# Prioritizing Climate Adaptation Investments across the Ontario Electric Sector

## IBWG meeting

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# COLLABORATION

EPRI's collaborative platform connects members to a global network of peers and accelerates learnings


# EXPERTISE

For over 50 years, EPRI has utilized R&D to address real challenges, establishing a comprehensive industry-wide repository of collective experiences, technical expertise, and training resources

# CREDIBILITY

EPRI's independent research is guided by our mission to benefit the public

## Who We Are

Founded in 1972, the Electric Power Research Institute (EPRI) is the world's preeminent independent, non-profit energy research and development organization, with offices around the world.

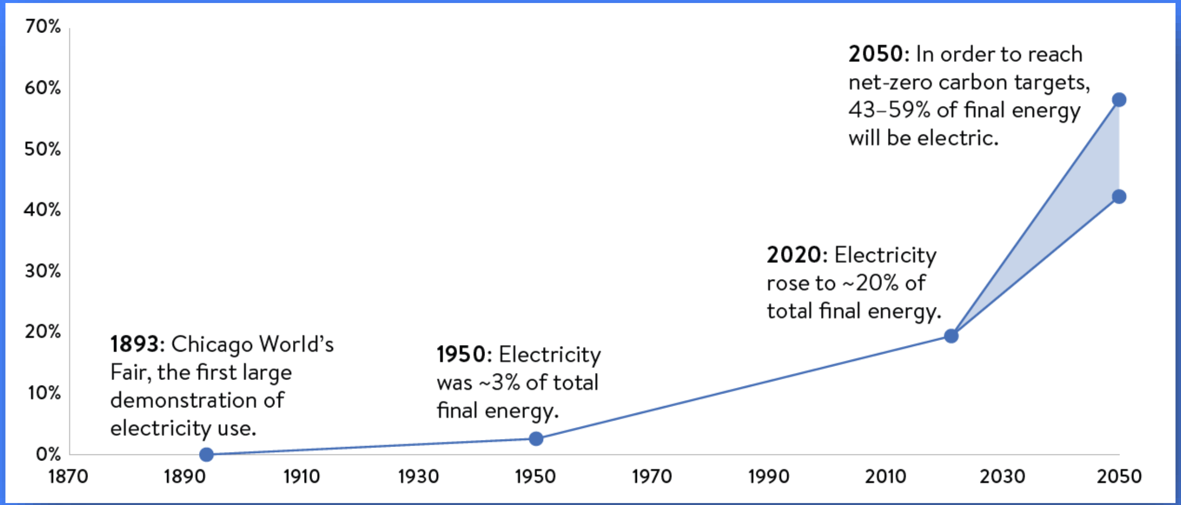
## Our Experts

EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe.

# A Growing Dependency on Electricity as Final Energy

**The picture when we launched READi…**

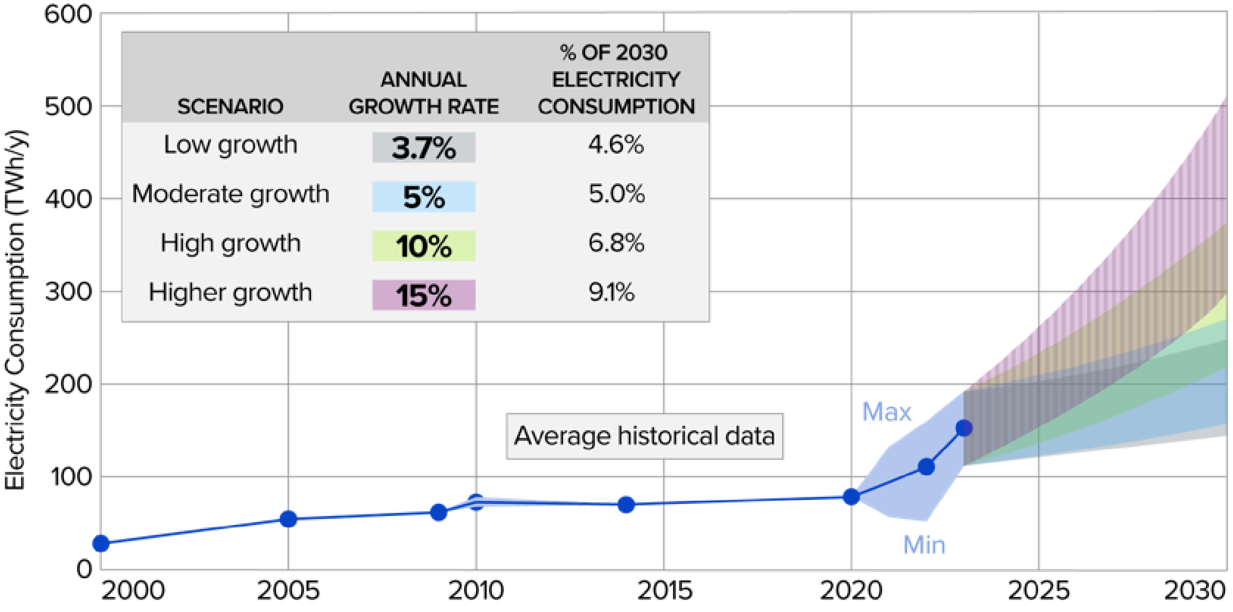
Electricity as a fraction of total energy consumption in the U.S.




