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Session 5: DISASTER MANAGEMENT AND CLIMATE READINESS OF UTILITIES

Grid Hardening Programs and Resiliency Planning

Presented By

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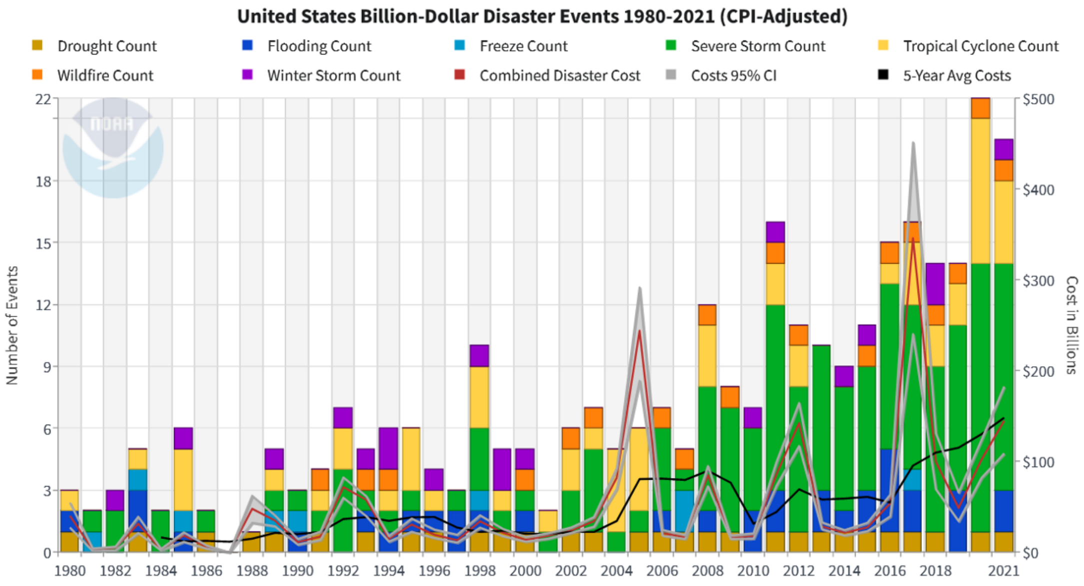
mitigation
consequence
threats
vulnerability

Increased Frequency of Extreme Events

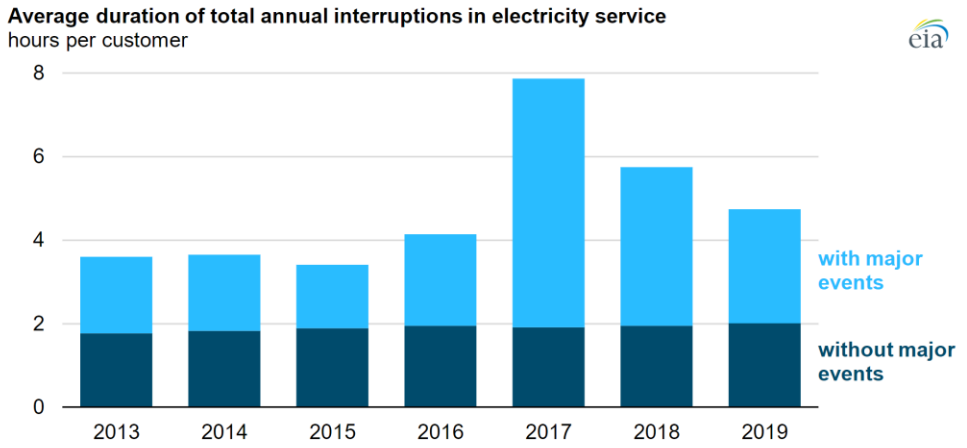
Frequency and **magnitude** of extreme events are increasing worldwide.

The U.S. has seen increases in severe storms, cyclones, and wildfires that have caused widespread **destruction of grid assets** and increases in **long-duration outages**.

