QUANTA TECHNOLOGY

Comprehensive Metrics-based Climate/Resilience Plan and Investment Strategy

October 2021

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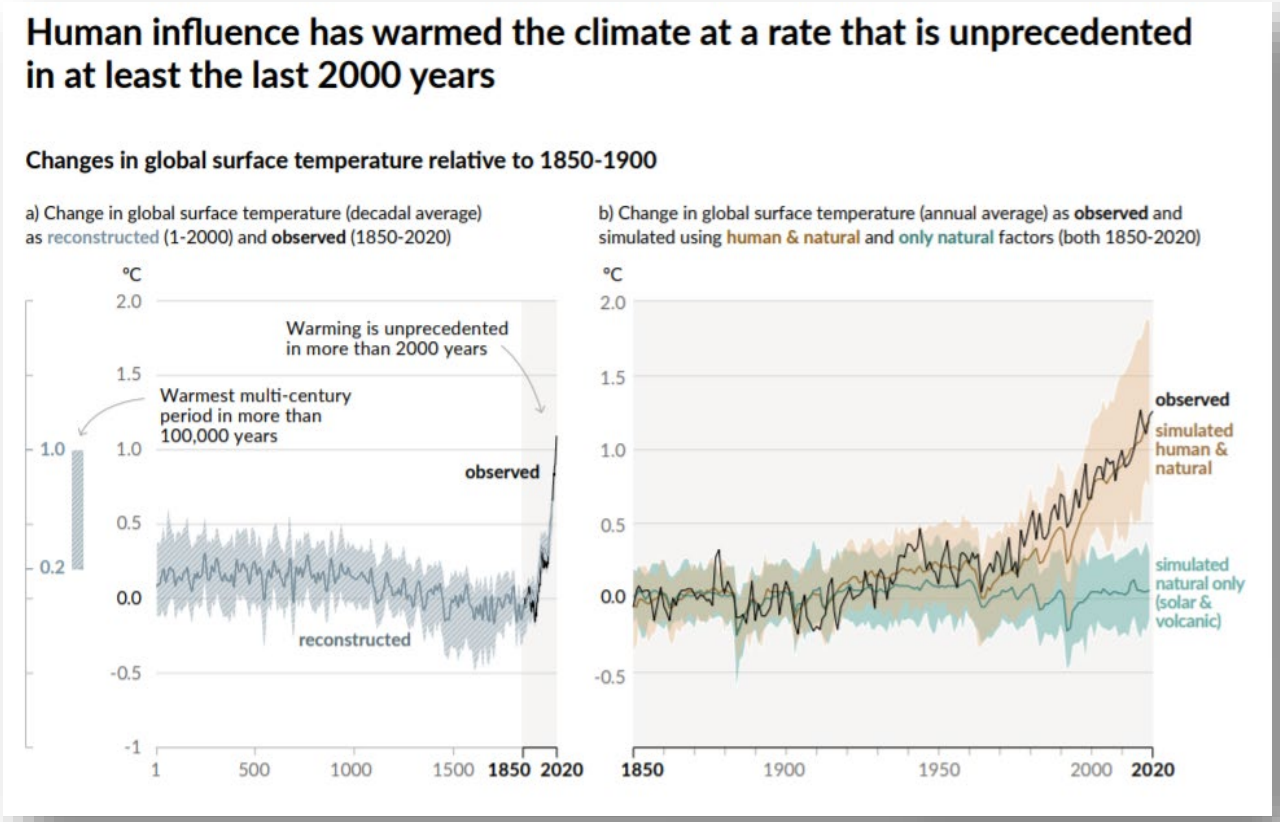
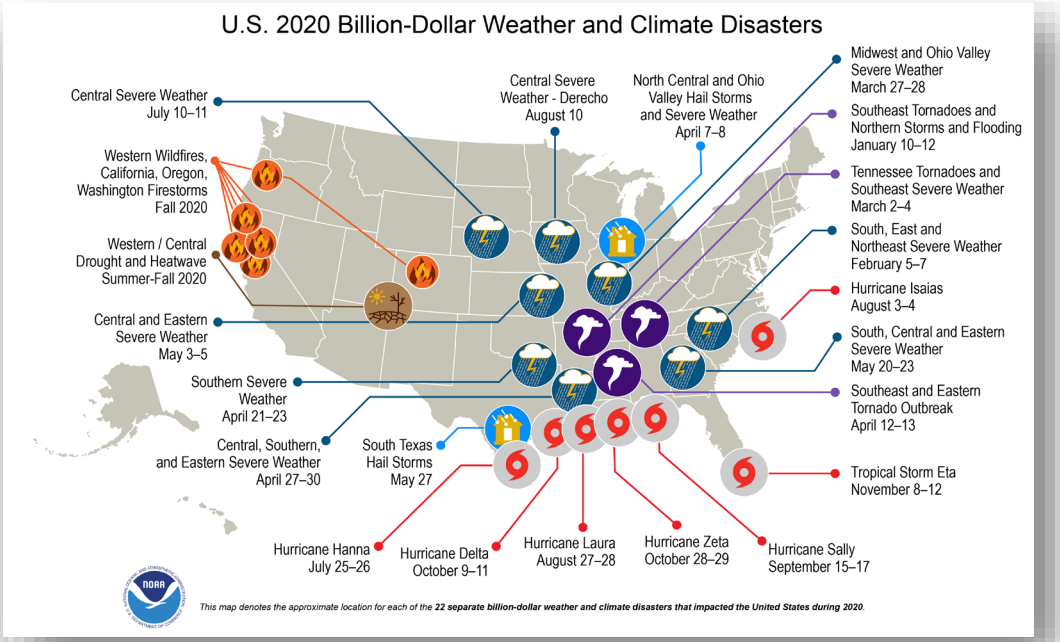
Outline