Source: EPRI, "LCRI Net-Zero 2050," 2022: https://lcri-netzero.epri.com/

**Three years later…**

U.S. Data Center Power Demand Growth




| SCENARIO | ANNUAL GROWTH RATE | % OF 2030 ELECTRICITY CONSUMPTION |
|---|---|---|
| Low growth | 3.7% | 4.6% |
| Moderate growth | 5% | 5.0% |
| High growth | 10% | 6.8% |
| Higher growth | 15% | 9.1% |

Source: EPRI Technology Innovation, *Powering Intelligence*, May 2024

**The Power System of the Future will be both more Weather Dependent & Operating in a Changing Climate**

# Potential energy system impacts from extreme weather and climate change

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### Energy Demand
Extreme temperatures increase electricity and fuel demands beyond capacity

ieso Connecting Today. Powering Tomorrow.

### Electric Grid
Wind, ice, floods and wildfires damage power lines and other infrastructure

Extreme heat decreases transmission/ distribution capacity

hydro one


### Wind, Solar, Hydropower, and Geothermal
Extreme weather damages on and offshore facilities

Cloudy or stagnant conditions reduce solar and wind production

Drought limits water-intensive geothermal and hydro production

OPG

### Thermoelectric Power
Flooding damages facilities and disrupts operations

Higher air and water temperatures decrease power plant efficiency and limit cooling water discharges

Limited cooling water availability reduces production and siting of new plants

OPG

Bruce Power Innovation at work

### Oil, Gas, and Coal
Extreme winds damage on and offshore platforms

Flooding damages production and storage facilities

Drought and severe storms constrain drilling, refining, fracking, mining and transport

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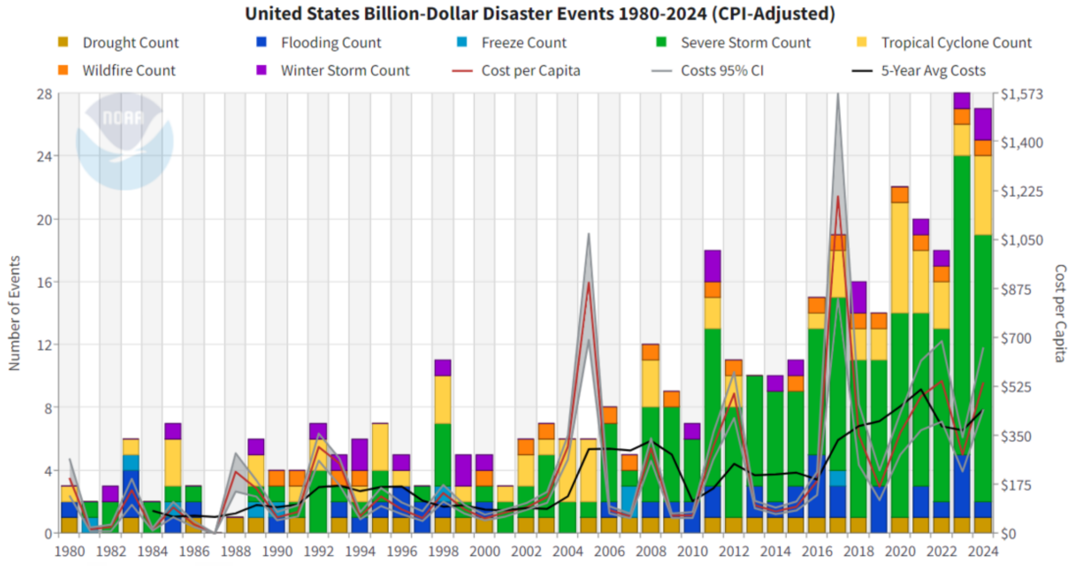
**Climate change impacts all aspects of the energy system**