U.S. utilities have initiated billions of dollars in investing in **resilience plans**, including; **undergrounding**, **vegetation management**, and **grid modernization**

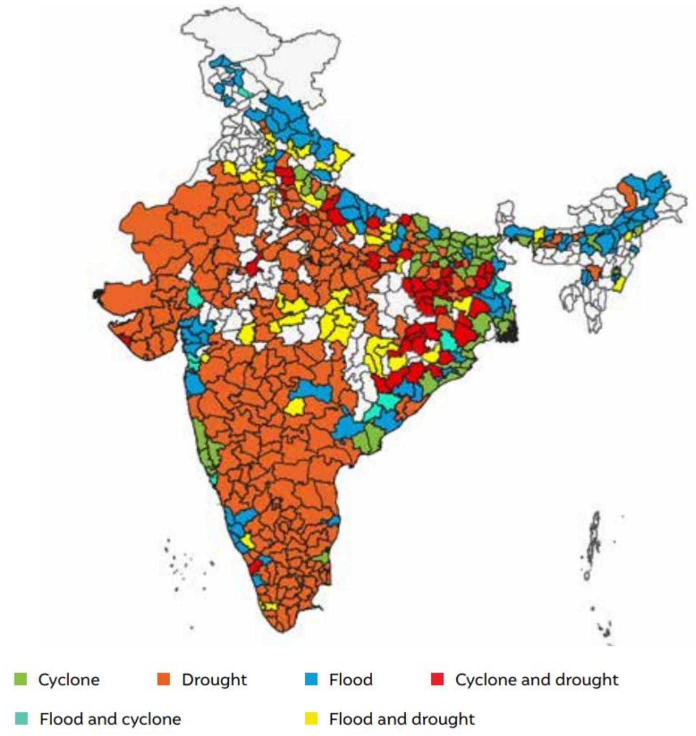


Source: Climate.gov



Source: [eia.gov](eia.gov)

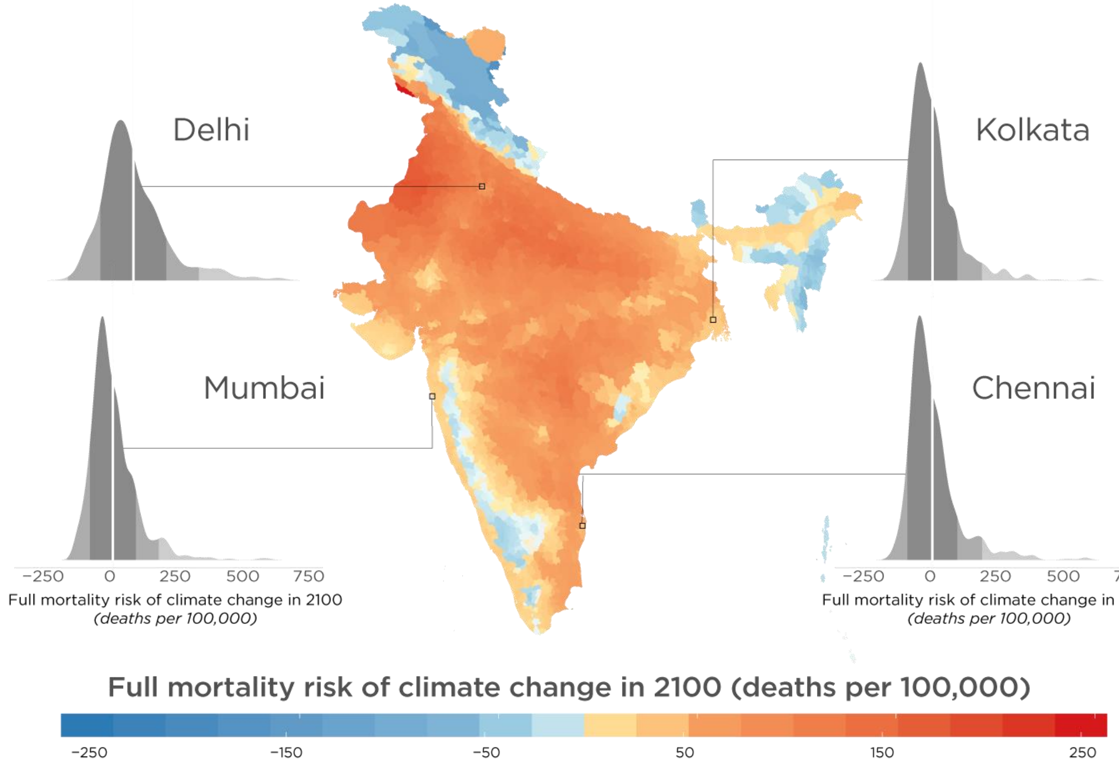
Critical risks in India include **cyclones** and **flooding**