- Climate change is the new normal
- The electric grid at the forefront for critical sectors and services
- Climate/resilience solutions: mitigation and adaptation
- Interplay between resilience and reliability
- A comprehensive climate/resilience plan
- Quantifying resilience metrics
- Vulnerability assessment and Investment prioritization
- Conclusions
- Q&A

Climate Change is The New Normal





E&E NEWS
CLIMATE

Unprecedented Heat Wave in Pacific Northwest Driven by Climate Change

Pacific Ocean cyclones are pumping up the high pressure system roasting the region

By Anne C. Mulkern, E&E News on June 28, 2021

A Glimpse of America's Future: Climate Change Means Trouble for Power Grids

Systems are designed to handle spikes in demand, but the wild and unpredictable weather linked to global warming will very likely push grids beyond their limits.

Texas gas well freeze-offs, power cuts persist

Domino Effect: The Power Sector is in the Center of All Critical Infrastructure

FEMA Community Lifelines

Safety and Security - Law Enforcement/Security, Fire Service, Search and Rescue, Government Service, Community Safety

Food, Water, Shelter - Food, Water, Shelter, Agriculture

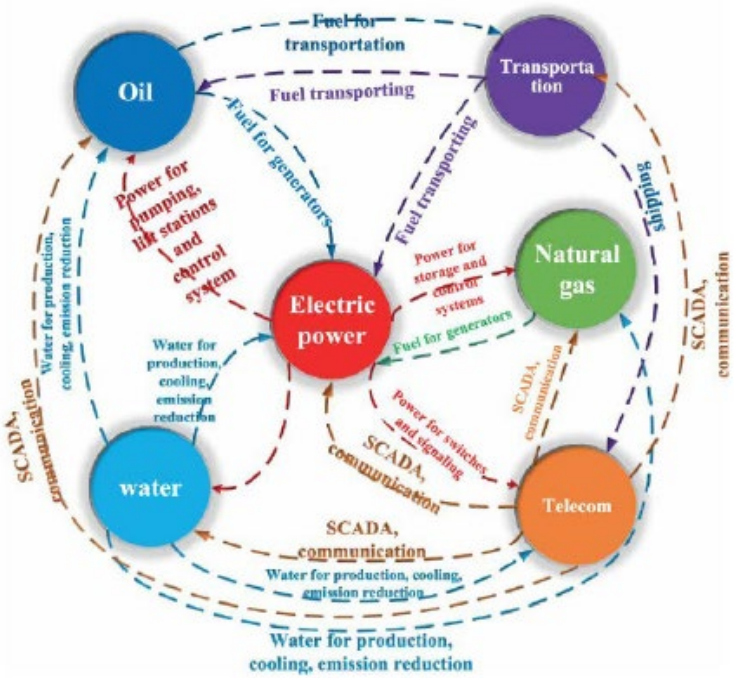
Health and Medical - Medical Care, Public Health, Patient Movement, Medical Supply Chain, Fatality Management

Energy - Power Grid, Fuel

Communications - Infrastructure, Responder Communications, Alerts Warnings and Messages, Finance, 911 and Dispatch

Transportation - Highway/Roadway/Motor Vehicle, Mass Transit, Railway, Aviation, Maritime

Hazardous Material - Facilities, HAZMAT, Pollutants, Contaminants



SCIENCE

The Texas Winter Storm And Power Outages Killed Hundreds More People Than The State Says

A BuzzFeed News analysis shows the catastrophic failure of Texas's power grid in February killed hundreds of medically vulnerable people.


