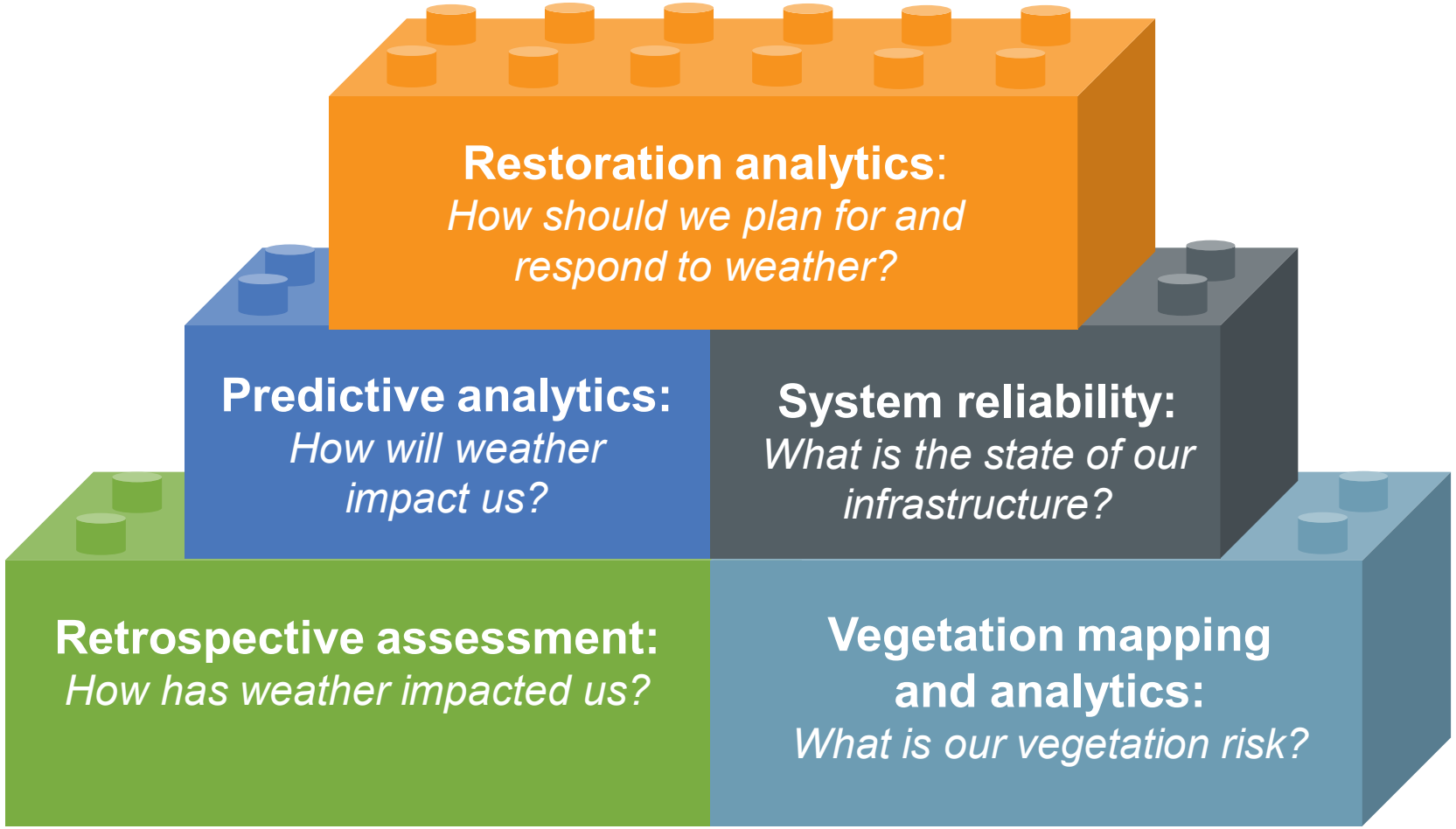


Collaborative and targeted change management strategies to help ensure that employees have proficiency and desire to adopt new practices

CX strategy development and benchmarking, including journey mapping and primary market research for vegetation management and outage experience

Weather and outage analytics

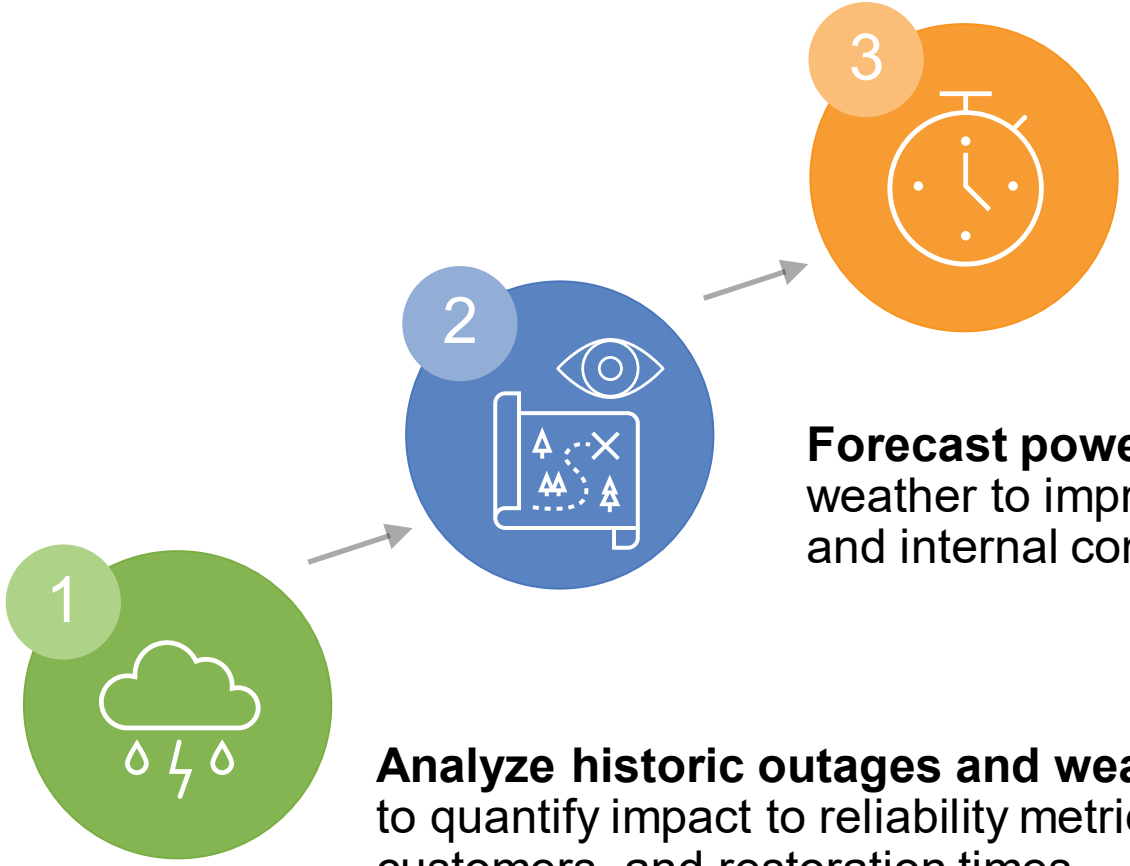
Building blocks to improved analytical results



E Source results

- 20% more accurate outage predictions compared to utility's previous method three days ahead of a storm, and 30% more accurate one day ahead
- Significantly less variability in outage predictions in days leading up to storm events
- Security of objective, data-backed estimated times of restoration (ETR) based on available personnel and outage incidents

E Source weather and outage analytics approach

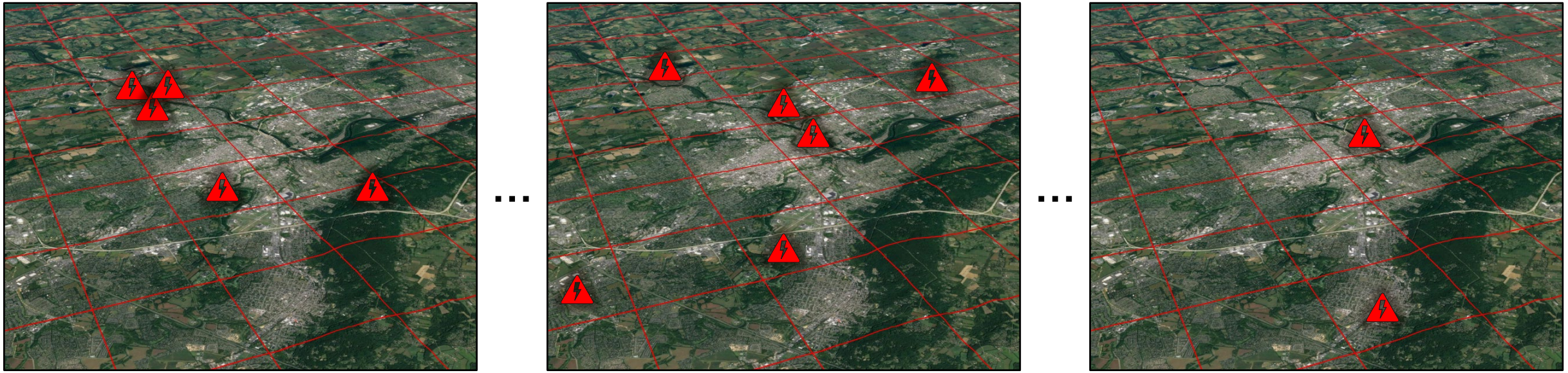


Predict restoration times based on storm impacts to inform decisions and improve customer communications after severe weather