Source: Preparing India for Extreme Climate Events Mapping Hotspots and Response Mechanisms, CEEW

Climate Impacts: Heat Events

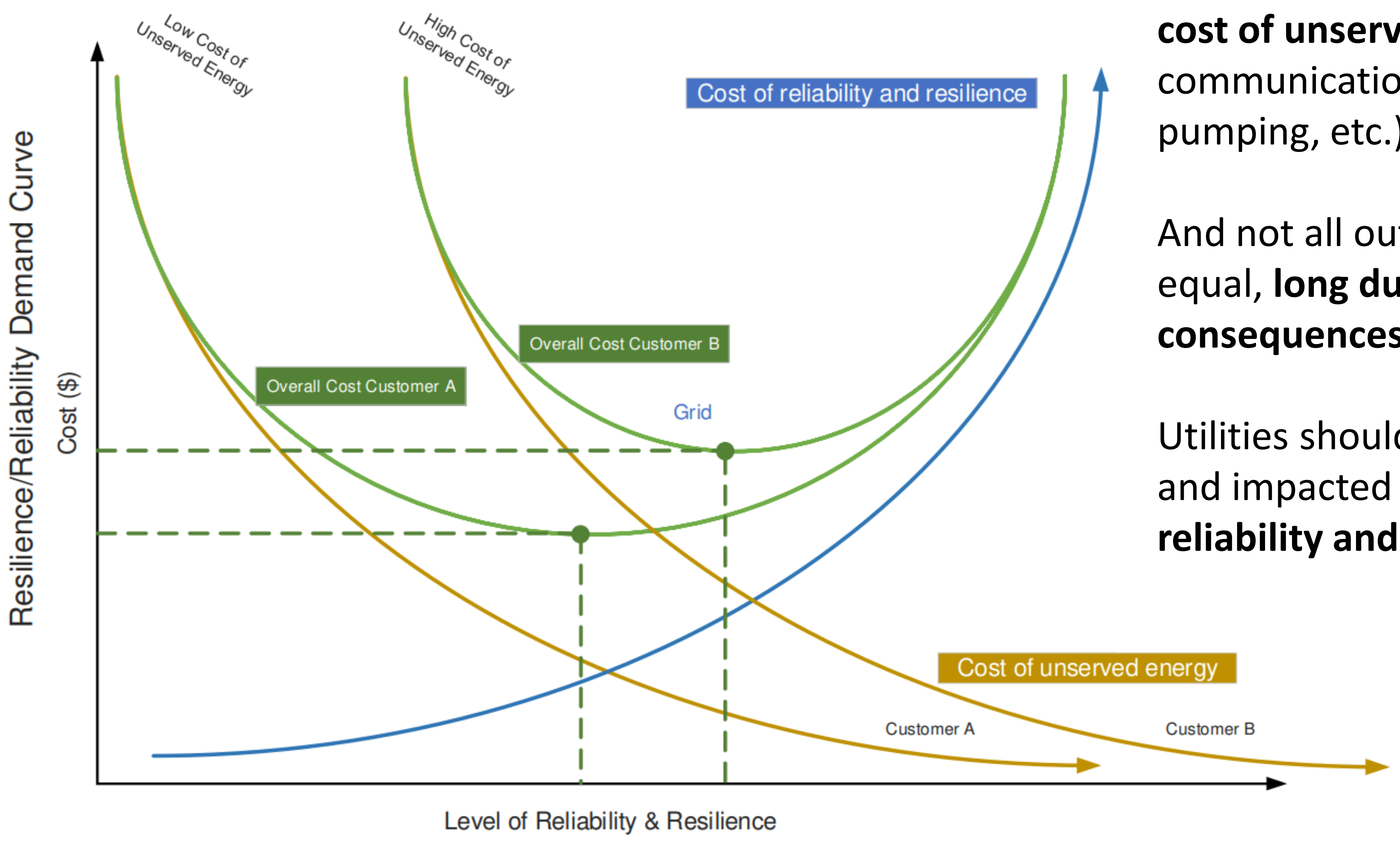
- **Impact on Distribution Assets:** Temperature rises will impact asset lifetimes both due to rising *ambient temperature* and *due to increased temperature-driven load*
- **Impact on Load:** Heat events are driving HVAC adoption, decreasing diversity factors, and increasing load on electrical assets
- **Grid reliability during extreme heat events** is becoming critical for reducing health impacts and mortality risk, and reliability *will need to increase*
  - *Projections for India show days over 35°C increasing from about 5 per year in 2010 to about 42 per year in 2100.*
- Assets being installed today will last 30-60 years and need to be designed with changing climate in mind