*Source: Adapted from NCA Volume 5, Chapter 5*

# The Costs of Extreme Events

## Billion-dollar disasters are growing in cost and increasing in frequency

**Without informed and timely adaptation, costs from climate disasters are likely to increase.**




Billion-dollar disaster events in the U.S. from 1980 through 2024. Source: [NOAA]


Canadian Insured Catastrophic Losses- 2022 Source: *Insurance Bureau of Canada, 2023*

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| Workstream 1 | Workstream 2 | Workstream 3 |
|---|---|---|
| **Physical Climate Data & Guidance** | **Asset Vulnerability & Design** | **System Planning & Prioritization** |
| • Identify climate hazards and data required for different applications<br>• Evaluate data availability, suitability, and methods for downscaling & localizing climate information<br>• Address data gaps | • Evaluate vulnerability at the component, system, and market levels from planning to operations<br>• Identify mitigation options from system to customer level<br>• Enhance criteria for planning and operations to account for event probability and uncertainty | • Assess power system and societal impacts: resilience metrics and value measures<br>• Create guidance for optimal investment priorities<br>• Develop cost-benefit analysis, risk mitigation, and adaptation strategies |

# EPRI Climate Resilience and Adaptation Initiative (READi)

- **COMPREHENSIVE:** Develop a *Common Framework* addressing the entirety of the power system, planning through operations
- **CONSISTENT:** Provide an informed approach to climate risk assessment and strategic resilience planning that can be replicated
- **COLLABORATIVE:** Drive stakeholder alignment on adaptation strategies for efficient and effective investment


## Final Product: A Common Framework

- Climate data assessment and application guidance
- Vulnerability assessment
- Risk mitigation investment
- Recovery planning
- Hardening technologies
- Adaptation strategies
- Research priorities



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# THE Climate READi: Power Framework

| | READi | Climate Data | Asset Vulnerability | System Risk |
|---|---|---|---|---|
| **Guidance** | Climate READi Compass: Navigating Physical Climate Risk Assessments for the Power System | Climate Data Users Guide<br>Climate Hazard and Exposure Assessment Guidance for Power System Applications | Asset Vulnerability and Response Assessment Guidance<br>Climate Vulnerability Assessment Guidance for Nuclear Power Plant<br>Fragility Curves for Quantifying Physical Climate Risk in the Electric Power Sector | Planning for Climate Resilience in the Power System: A Guide for Model Implementation<br>Investing for Climate Resilience in the Power System: A Guide for Adaptation Prioritization and Decision-Making |
| **References** | Climate 101 Modules<br>Case Studies and Story Maps | Approaches to Future Hourly Time Series for Climate-Resilient Power System Planning<br>An Approach to Defining Temperature Extreme Events: A Threshold-based Probabilistic Approach to Defining Extreme Temperature Events<br>Compound Hazards and the Power Sector in a Changing Climate<br>Climate Data Gaps Assessment | Asset Vulnerability Literature Review Series | Developing a Climate Informed Modeling Framework for Power System Planning – A Synthetic Texas Case Study<br>Practices for Representing Climate Impacts in Bulk Electric System Models<br>Metrics to Evaluate Effectiveness of Resilience Strategy Deployment |
| **Tools** | Disclosing Physical Climate Risk: Inventory of Climate READi Resources to Support Reporting and Disclosure Activities | Climate Data Inventory<br>Wildfire Tool Inventory and Evaluation | Climate-Related Vulnerabilities and Adaptations for Electric Power System Assets | Climate Risk Screening (RiSc) Tool |

# How to make climate-informed decisions and improve resilience?

Near-term or long-term investments

Individual asset or whole system

Assessment or adaptation justification

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## READi Approach:

1. Scope the problem to address the system needs and time frame of interest
2. Select climate data, vulnerability functions, and adaptation strategies for analysis
3. Conduct integrated model runs for planning and/or evaluation
4. Evaluate cost effectiveness of adaptation strategies

# Example: Texas Case Study

# Power System Planning: How is infrastructure typically planned for?

In the past, power system planning happened mostly in ‘silos’ with different planning functions mostly disjointed within and across companies.