Peter Aldhous
BuzzFeed News Reporter


Stephanie M. Lee
BuzzFeed News Reporter


Zahra Hirji
BuzzFeed News Reporter

Posted on May 26, 2021, at 6:09 p.m. ET

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Health care during electricity failure: The hidden costs

Abigail Mechtenberg, Brady McLaughlin, Michael DiGaetano, Abigail Awodele, Leslie Omeeboh, Emmanuel Etwalu, Lydia Nanjula, Moses Musaazi †, Mark Shrime

Published: November 4, 2020 • https://doi.org/10.1371/journal.pone.0235760

Research

Heat-Related Mortality in Japan after the 2011 Fukushima Disaster: An Analysis of Potential Influence of Reduced Electricity Consumption

Yoonhee Kim,[1] Antonio Gasparrini,[2,3] Masahiro Hashizume,[1] Yasushi Honda,[4] Chris Fook Sheng Ng,[1] and Ben Armstrong[2]

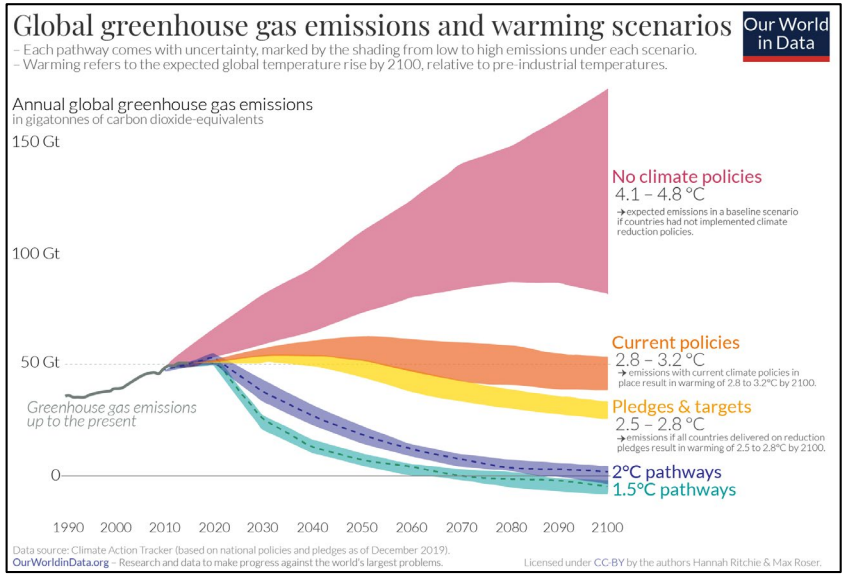
[1]Department of Pediatric Infectious Diseases, Institute of Tropical Medicine, Nagasaki University, Nagasaki, Japan
[2]Department of Social and Environmental Health Research, London School of Hygiene and Tropical Medicine, London, UK
[3]Department of Medical Statistics, London School of Hygiene and Tropical Medicine, London, UK
[4]Faculty of Health and Sport Sciences, University of Tsukuba, Tsukuba, Japan

Source: Buzzfeed https://www.buzzfeednews.com/article/peteraldhous/texas-winter-storm-power-outage-death-toll

Climate Change Solutions: Mitigation and Adaptation

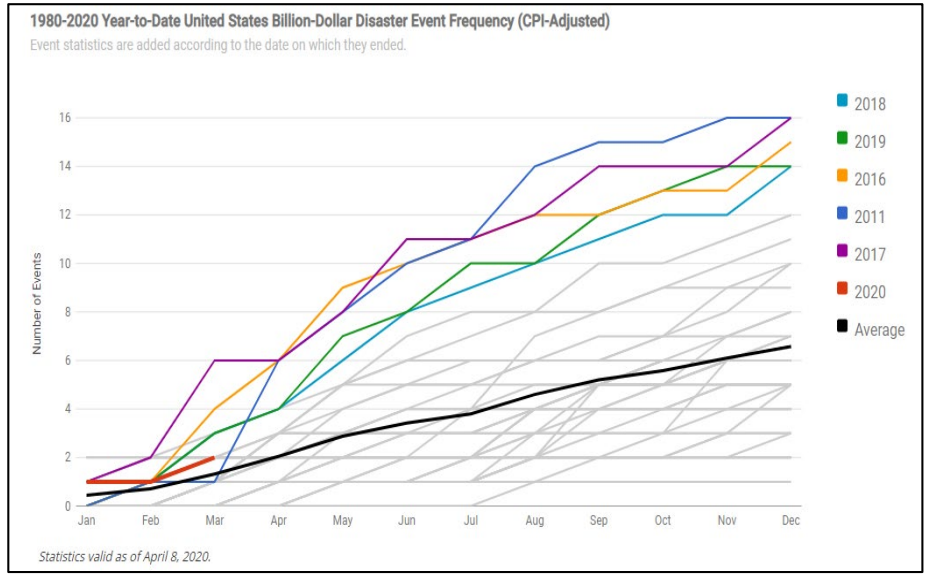
Mitigation

Reducing the pace of climate change prioritizes increased electrification of our infrastructure, while simultaneously decarbonizing the grid