Source: "Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits" (July 31, 2019). University of Chicago

Resilience/Reliability Demand Curve

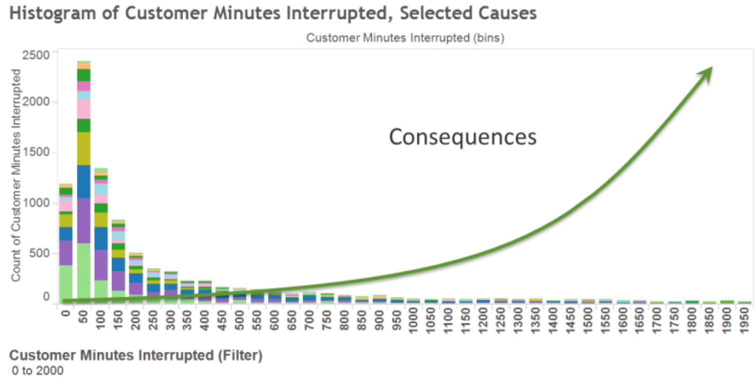
Heterogenous customer resiliency/reliability needs



Not all customers have the same impact of **cost of unserved energy** (i.e., hospitals, communication towers, sanitation and pumping, etc.)

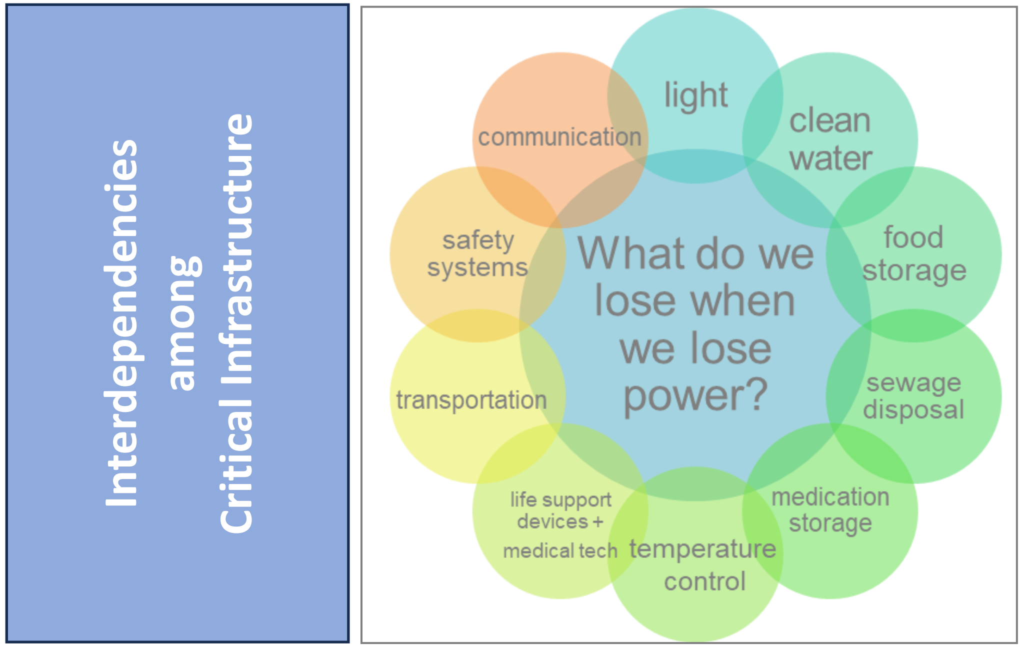
And not all outages or outage durations are equal, **long duration outages have higher consequences**