**Local Level Load Projections**

**Regional Technology Adoption Pathways Modeling**

Understand potential technologies that could be considered in future electricity plans

**Bulk System Capacity Expansion Model**

Identify the most cost-optimal resources (such as generation, transmission or demand side management) that can meet future electricity demand

**Bulk System Reliability Model**

Detailed simulation to assess that that the planned resource mix can satisfy a wide range of conditions

**Operational Model**

Very detailed model to understand behavior and costs of future resource mix, under specified scenarios

**Power Flow & Stability Model**

Determine whether there is sufficient transmission to satisfy reliability standards

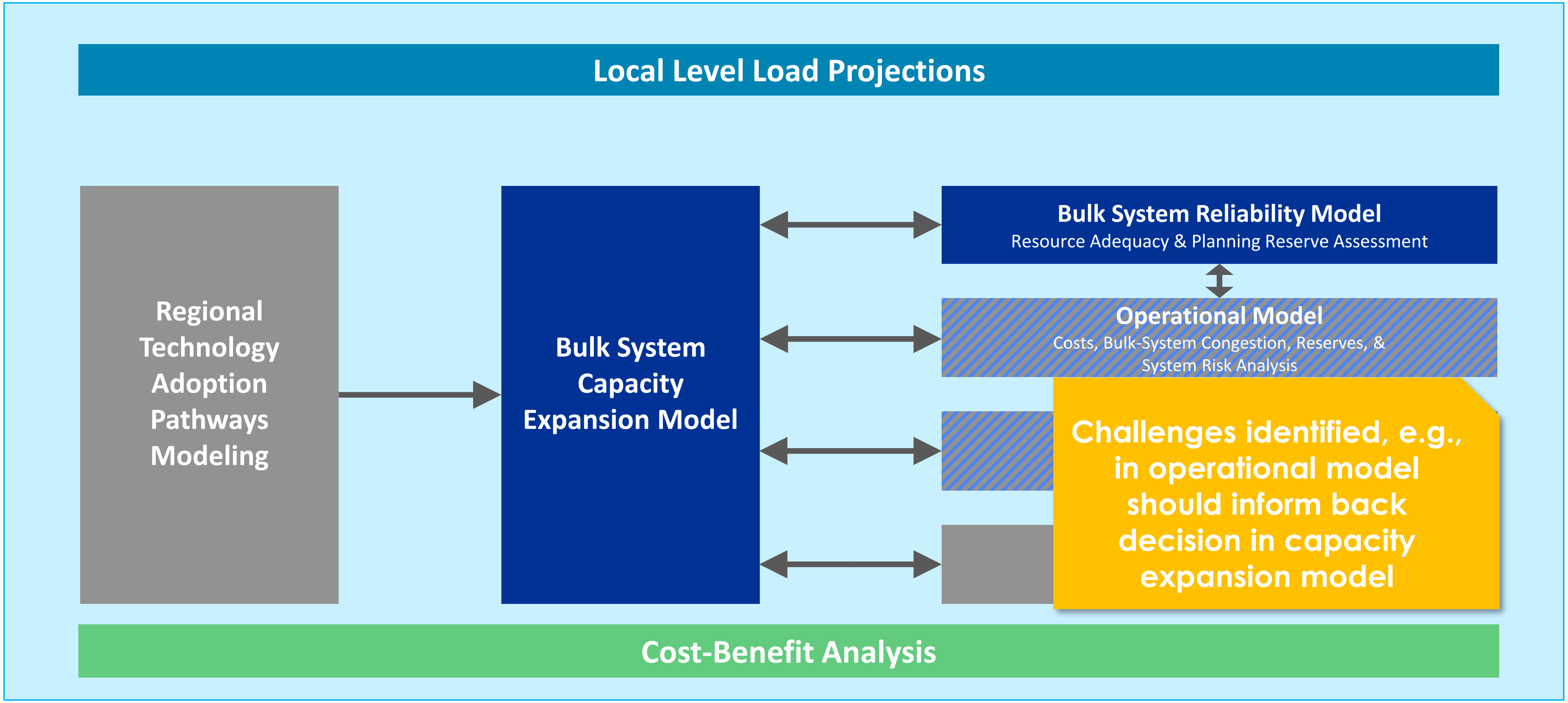
**Distribution Model**

Feeder Level Planning and Operations Assessments

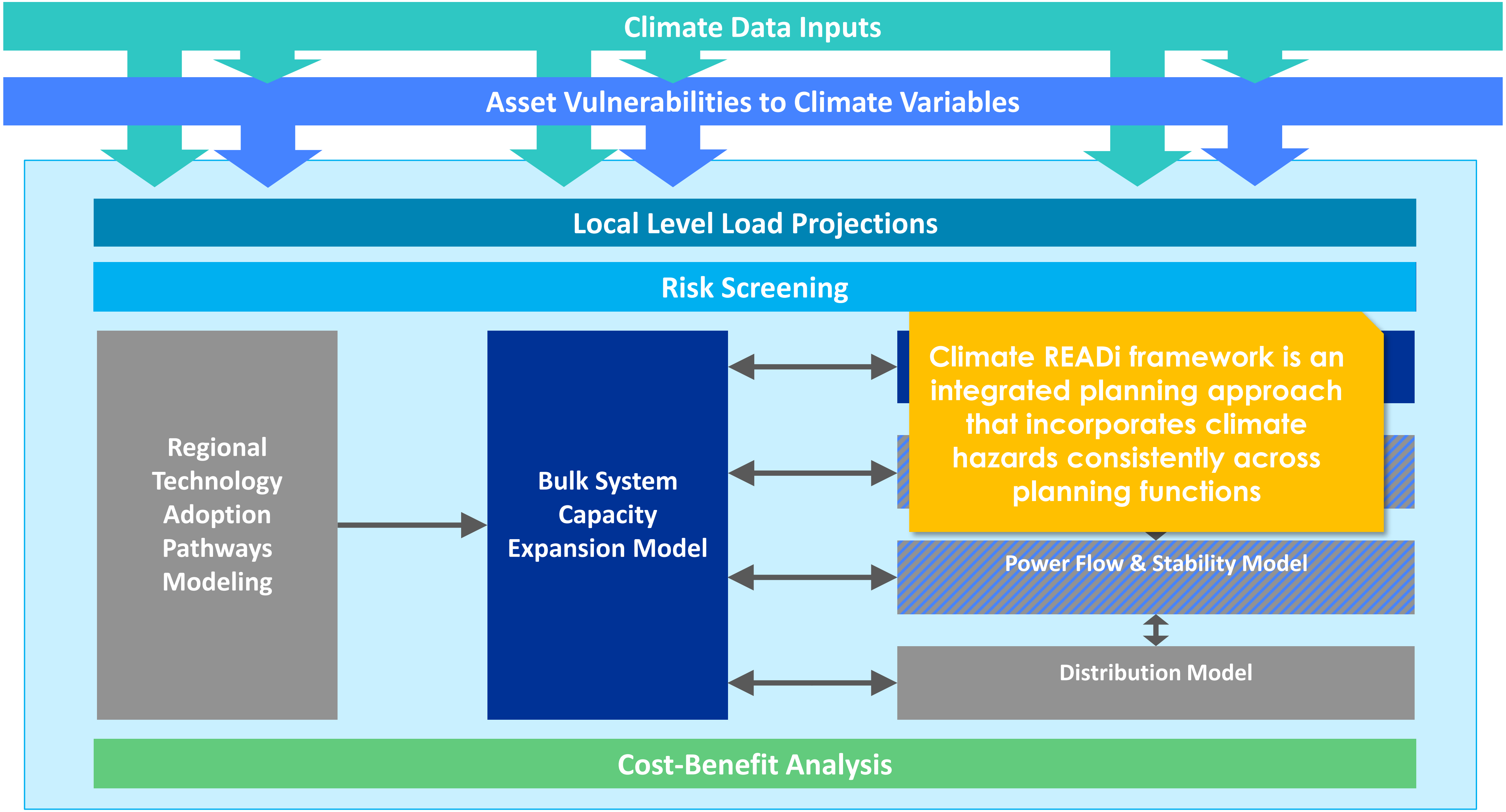
**Cost-Benefit Analysis**

# Integrated planning approach

Integrating the various functions involved in power system planning in an iterative manner helps identify opportunities and vulnerabilities holistically.