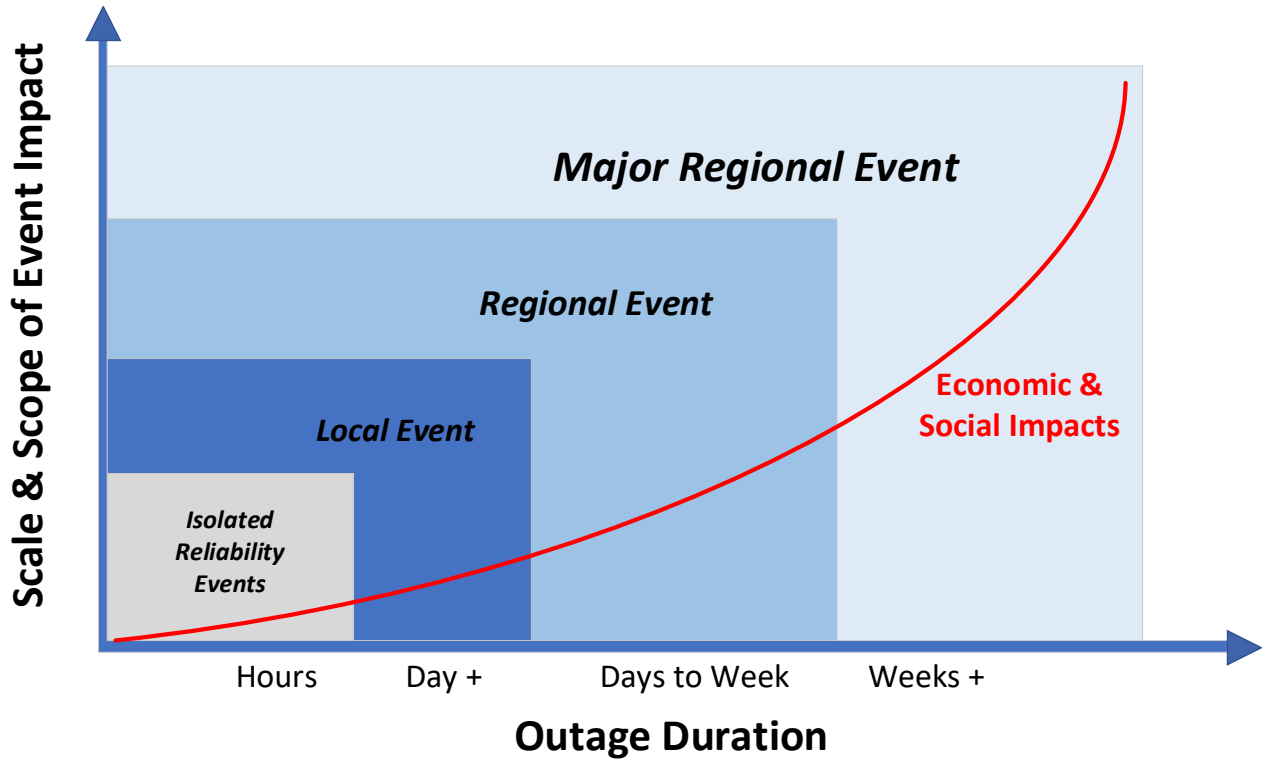
Adaptation

Building resilience for the impacts that can not be avoided requires hardening infrastructure we are increasingly dependent on, with a focus on equity and broader societal resilience