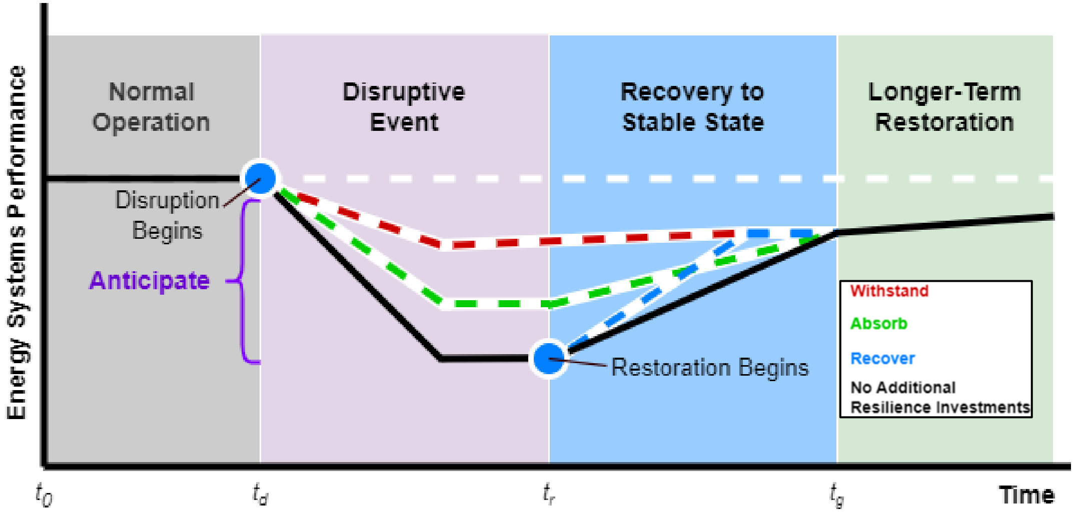
Utilities should examine their customers and impacted end-use to determine **local reliability and resilience investments**



Resilience in Distribution Systems

- **Resilience:** ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions.
- **Resiliency vs. Reliability**
  - Resilience focuses on “major event days”: events that exceeds reasonable design and/or operational limits of the electric power system (IEEE 1366-2022)
  - Reliability focuses on reducing impact of day-to-day events that impact system performance
- **Resiliency Phases:**
  - **Anticipation:** Ability to withstand, absorb or recover.
  - **Absorption:** Arrest the decrease in performance
  - **Withstand:** Preventing greater impact on performance
  - **Recovery:** Restoration post event-impact





Key Resilience Planning Components

1. **Preliminary Hazard Characterization:**
   - Determining the relative risk of different hazards and where to focus investments
2. **Network Health/Resiliency-Levels:**
   - These metrics help characterize systems and describe the ability of utilities to anticipate, absorb, withstand and recover from hazards.
3. **Network Performance Metrics:**
   - Track a utility’s progress towards improvements in its core objectives (e.g., affordability, safety, reliability, resilience, equity)
4. **Threat Risk Analysis:**
   - Historical and/or future analysis or modelling efforts to identify exposure to threats, including whether their entire territory is exposed to a threat or if there are specific areas that can see a greater impact
5. **Investment Planning:**
   - Targeting various levels of utility infrastructure and community support, depending on the hazard.
6. **Investment Prioritization:**
   - Examine the impact of an investment and possibly its cost. Investments can be prioritized by cost, risk reduction, other benefits, or some combination of these investment impacts.

Threat Risk Analysis

Historical Analysis

Example

During a cyclone event, which specific substations were impacted, what was the water level/inundation, and what was the extent of the damage due to salt water?

Strengths

Based on real-world past events and data to make for compelling supporting evidence for making investments

Weaknesses

Granularity and detail of storm records may not be sufficient to draw correlations between events and damaged assets.

Forward-Looking Analysis

Example

If flooding occurs due to inland precipitation, a simulation can identify which areas will be flooded and what the water level/inundation will, identify flooded substations.

Strengths

Can account for changing conditions (e.g., climate change) that may not be captured with historical data.