# Climate Resilience Assessment Framework



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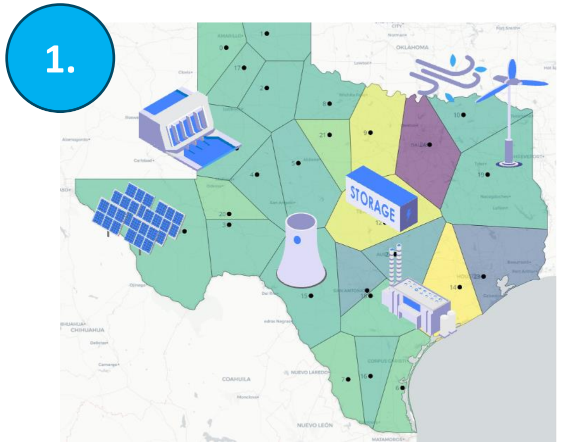
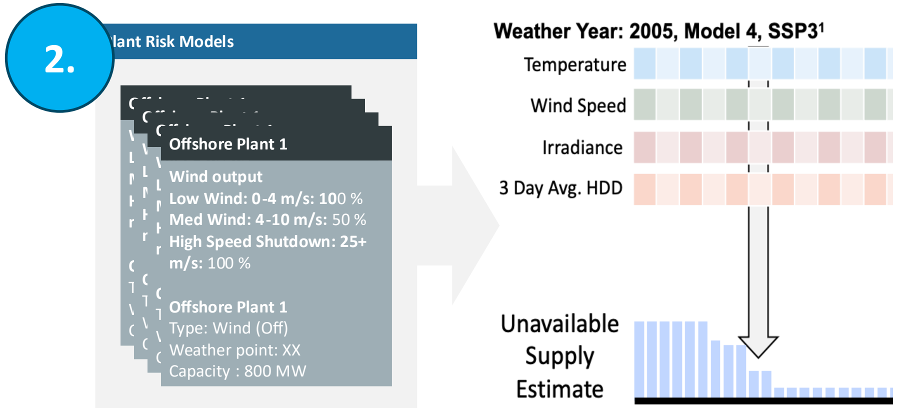
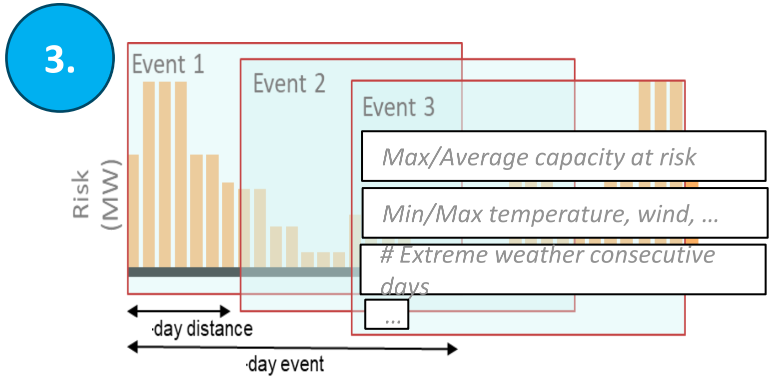
# Climate Risk Screening (RiSc): Identifying extreme events