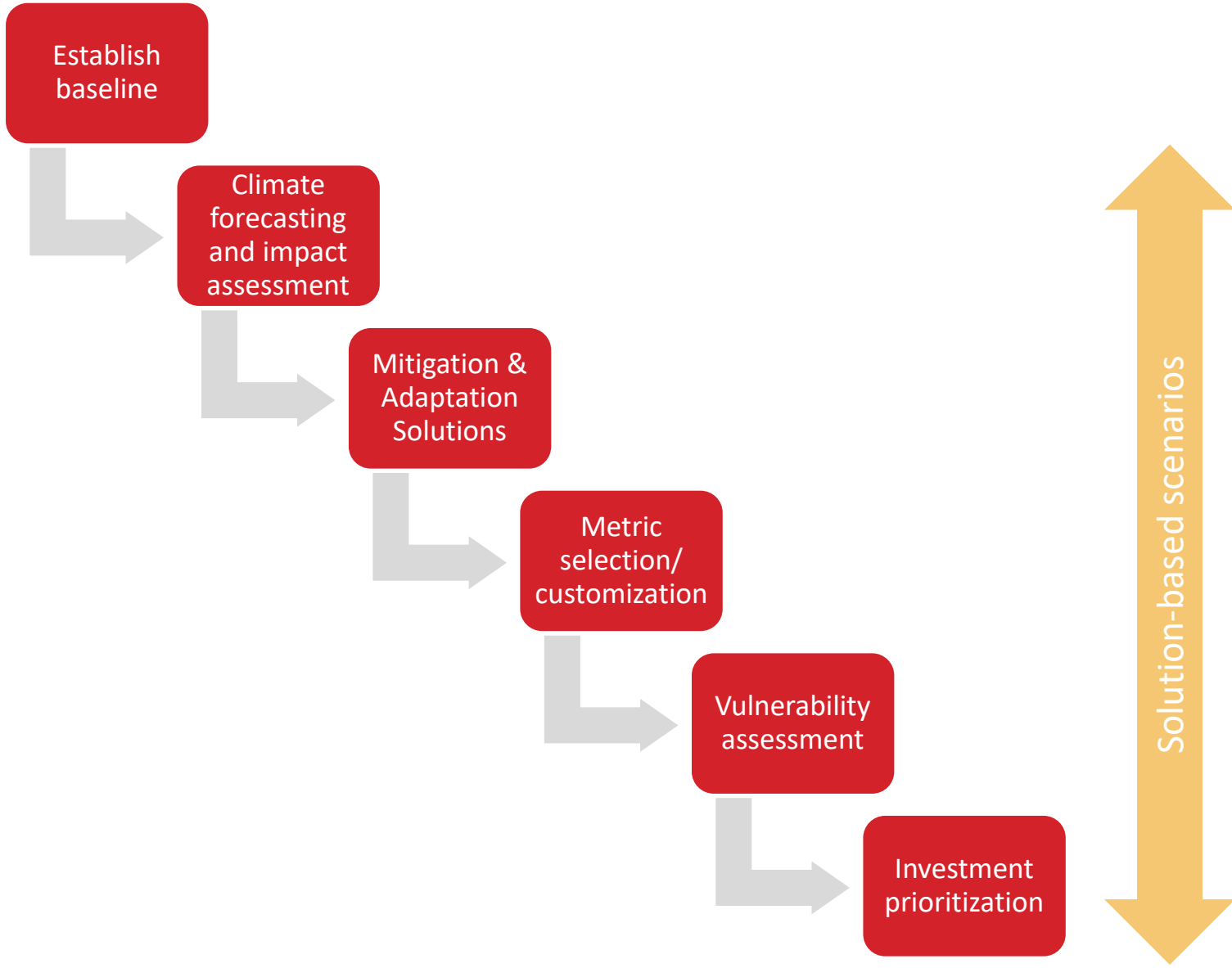
Interplay Between Reliability and Resilience

- *Reliability* is commonly acknowledged as a system performance measure → statistical past performance
- *Resilience* is a system characteristic/capability encompassing all hazards and events, including high-impact low-probability events that are excluded from reliability calculations → forward looking projection
  - While reliability metrics (SAIDI, SAIFI, etc.) can still be used to gauge larger scale impacts, they do not provide the complete picture of process of recovery
- *Reliability and Resilience* often improve each other (e.g., system hardening), however, there could be opposing tradeoffs
  - Reclosers