Weaknesses

More speculative incorporating assumptions which may prove inaccurate

Risk = Probability x Vulnerability x Consequence

Probability is the likelihood of the occurrence of a hazard

A **vulnerability** in a system has a high likelihood of failure in the event of a hazard

A **consequence** is the impact from a hazard (i.e., physical, economic, or social)

Resilience Investments and Prioritization

- **There is no "one-size-fits-all" solution**
- Investment may be made solely for resiliency improvements or can be part of multi-objective planning framework
  - An investment that supports multiple objectives might support both resilience and other system objectives, such as clean energy or grid equity
- Specific actions and infrastructure the utility can take to improve system resilience.
  - Depending on the hazard, this could target various levels of utility infrastructure and community support.

Category	Examples
Vegetation	Targeted vegetation management Widening right-of-way for lines
Overhead Hardening	Pole materials (e.g., steel poles) Fire wrapping poles
Undergrounding	Targeted undergrounding
Network Redundancy	Split network Adding primary feeder loops within and between networks Ties between exposed substations and/or distribution networks Additional distribution substations
Non-Electric Grid Physical Infrastructure	Floodwalls at substations Debris booms near fire damaged area More frequent equipment maintenance to mitigate increased equipment wear
Grid Modernization	DER and NWA AMI for targeted load shedding Microgrid formation Automated switching operations Energy storage, on-site generation Resilience hubs
Forward Looking Analysis	Stochastic event analysis Hazard modeling and analysis Debris flow exposure projections Coastal storm exposure projections
Advanced Resource Planning	Mutual Aid Assistance Resilient supply chains
Operations	Training and threat response Emergency drills

NREL Resiliency Toolset

- **ERAD**: Equitable Resilience Analysis for Distribution Power System
  - ERAD is a free, open-source Python toolkit for computing equity and resilience measures in the face of hazards like earthquakes and flooding.
- **ReOpt**: Renewable Energy Integration and Optimization
  - REopt recommends the optimal mix of renewable energy, conventional generation, and energy storage technologies to meet cost savings, resilience, emissions reductions, and energy performance goals.
- **ARIES**: Advanced Research and Integrated Energy Systems
  - The nation's most advanced platform for energy system integration research and validation at scale
- **CADET (in development)**
  - A flexible platform for multi-objective distribution capacity expansion decision support

Photo: July 7, 2023 - Aerial view of the hydrogen infrastructure and grid integration research pads at National Renewable Energy Laboratory's (NREL's) Flatirons Campus. These capabilities are part of the ARIES research platform. (Photo by Josh Bauer / Bryan Bechtold / NREL)