Forecast power outages ahead of oncoming weather to improve storm-response planning and internal communications

Analyze historic outages and weather to quantify impact to reliability metrics, customers, and restoration times

Probing space and time effects



Each space-time unit can be defined by:

- Count of outages
- Temporal effects (e.g., forecasted weather, seasonality)
- Spatial effects (e.g., vegetation and infrastructure)

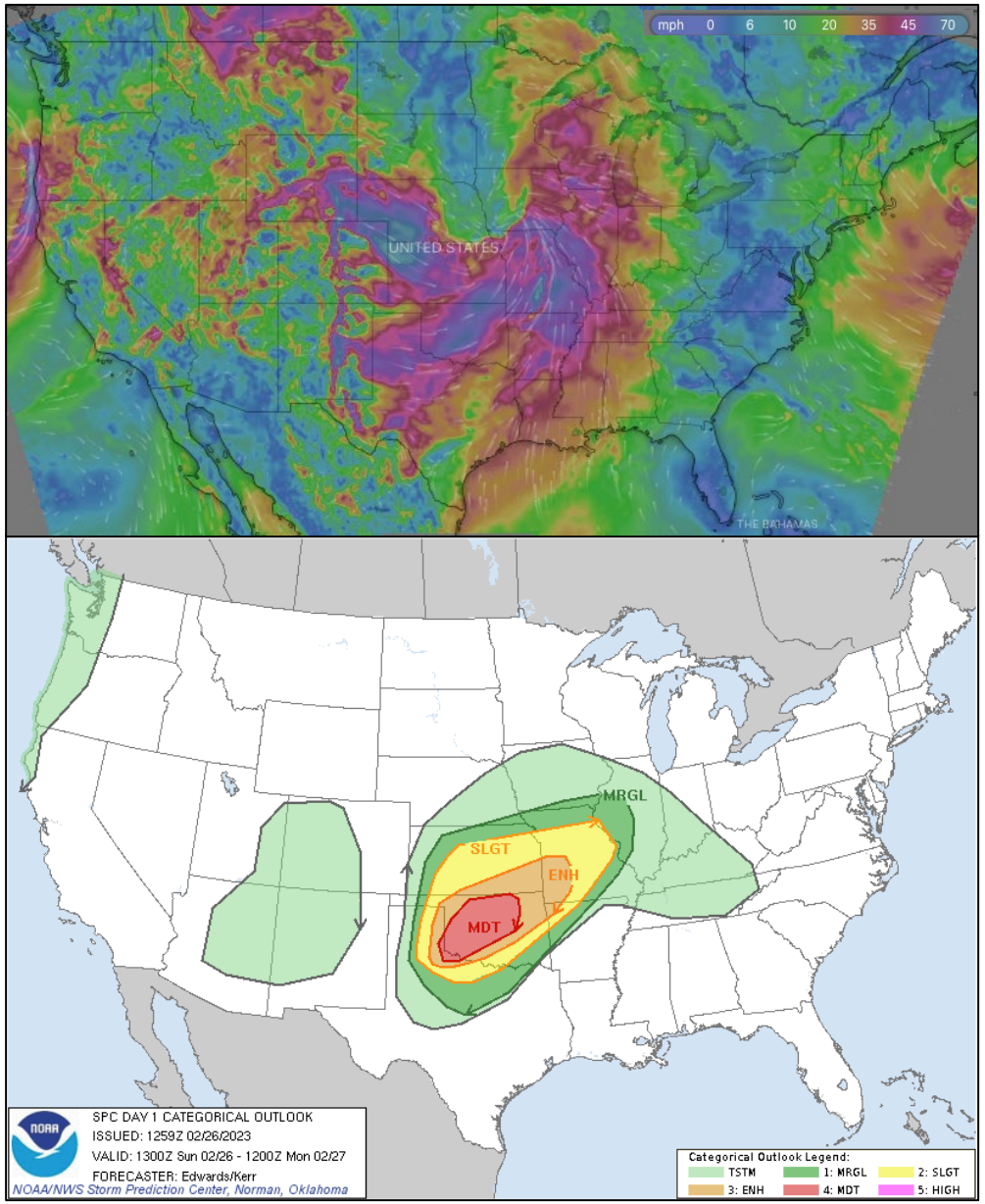
Comprehensive data sources

We bring together disparate data sources capturing key mechanistic effects

Mechanism	Data source
Current weather conditions	Weather forecasts
Meteorological threats	Storm Prediction Center convective threats
Preceding weather conditions	Recent observational and forecast data
Vegetation abundance and risk	E Source tree canopy and outage analytics
Infrastructure exposure	Conductor and asset locational and attribute data
Accessibility	Land use, slope, other geospatial attributes
Major system upgrades	Dropout reclosers, spacer cables, feeders / segments moved underground
System at risk	Preceding permanent and momentary outages

Weather forecast data

- Numerical Weather Prediction model forecasts updated hourly
- We compile historical forecasts for training outage prediction models
  - Hourly resolution out to multiple days
  - Spatial resolution of up to 3 kilometers
  - Millions to billions of records …
    - Big data problem!
  - Data is blended from multiple sources with varying resolutions

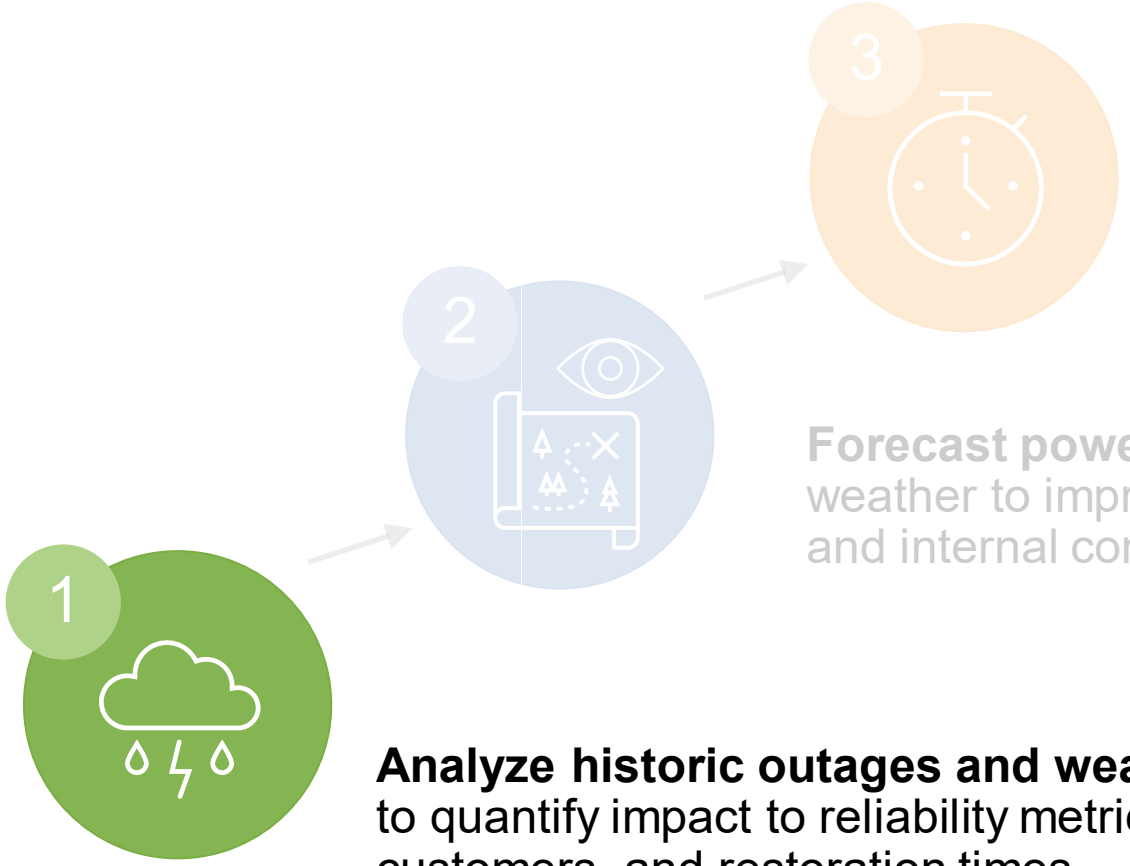


E Source tree canopy mapping

Remote sensing analytics to map tree cover and tree heights in proximity to distribution conductor

Vegetation and weather-induced outages are inherently correlated

E Source weather and outage analytics approach



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Retrospective assessment: Monitoring