Source: IEEE Resilience TR83 PES Webinar

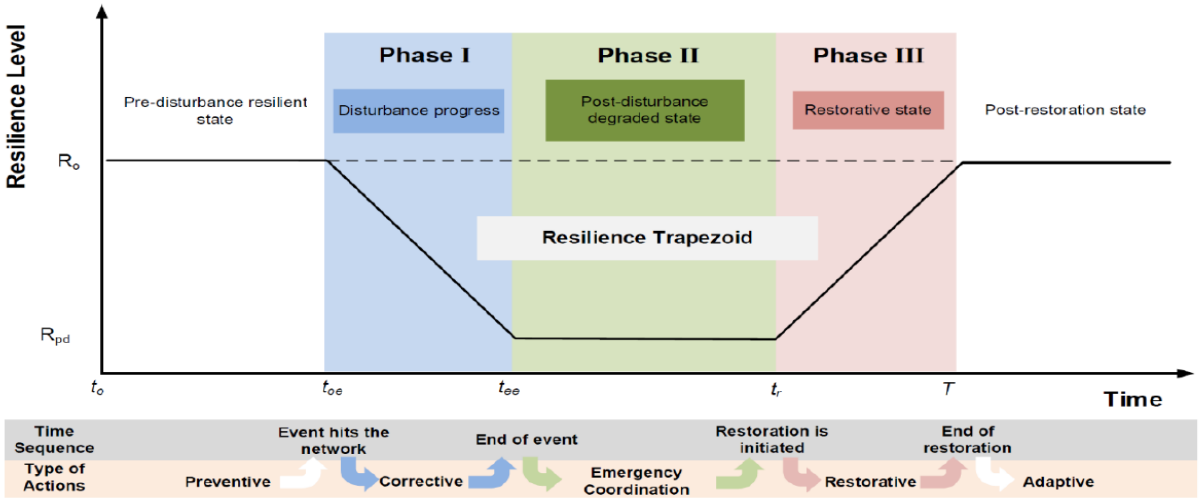
Climate/Resilience Plan



Pairing a portfolio of solutions to climate change pace (low, moderate, high as measured by °Fahrenheit temperature rise and risk)

Quantifying Resilience Metrics

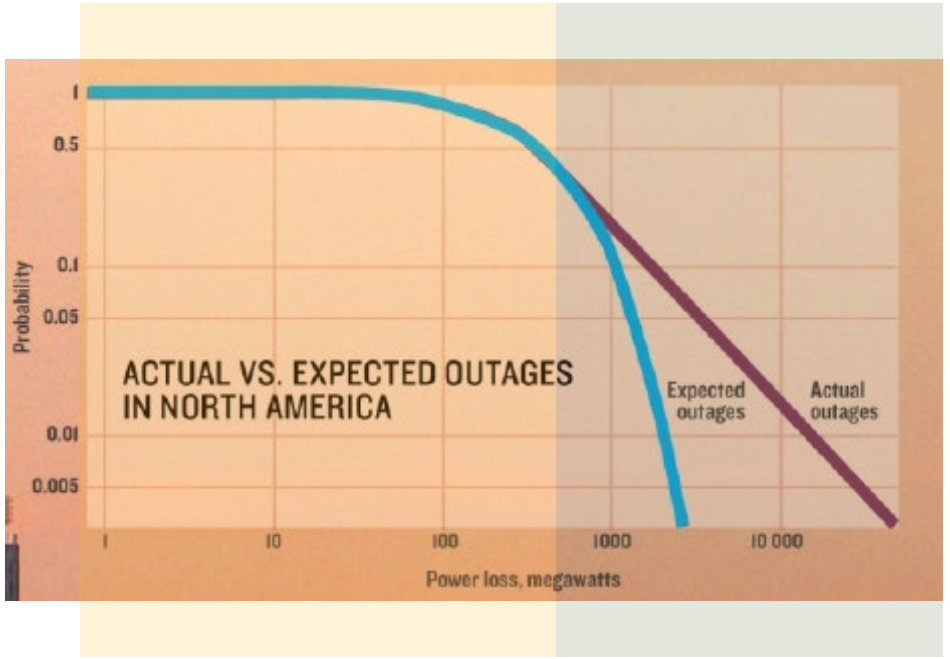
- No universal “One-size fits all” resilience metrics
  - Appropriate metrics are case-specific dependent on status of the grid, and regional and operational differences
- Resilience metrics should
  - Facilitate continuous improvement and benchmarking
  - Be evaluated with high locational granularity
  - Span all environments (health and social, community in addition to grid and services)
  - Span all event lifecycle stages
  - Incorporate uncertainty (probabilistic approach)
  - Avoid double counting and allow proper separation of solutions’ benefits