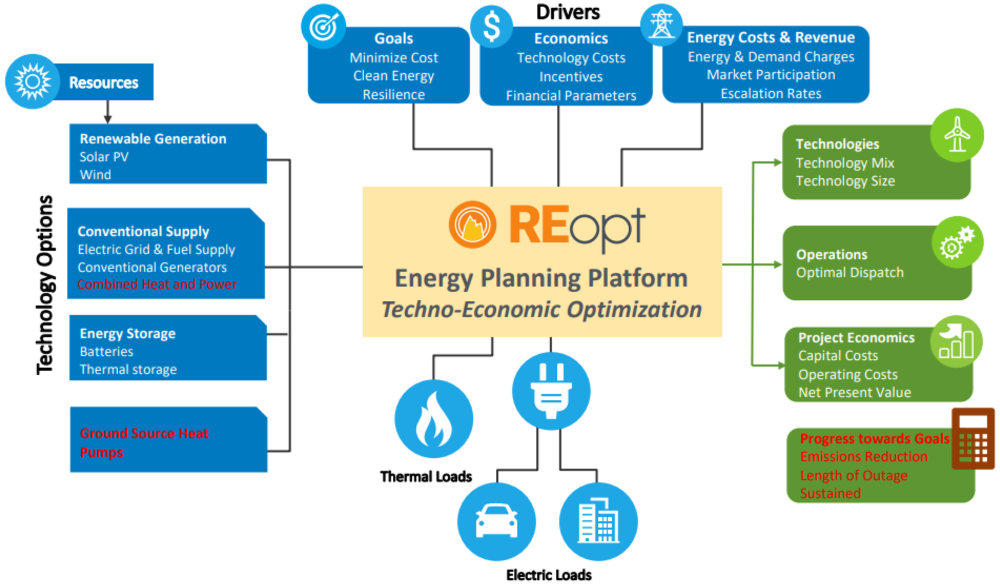
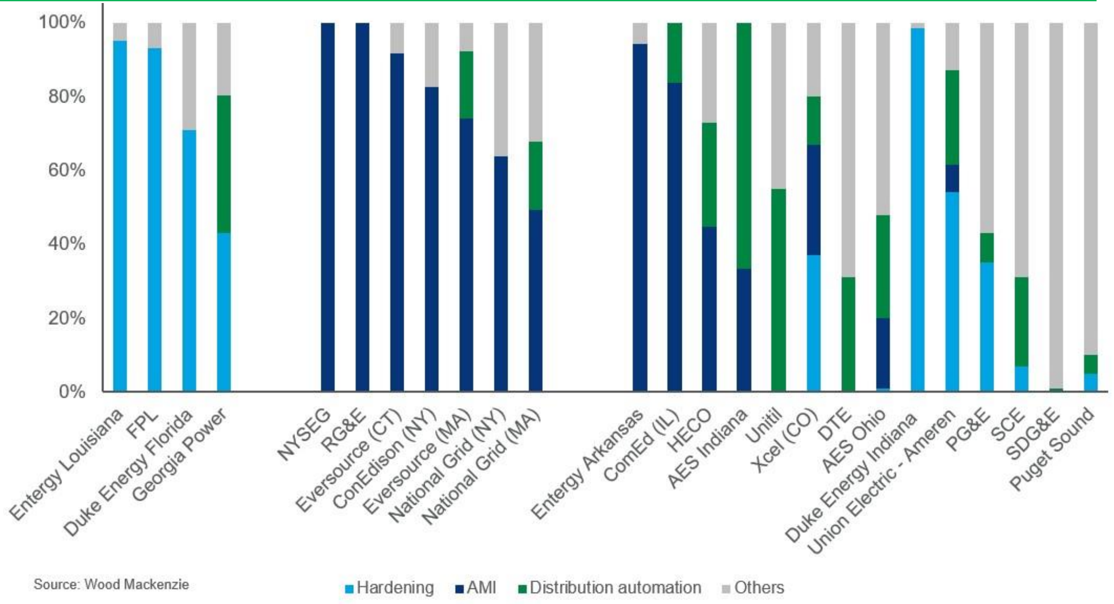


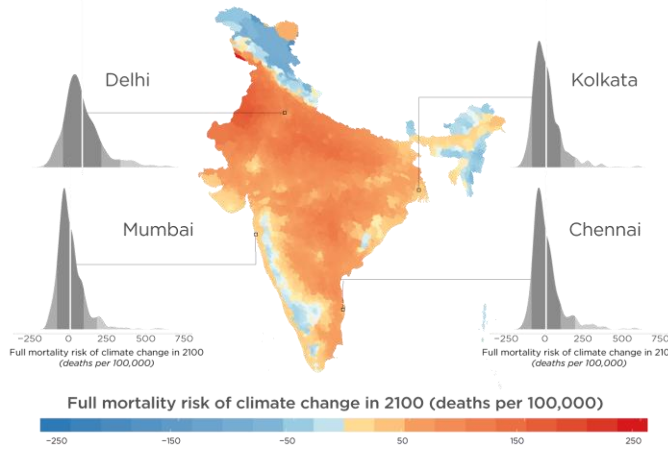
Photo: Manogaran, Indu. "REopt for Resilient Buildings: Leveraging Energy Efficiency and Distributed Energy Resources for Resilience Solutions." n.d.

Summary

- Resilience investments are critical given the **magnitude and frequency** of **extreme weather events** are increasing.
- Increased temperatures will impact asset lifetimes to due rising heat and heat-driven demand.
- Resilience planning needs to be based on examining the **probability of events**, the **vulnerability of the system**, and the **consequence of failure**.
- **Resilience investments are expensive**, $36.4B have been filed by 25 U.S. IOU's into grid modernization, and for some over 90% of that investment is for **grid hardening**
- **Consequences are high**, heat related mortality is expected to increase, in the U.S., failures in grid resilience have costed human life (load shedding from 2021 Winter Storm Uri resulted in major loss of life in Texas)



Source: Wood Mackenzie "US$36.4B of grid modernization planned by investor-owned utilities", April 2023



Source: "Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits" (July 31, 2019). University of Chicago

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Links/References (If any)