Multi-resolution: Long term and short term

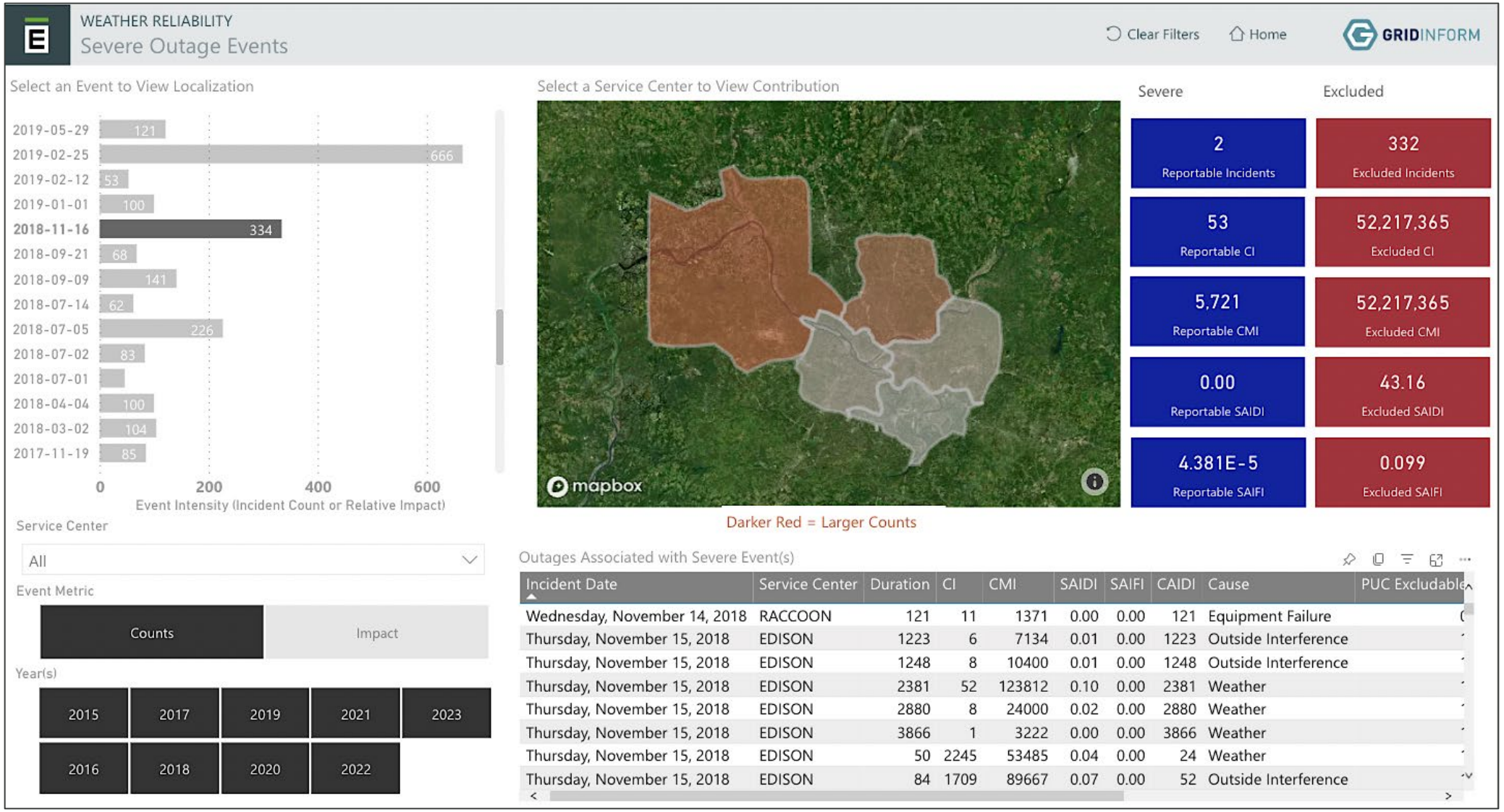
Weather damage: Outage analytics

Weather impact: KPI tracking

E Source

Retrospective assessment: Storm view

Compare impacts and response across storms



Understand impact and response for each event

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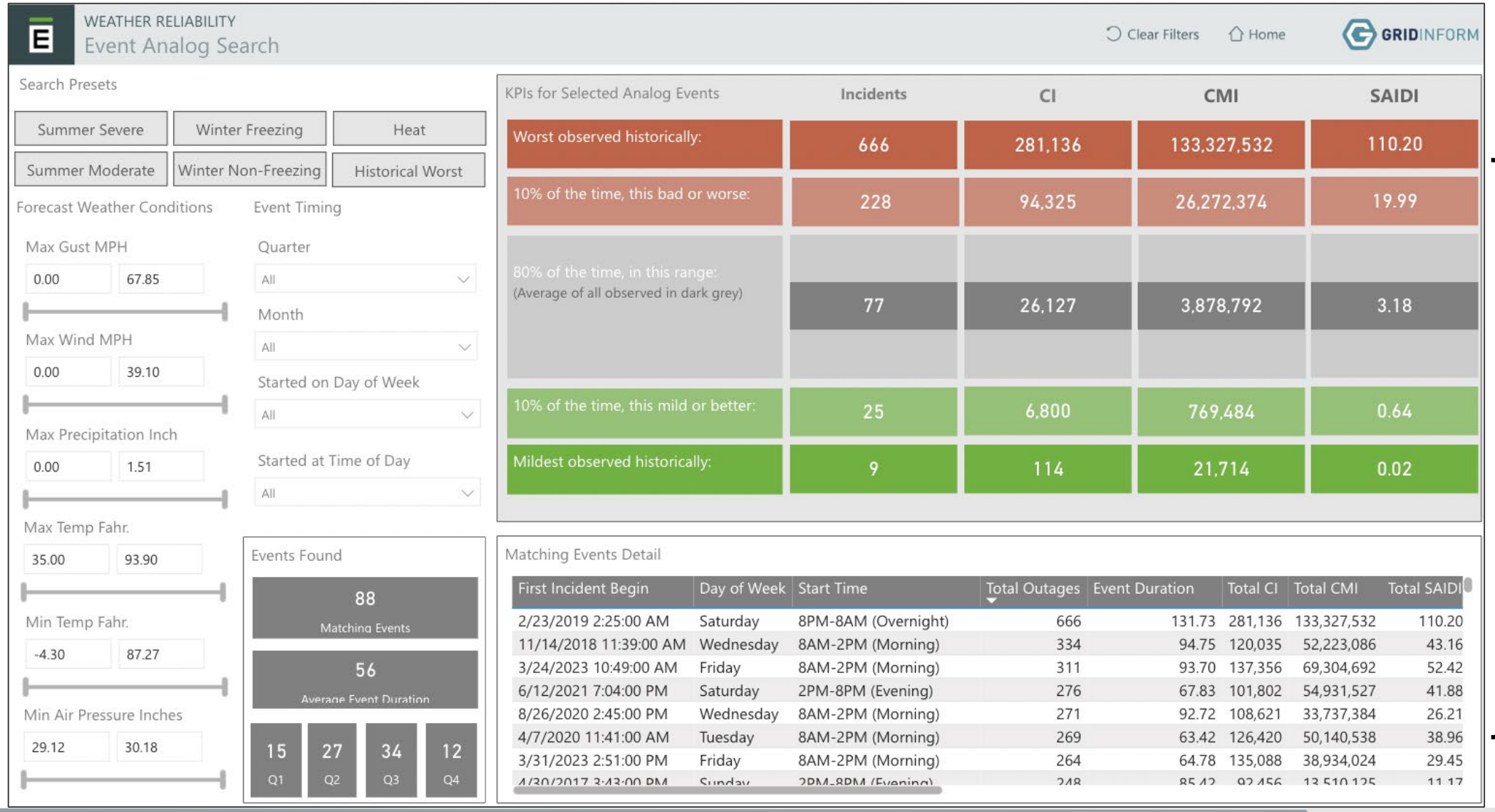
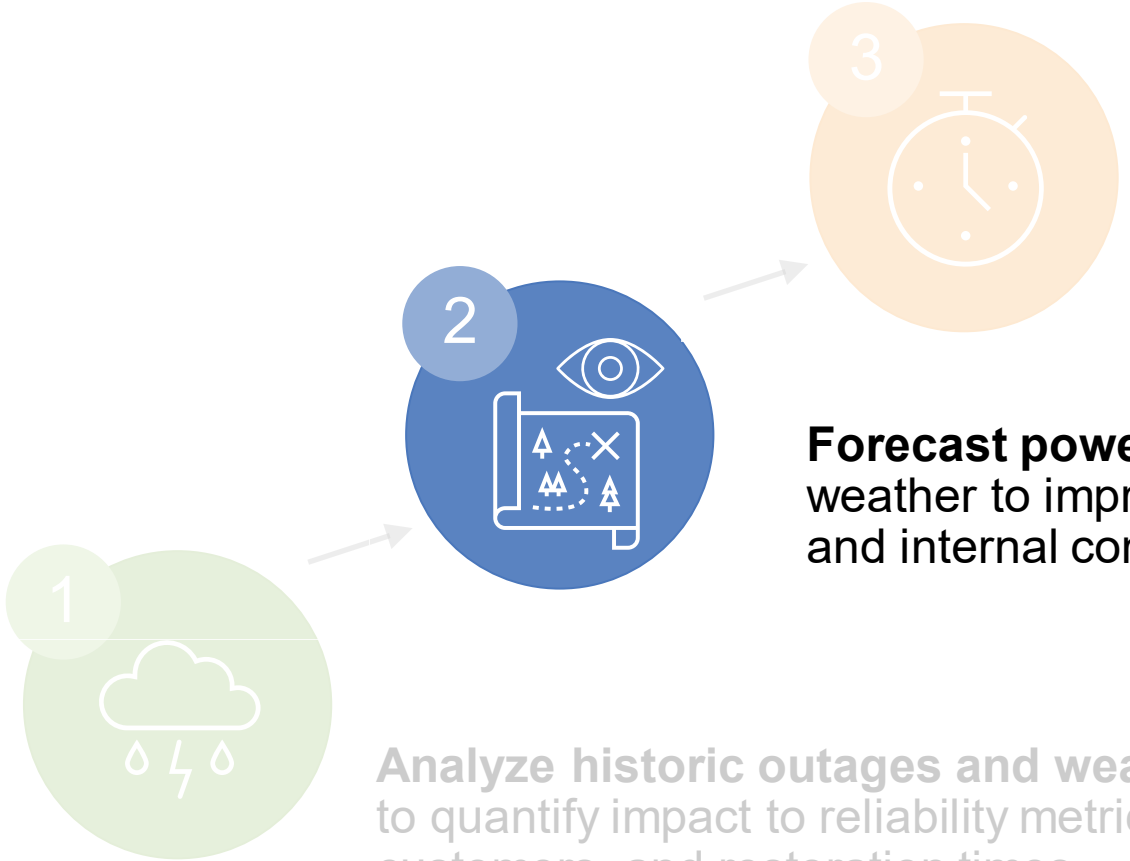
Retrospective assessment: Analog search