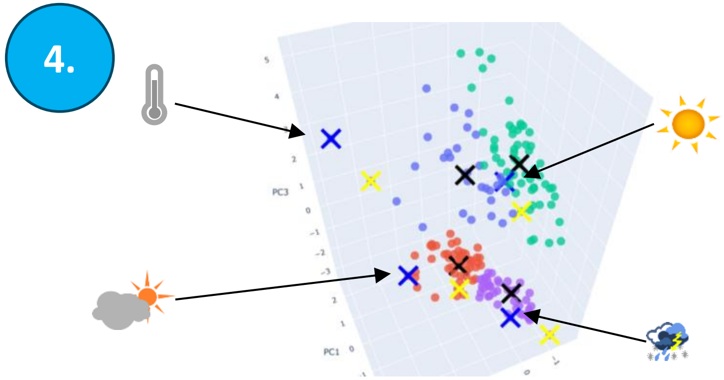

Map asset to weather




Apply asset vulnerabilities to weather data




Identify set of most stressful events

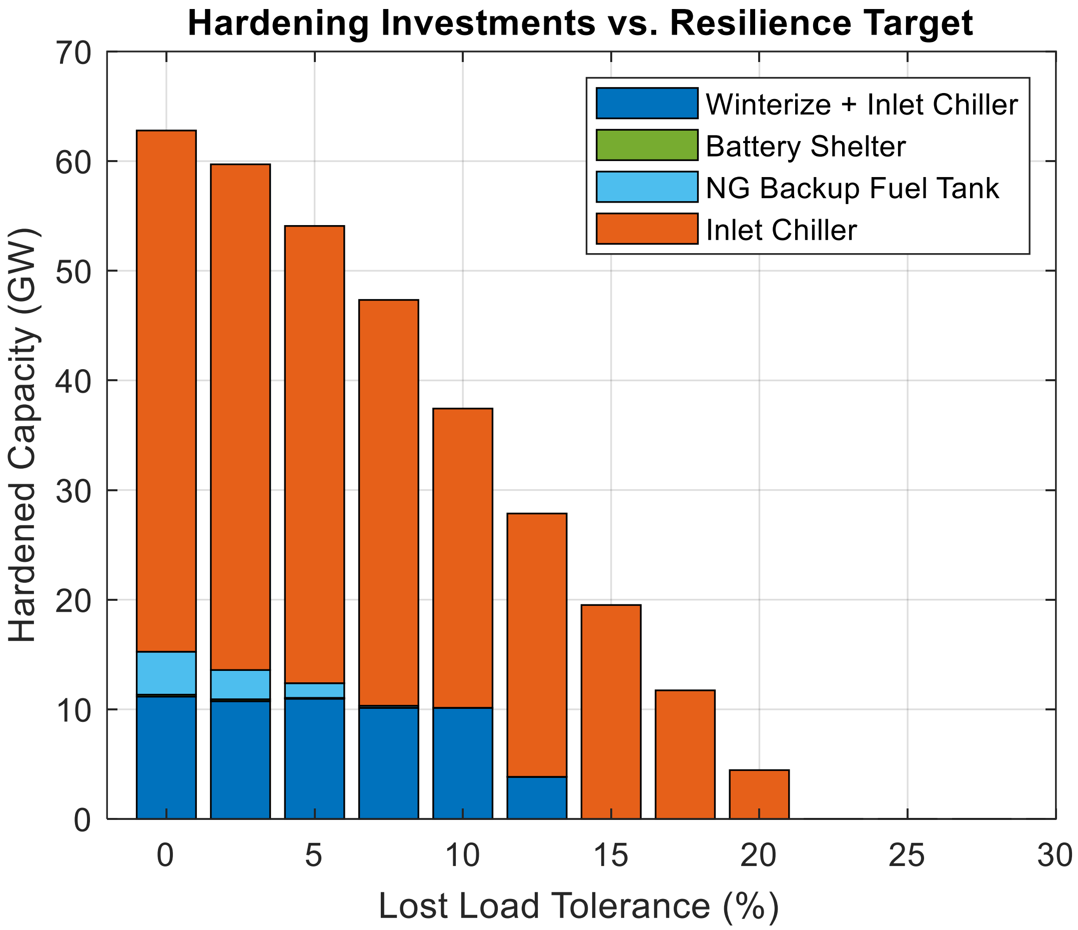



Group and select representative events

https://github.com/epri-dev/Risk-Screening-Tool

# Climate informed Bulk System Capacity Expansion

- ‘Business-as-usual’ capacity expansion model consider only a handful of representative, i.e., normal operating conditions
- **Climate informed** capacity planning model optimizes investments while explicitly considering extreme events provided by Screening tool
  - Considers derates/unavailability as a function of weather variables
  - Adaptation through technology choice and hardening options
- Resilience constraint for extreme event:
  - Investment decisions need to meet target Lost Load Tolerance metric (LLT) defined as percentage of system load that can be shed during extreme events




**Example from our Texas case study**

# Climate informed Resource Adequacy assessment

- 'Business-as usual' assessment of system reliability may only rely on a hand full of weather-years
- Our climate informed resource adequacy assessment included Monte-carlo simulations for 71 climate projected weather years including technical detail, such as ramps and minimum operating points
- Climate data incorporated through weather-dependent load profiles, variable Renewable Energy Sources production, outage probabilities and temperature derates

Expansion plans with varying levels of resilience

| Scenario | Loss-Of-Load-Expectation (LOLE) [days w. unserved energy/year] |
| --- | --- |
| LLT - 0% | 0.08 |
| LLT - 10% | 0.46 |
| Baseline | 3.06 |

(Resilience ↑ / Reliability ↑)

**Standard '1-in-10' reliability criterion only met by most resilient plan. Planning for resilience also showed to increase system reliability**

**Example from our Texas case study**



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# Learning & Limitations of Synthetic Texas Case Study

## Learnings

- Showcase value of the climate informed, integrated planning framework
- Illustrate system benefits of climate-resilient
- Consistently accounting for climate-hazards across planning function leads to more resilient & reliable system design

## Limitations

- Applying the framework to a system with multiple companies with different ownerships and objectives with shared responsibilities
- Moving from synthetic system to real world case study brings additional challenges:
  - Data sharing (agreements, collection, etc.)
  - Consensus & agreement on assumption
- Incorporating additional, region-specific climate hazards (e.g., ice, wildfires)