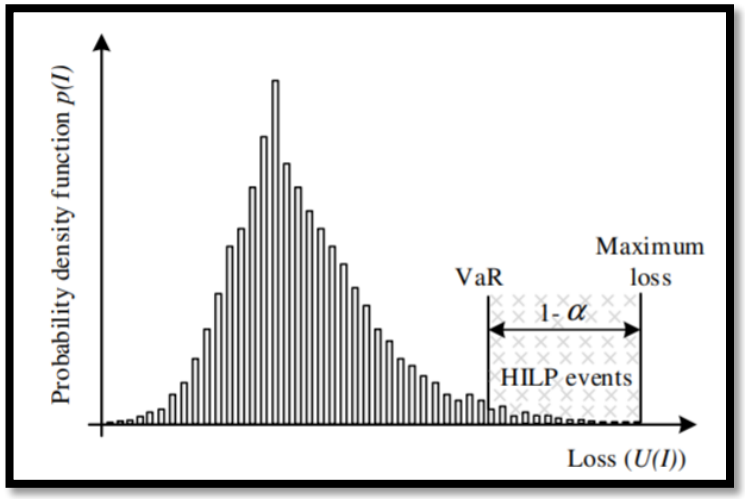
Stages of disturbance

Conditional Value at Risk

- Although traditional probabilistic methods estimate the consequence of low-to-moderate outages well, they can underestimate the actual consequence of extreme events, due to their lower probabilities
- High impact low probability (HILP) events at the “tail” of probability distributions
- Conditional value at risk (CVaR) approach: Calculate expected consequence **assuming an extreme event will occur**

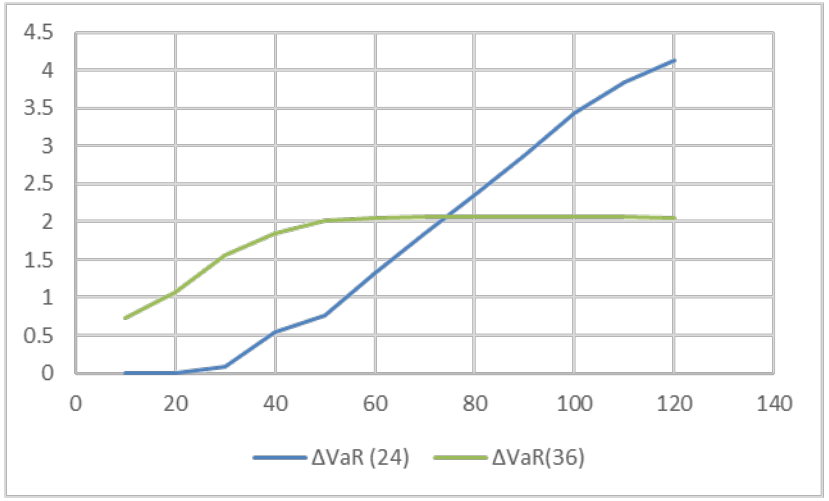


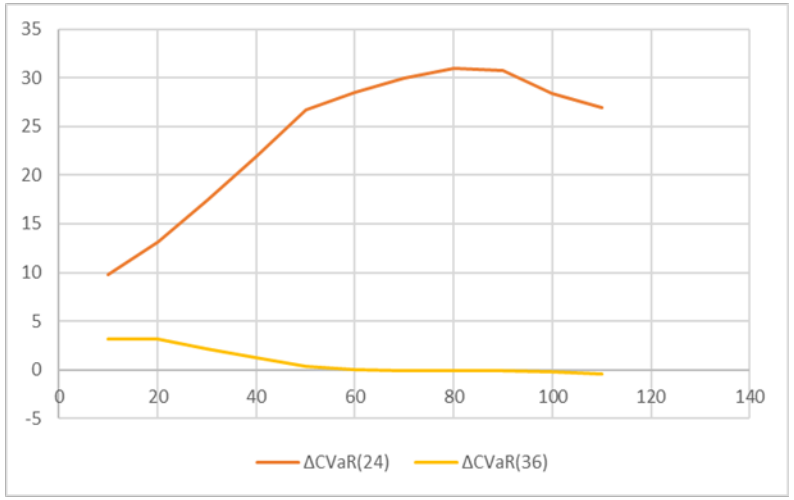
Small-to-moderate outages Larger outages



Case Study: Using Risk-Based Values

- **Objective –** We must choose between hardening two lines (let's say line 36 and line 24) in the system. We consider both Average (Expected) Value of Load at risk (VAR) and Conditional Value of Load at risk (CVAR).
- We now compare both projects performance in terms of VAR and CVAR , (difference relative to the baseline)
  - **Project 36 shows the best improvement in Value at Risk (VAR) ← no contribution under extreme events**
  - **Project 24 shows the best improvement in Conditional Value at Risk (CVAR) ← contribution under extreme events**
- Taking into consideration the strategy of preparedness for extreme events, Project 24 is preferred.