Compare storm weather and conditions



Understand impact and response under differing weather conditions

E Source weather and outage analytics approach



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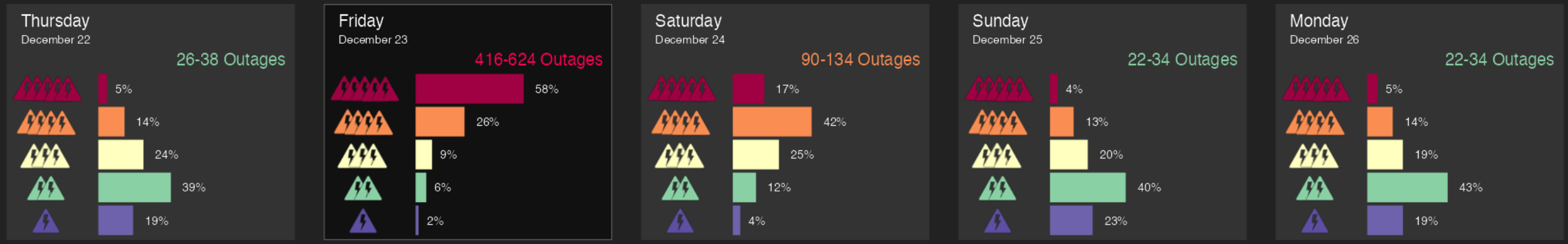
Predictive analytics: Days ahead

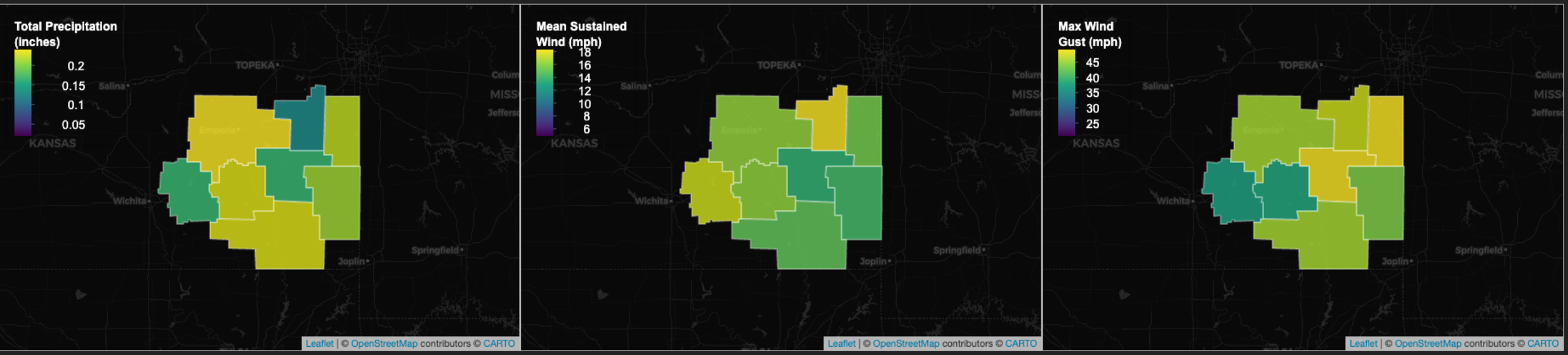
As of 3:00 PM Thursday, December 22nd

Hourly | Daily



Spatial aggregates of forecasted weather for Friday

Select Weather Features



*all data simulated for demo purposes

Predictive analytics: Hours ahead

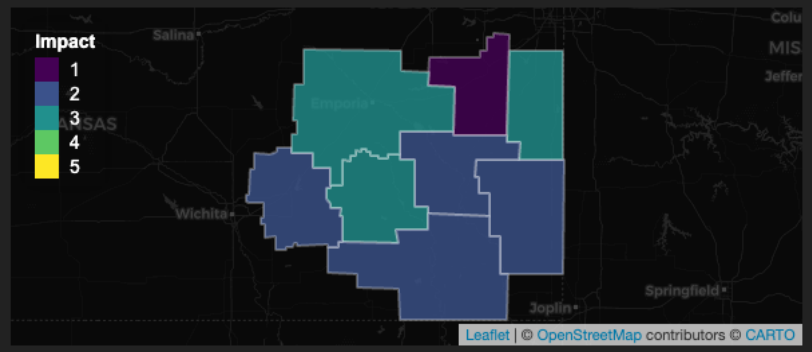
As of 3:00 PM Thursday, December 22nd

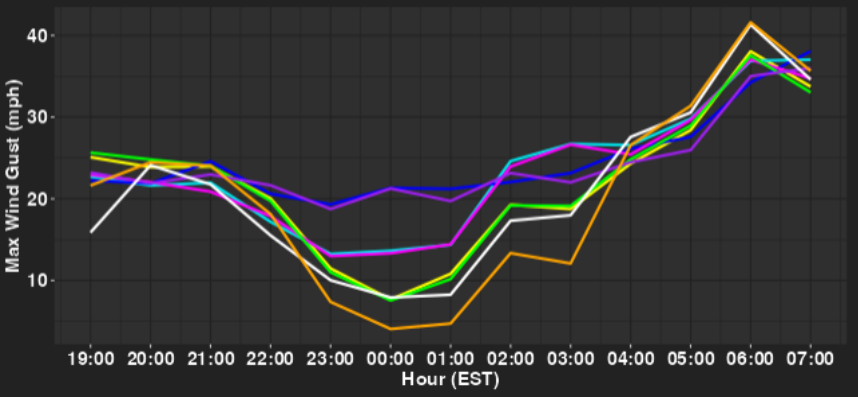
Hourly | Daily

458-686 Outages

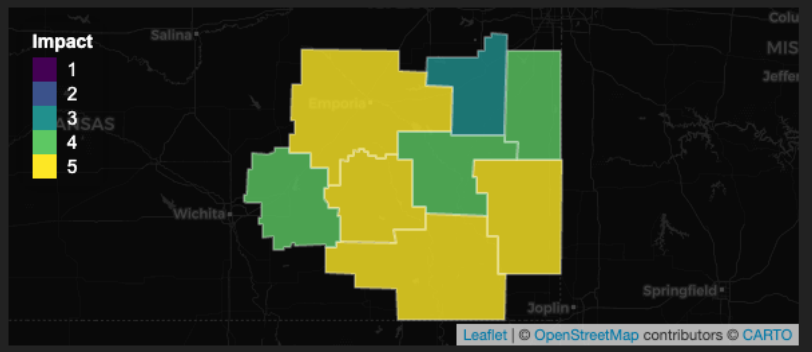
in the next 36 hours

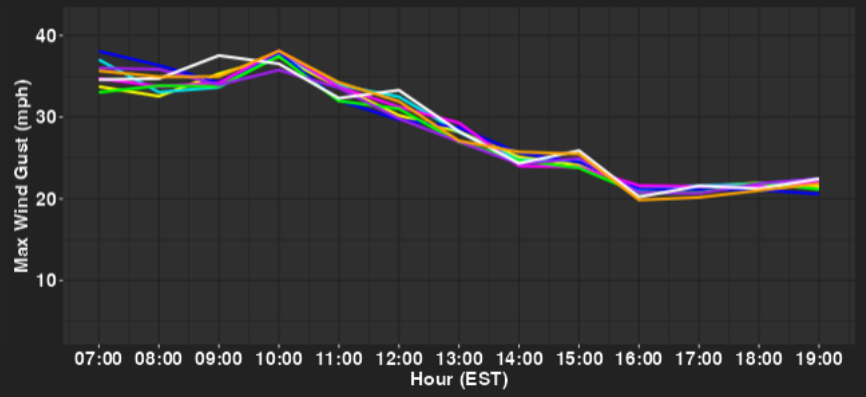
December 22-December 23 , 7pm-7am
122-182 Outages