**Ontario case study to showcase climate-resilient planning with multi-organization involvement**

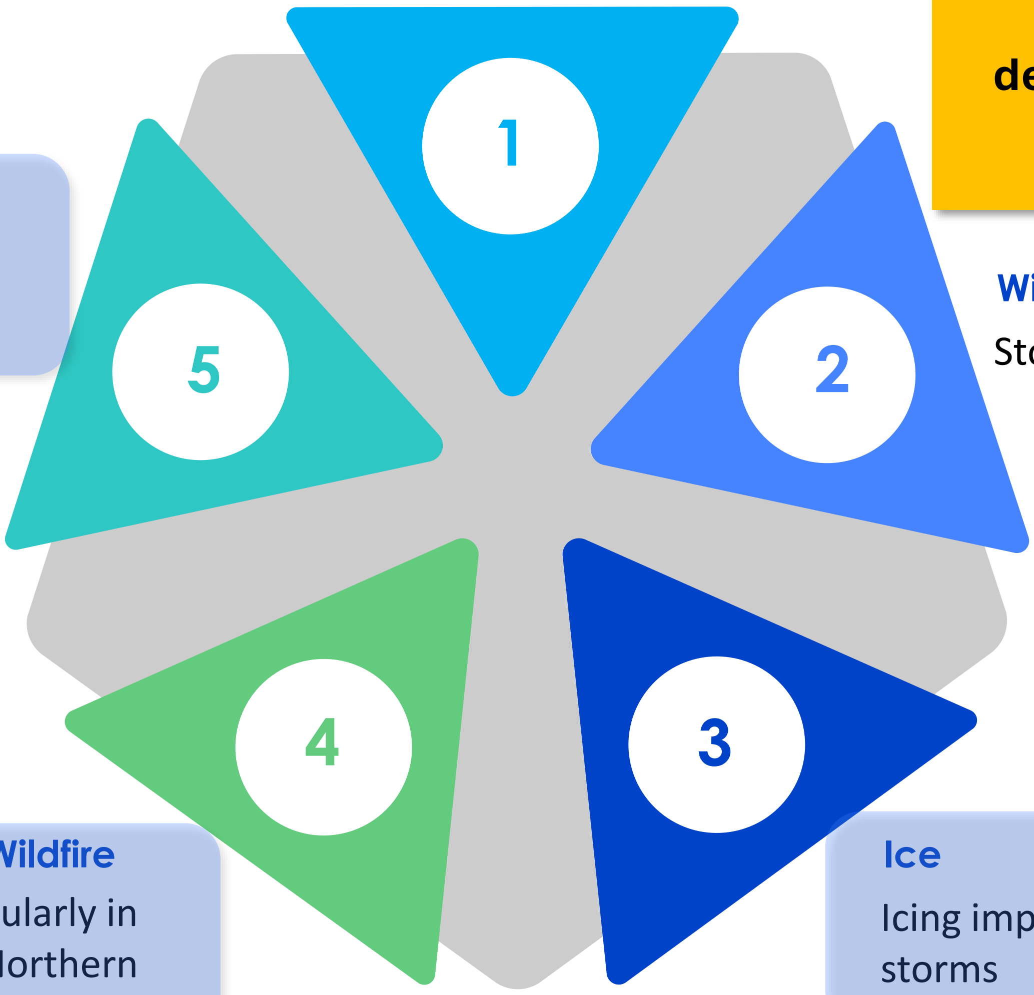
# Case Study: Climate READi meets Ontario

# Hazards Considered for Ontario Case Study

**Worked with the funders to develop a consensus on priority hazards to assess**

**Temperature**

Higher sustained temperatures, extreme heat/cold




**Drought**

Given reliance on hydro in Ontario

**Wind**

Storm impacts

**Ice**

Icing impacts, storms

**Wildfire**

Particularly in Northern Ontario

# What will it take for a Climate READi Ontario?

Representing **future climate conditions** in power system models with appropriate selection of climate data and consistent translation of climate conditions into **asset and system impacts**

Running a **suite of integrated models** to provide insight into broader system-level risks that no one model can address alone through **planning-to-evaluation processes**

Performing **cost-benefit assessment** that accounts for the full range of expected operating conditions, nominal and extreme, comparing among resilient investments or to the no-action baseline

**Coordination within and across organizations**, with varying objectives and accountabilities (consensus building on assumptions (e.g., climate data), data sharing agreements etc.)

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