Line 36 shows the best improvement in Value at Risk (VAR)
Line 24 shows the best improvement in Conditional Value at Risk (CVAR)

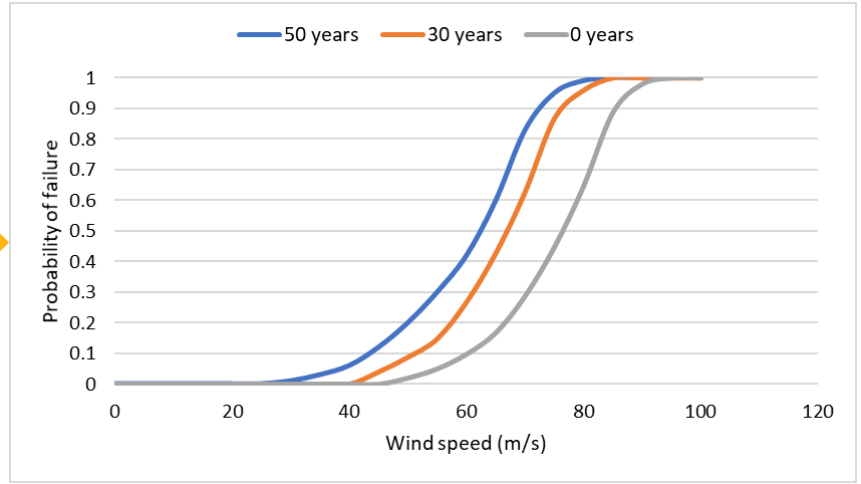
Vulnerability Assessment

- Vulnerability assessment is identifying pain points of the system
- Metrics → sensitive and critical grid assets
  - Resilience metric→ areas with microgrid needs
  - Social metric→ critical customers without power
    - Community metric
- Must be highly granular

Metric

Storm severity

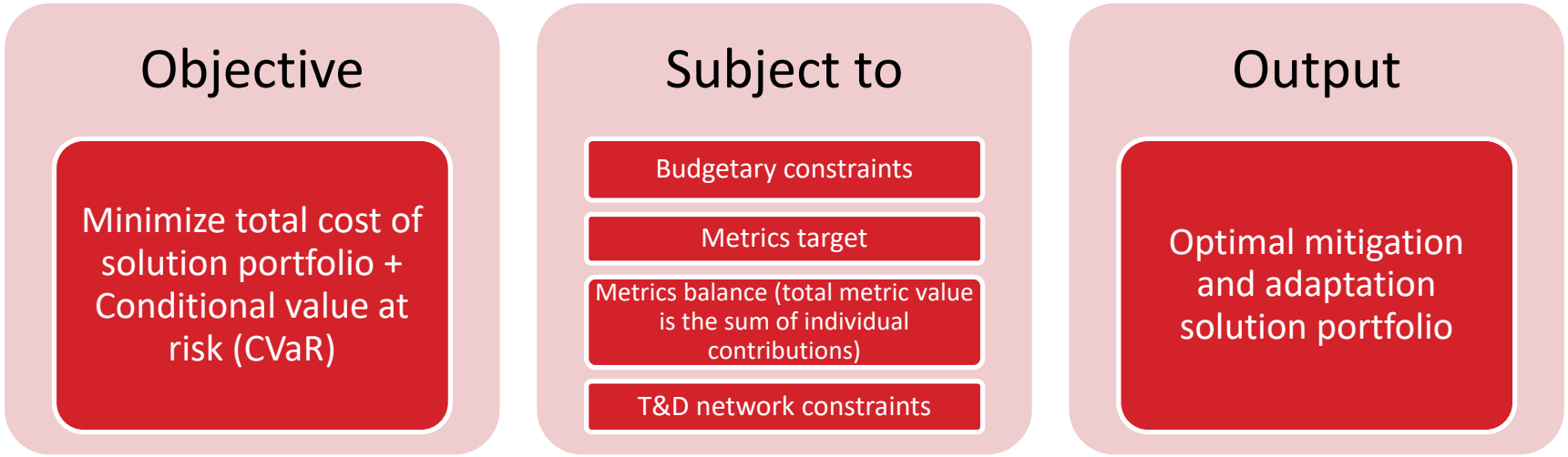
Critical Assets



Asset information (pole age and class)
Soil type

Optimization Based Investment Prioritization

Multi-objective integer optimization



- Locational and temporal granularity
- Mitigation and adaptation solution portfolio
- Risk averse logic: based on Conditional Value at Risk (CVaR)
- Timescales
  - Solve for both mitigation & adaptation
- Need to incorporate climate/resilience planning as part of coordinated planning functions that map objectives into investment decisions

Conclusion

Necessary

- Climate change is the new norm
- Extreme events are inevitable
- Need strategic investments for critical infrastructure

Complex

- The study of resilience requires a ***multi-disciplinary approach*** that includes specialties from weather forecasting, forestry, geospatial mapping, geotechnical, structural, electrical, communications, cyber, forensics, data analytics, etc

Quantitative

- No “one-size-fits-all” metrics
- How to access performance ***during*** the lifecycle of an extreme event?
- Resilience metrics should facilitate continuous improvement and benchmarking