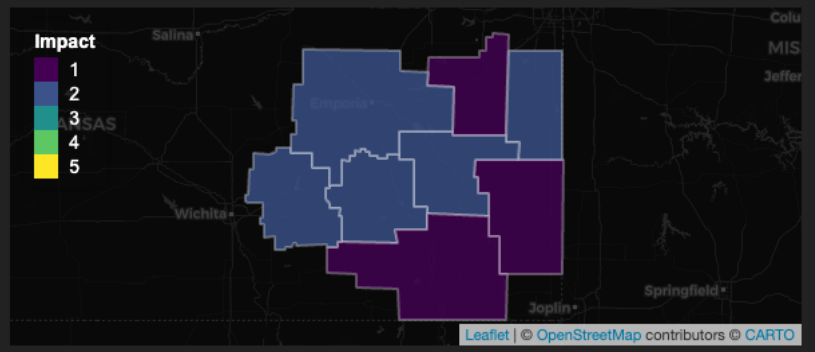


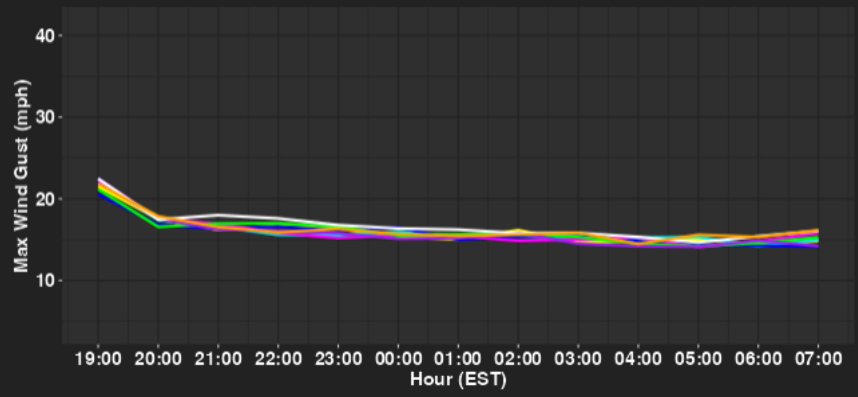
December 23 , 7am-7pm
262-394 Outages





December 23-December 24 , 7pm-7am
74-110 Outages

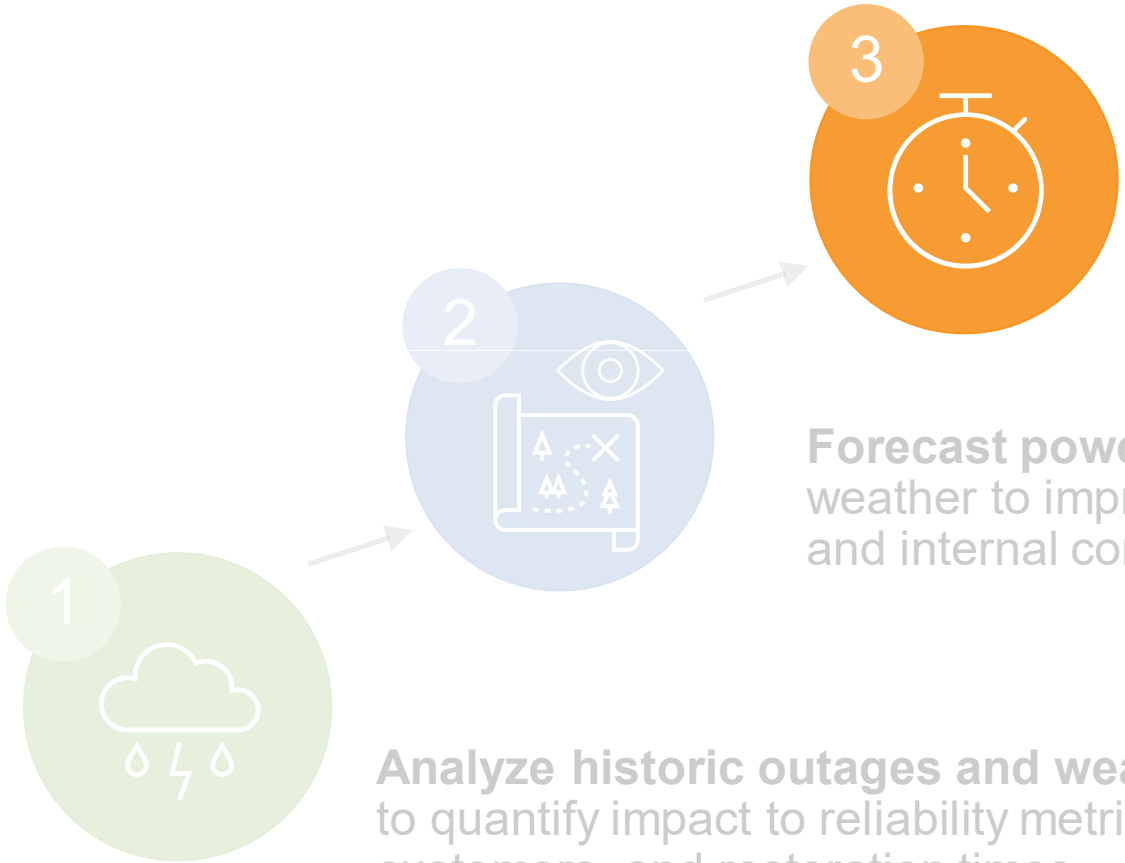




Max Wind Gust (mph)

*all data simulated for demo purposes

E Source weather and outage analytics approach



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E Source Storm Insights

Restoration analytics: Planning view

As of December 23, 6:30 AM

Severe Weather Start Time : December 23, 2:30 AM

	Active Incidents	Active Customer Outages	Resident Company Crew	Resident Contractor Crew	Non-Resident Crew	Total Resources	Projected ETR	Targeted ETR	Percent Restored
*Service Center 1	*56	*2,241	62	11	0	73	12-25 16:00	12-25 08:00	0%
Service Center 2	68	2,652	65	13	0	78	12-25 17:30	12-25 08:00	2%
Service Center 3	22	990	58	8	0	66	12-24 20:00	12-25 08:00	12%
*Service Center 4	*31	*1,488	72	19	0	91	12-25 03:00	12-25 08:00	7%
*Service Center 5	*82	*3,116	67	15	0	82	12-25 21:30	12-25 08:00	3%
	*259	*10,487	324	66	0	390	12-25 21:30	12-25 08:00	4%

*Severe Weather is still affecting this area, ETRs may change

ON — Enable manual edits to crew allocation

OFF — Auto-adjust crew allocation to achieve targeted ETR

OFF — Optimize current crew allocation to achieve earliest system-wide ETR

13.5 Hours Behind
targeted ETR
given current crew allocation

Using analytics to improve storm response and customer experience

Analytical suite spans full timeline of storm response

Before storm

Use weather to forecast outages, predict area-specific impacts, stage resources, and estimate ETRs days in advance

During storm

Use a combination of forecasted and actual outages and crews to predict ETRs while storm is active

After storm

Use actual outage impacts and available crews to estimate ETRs, or estimate crews needed to meet ETR goals after the storm

E Source restoration analytics enable optimal support for planning, monitoring, and communication from days ahead of storm impact until the last customer is restored.

Outages and customer experience

Reliability is key driver of overall customer satisfaction

© E Source. **Base:** n = 4,472 electric, gas, and water customers from Georgia, New Hampshire, Massachusetts, Missouri, California, Arizona, and Arkansas.

Reliability is key driver of overall customer satisfaction

Key drivers of reliability perception:

- Frequency and duration of outages
- Accuracy, timeliness, and convenience of communications *during* an outage
- Vegetation management practices
- Grid investment practices (hardening, resiliency, etc.)

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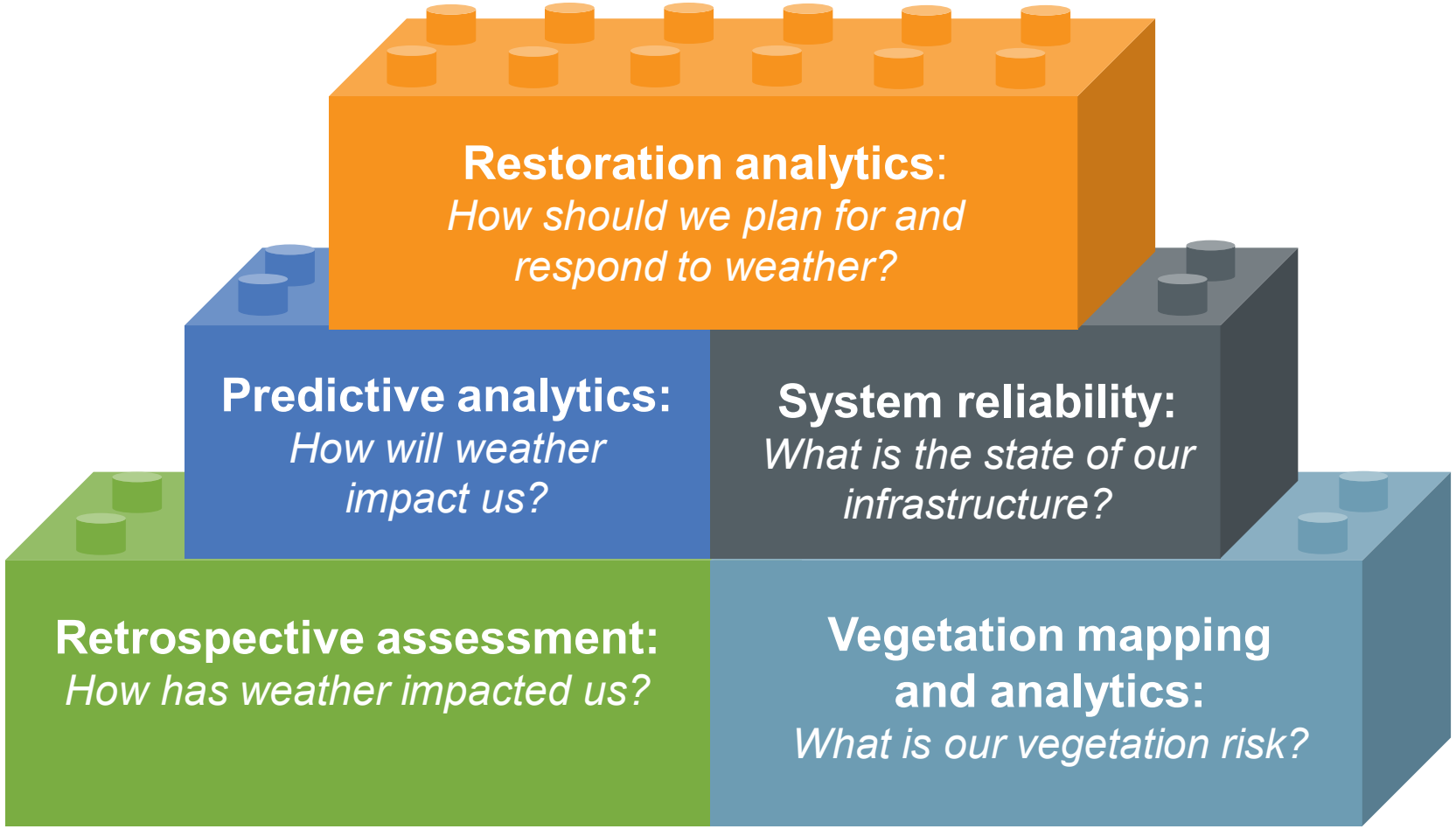
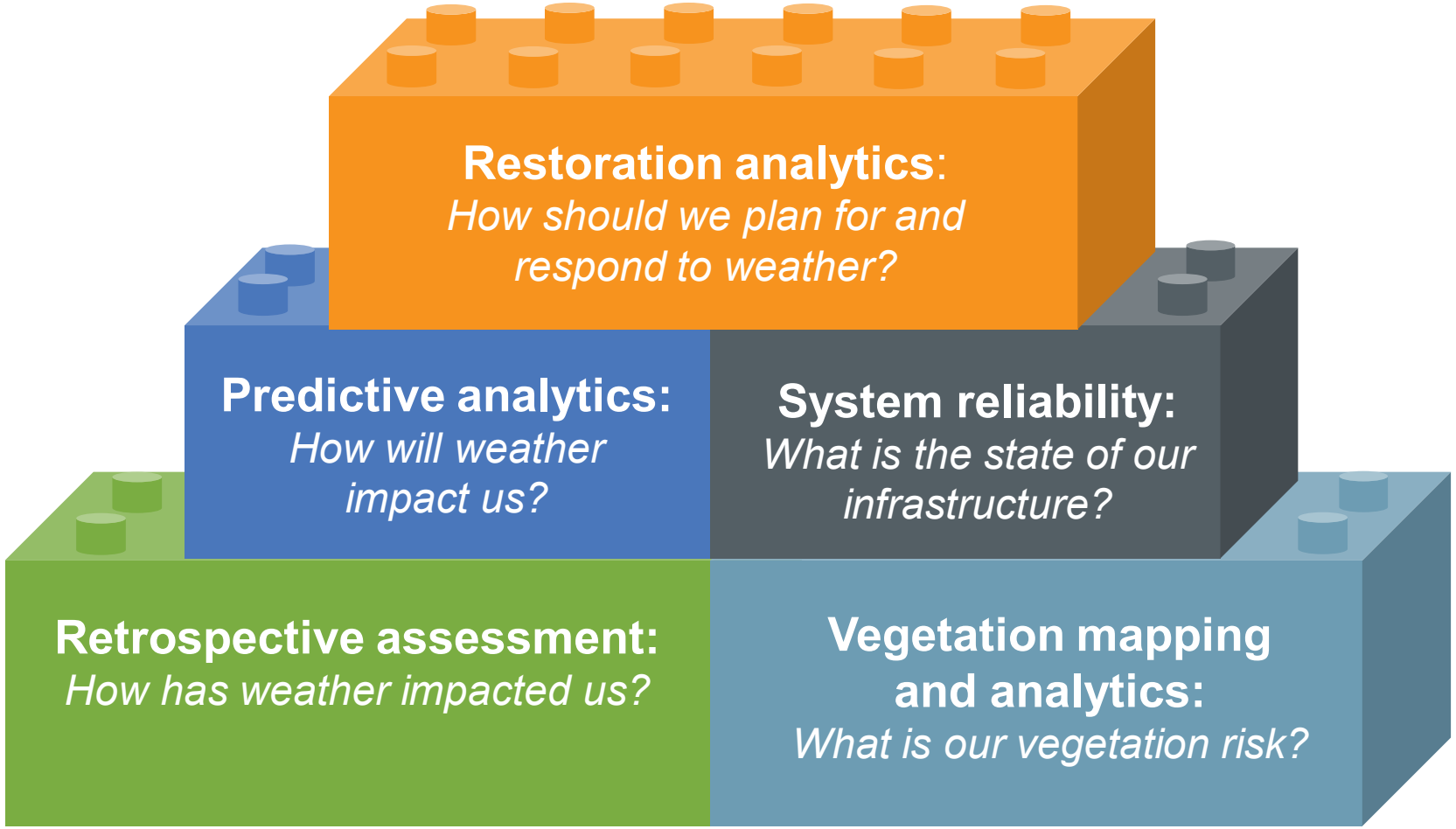
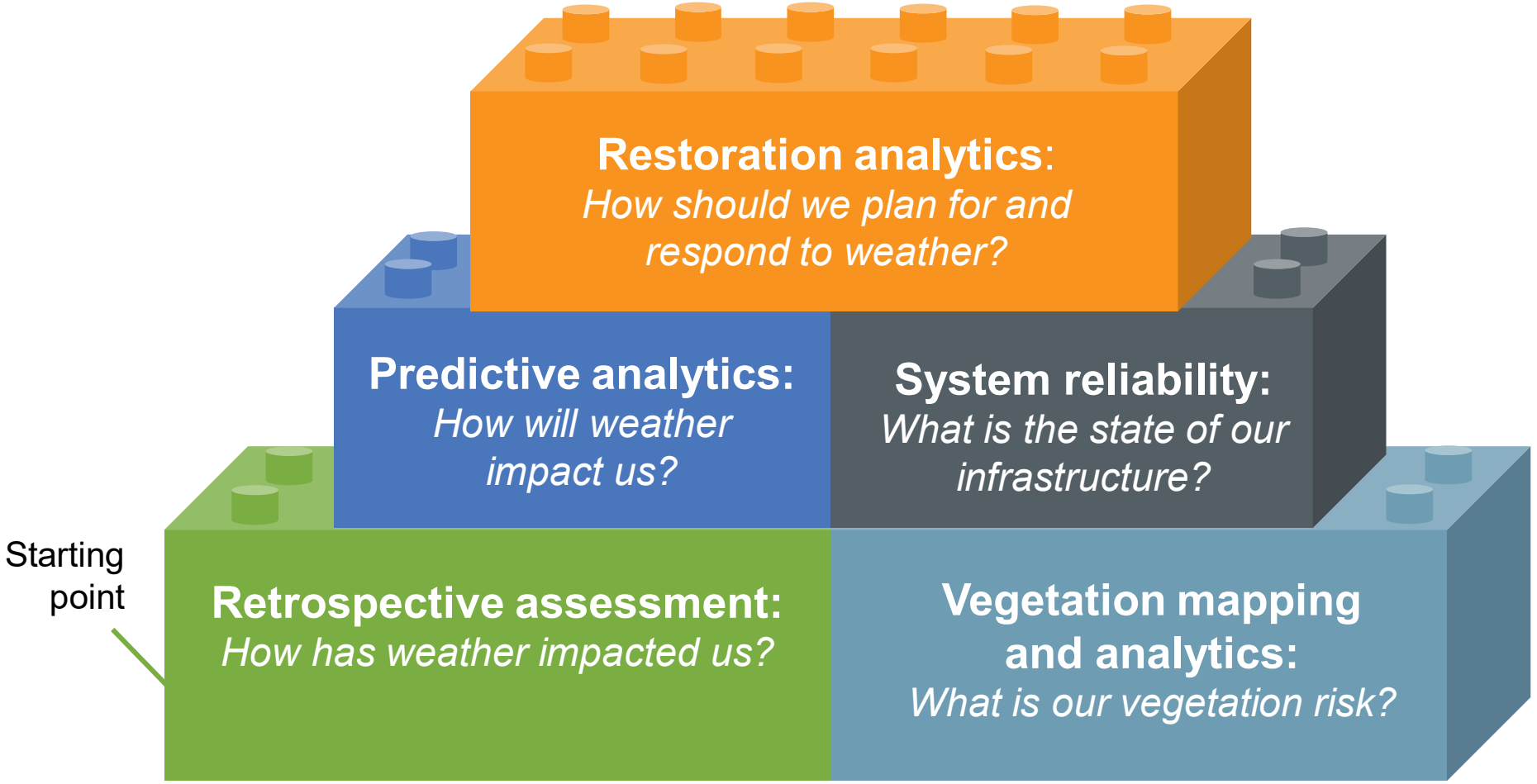
Building blocks to improved analytical results



Building blocks to improved ~~analytical results~~ customer experience

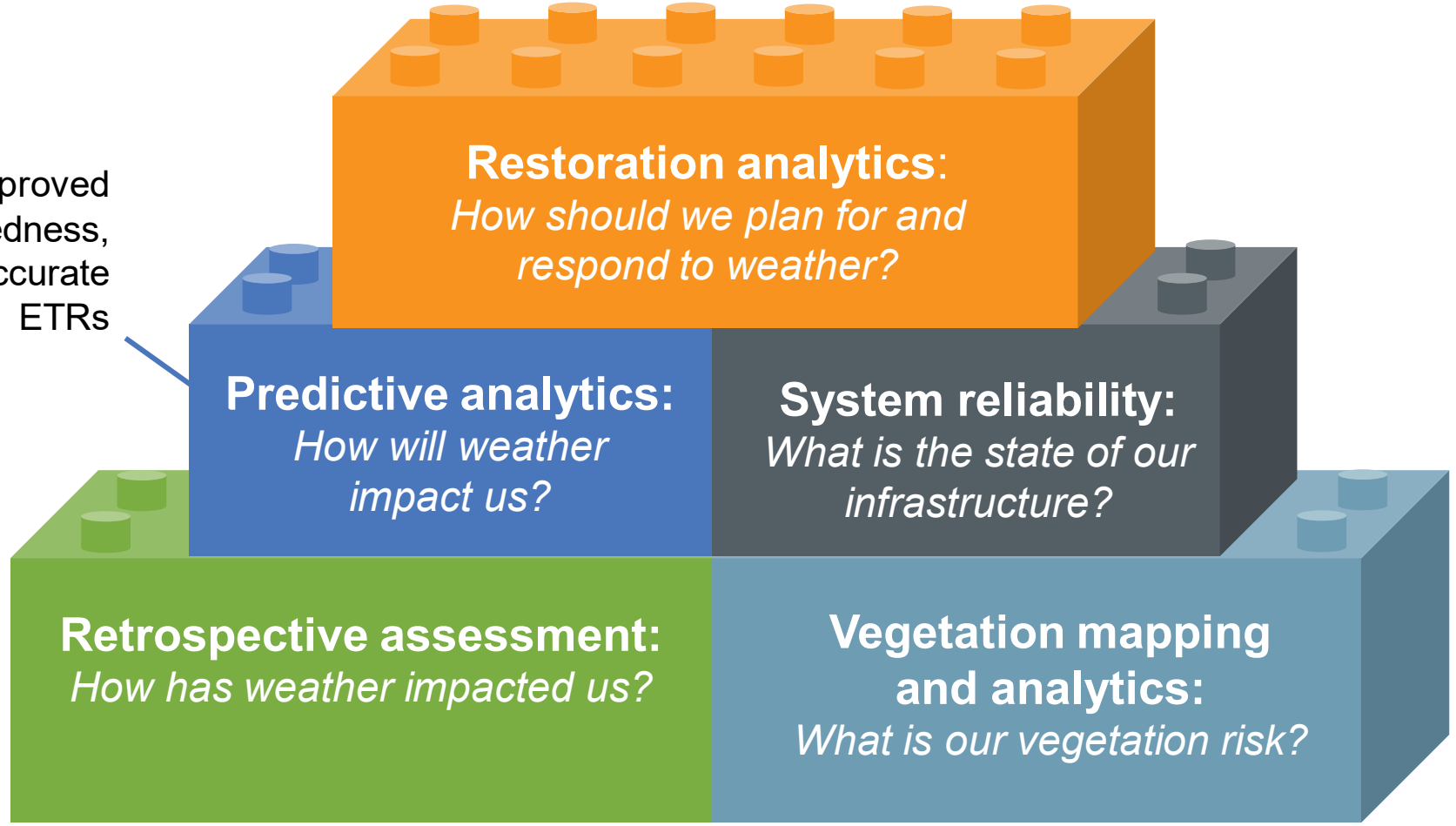


Building blocks to improved customer experience



Building blocks to improved customer experience

Results in improved storm preparedness, rapid and accurate ETRs



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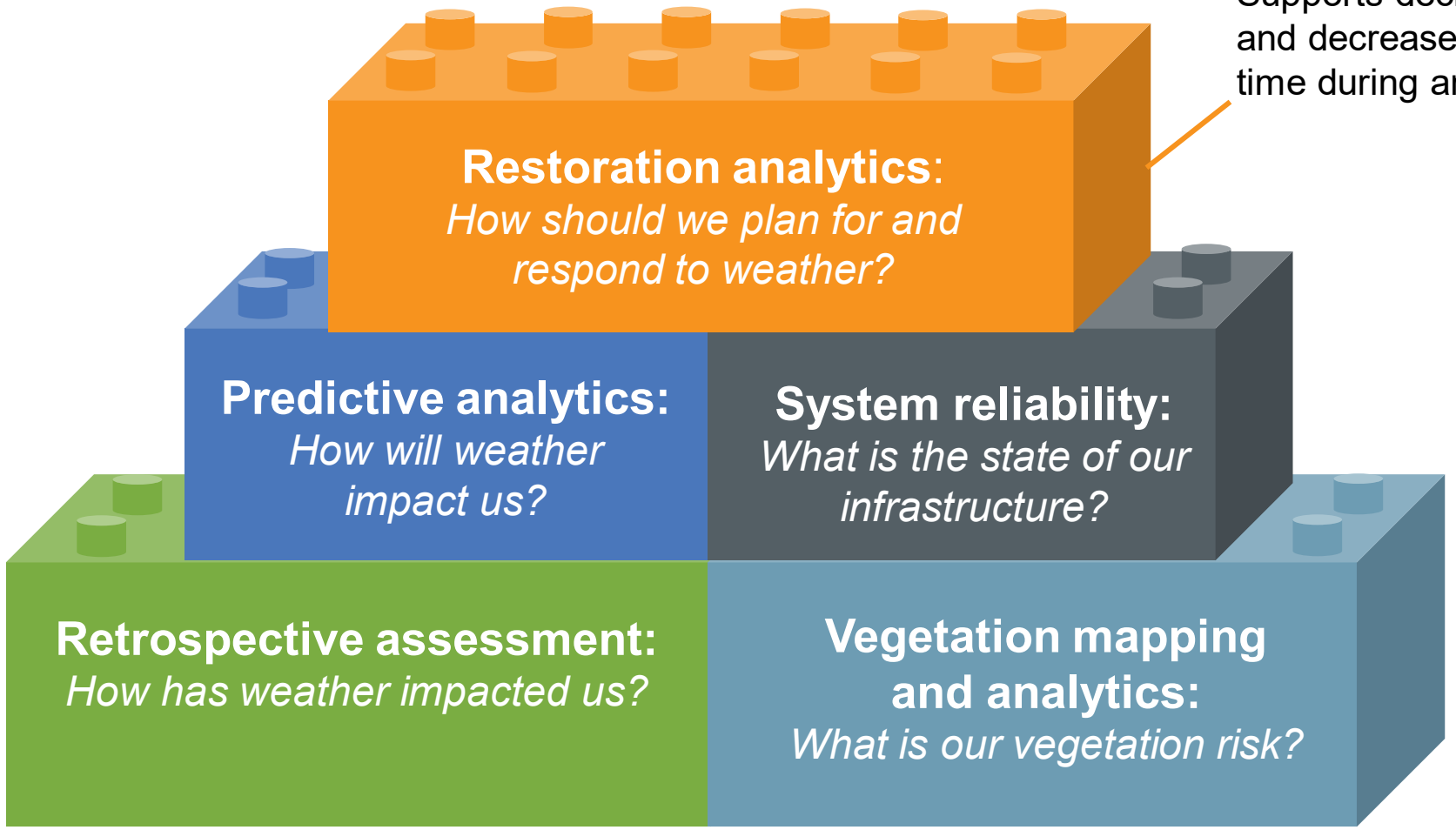
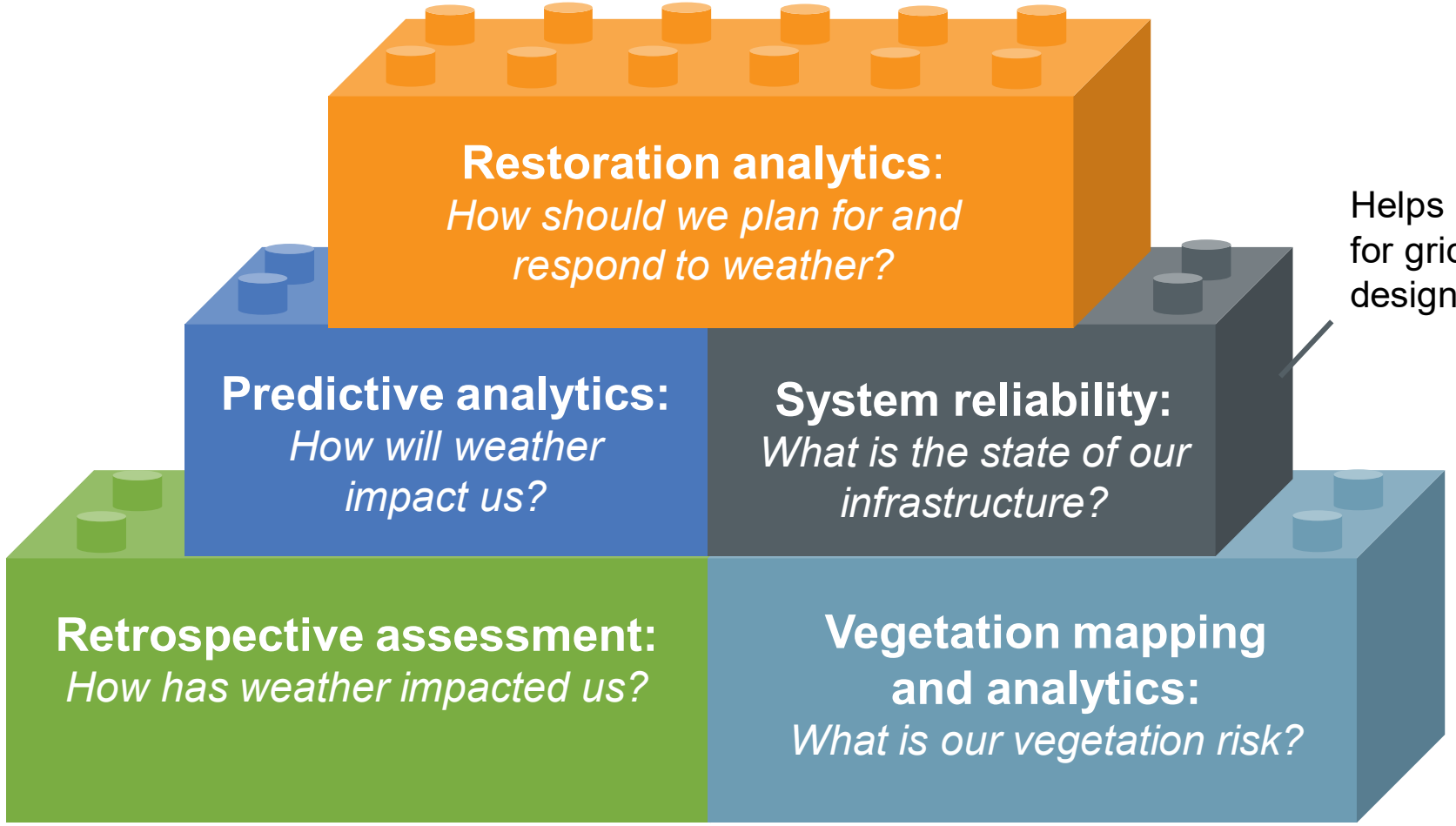


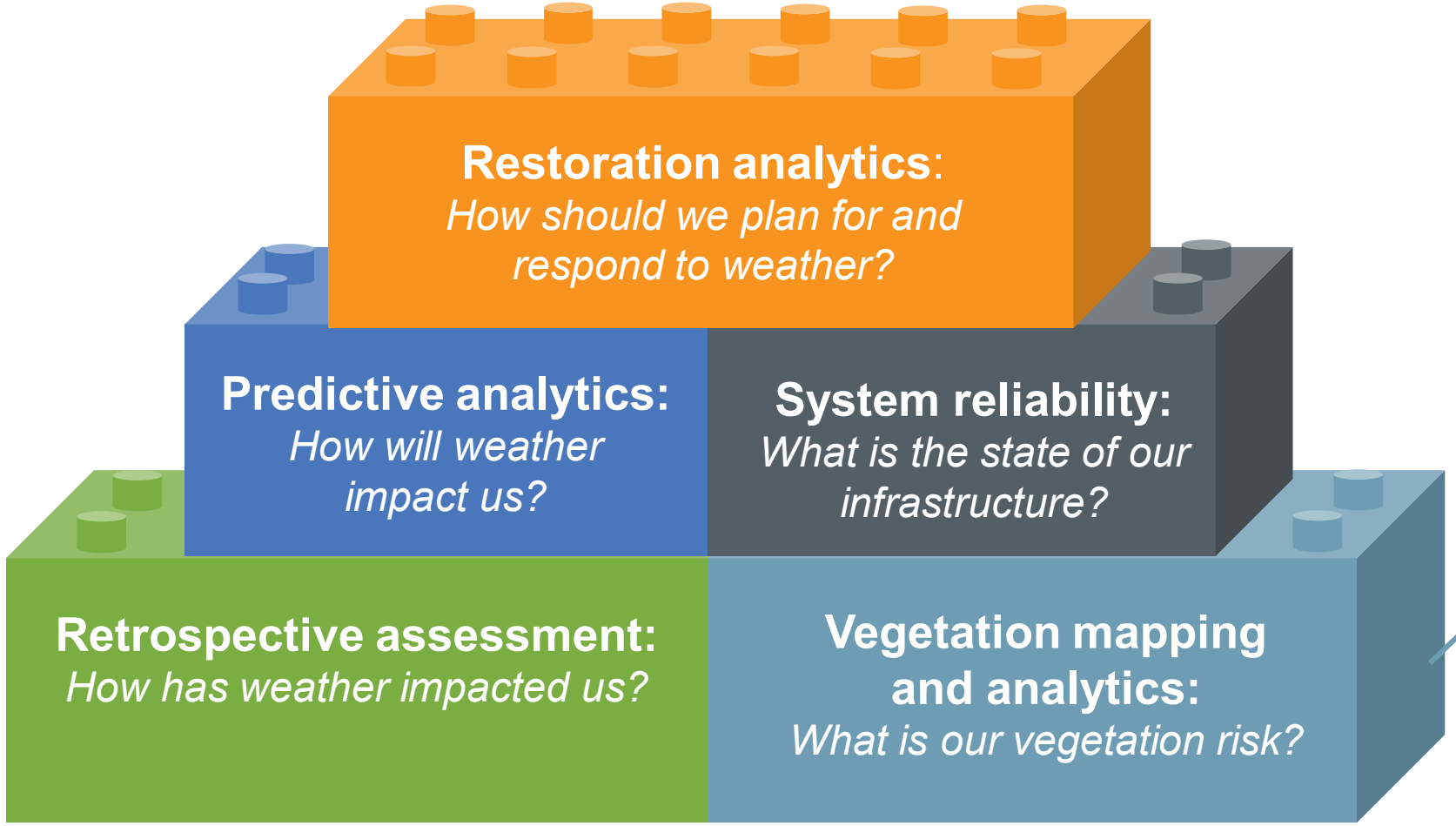
Supports decision-making and decreases response time during and after a storm

Building blocks to improved customer experience



Helps identify the best areas for grid investments that are designed to mitigate outages

Building blocks to improved customer experience



Input to strategic vegetation management initiatives to reduce frequency and duration of future outages

For more information

Kyle Decker
Director, Data Science
kyle_decker@esource.com

Jesse Woods
Vice President of Strategic Accounts, Data Science
jesse_woods@esource.com

Melanie Wemple
Director, Data Science
melanie_wemple@esource.com