Linking Different Modeling Tools and Domains

EPRI's Integrated Resilience and Strategic Planning Initiative

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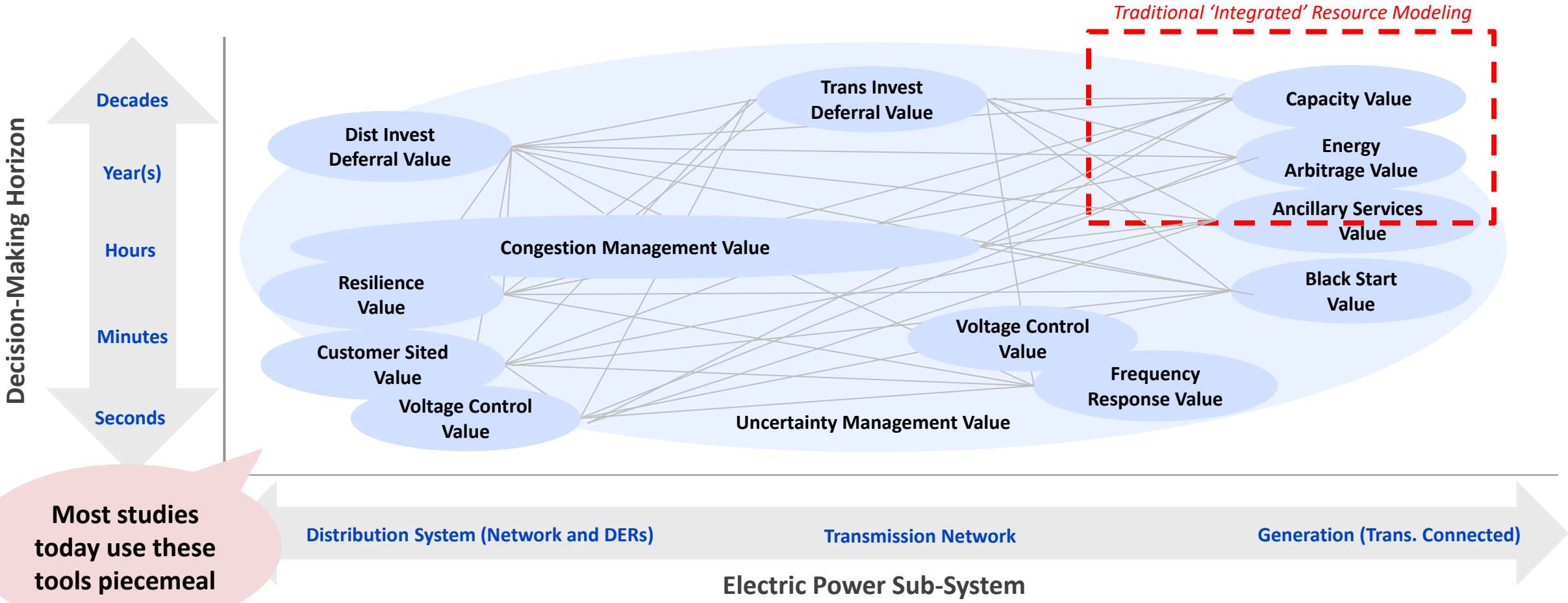
EPRI's Integrated Resilience & Strategic Planning Framework Initiative

Objective: Develop a state-of-the-art modeling framework/tool(s) to analyze system integration challenges the industry faces.

Who?	What?	How?
Cross-area EPRI staff: + Energy/Climate + T & D Planning + DER/Energy Storage + Customer resources Cross-area utility planning advisors	Integrate G/T/D models and planning tools Customer resources Operational reliability Climate considerations	EPRI BOD Initiative (internal funds) 3 years + R&D: 2 years + Application: 3rd year

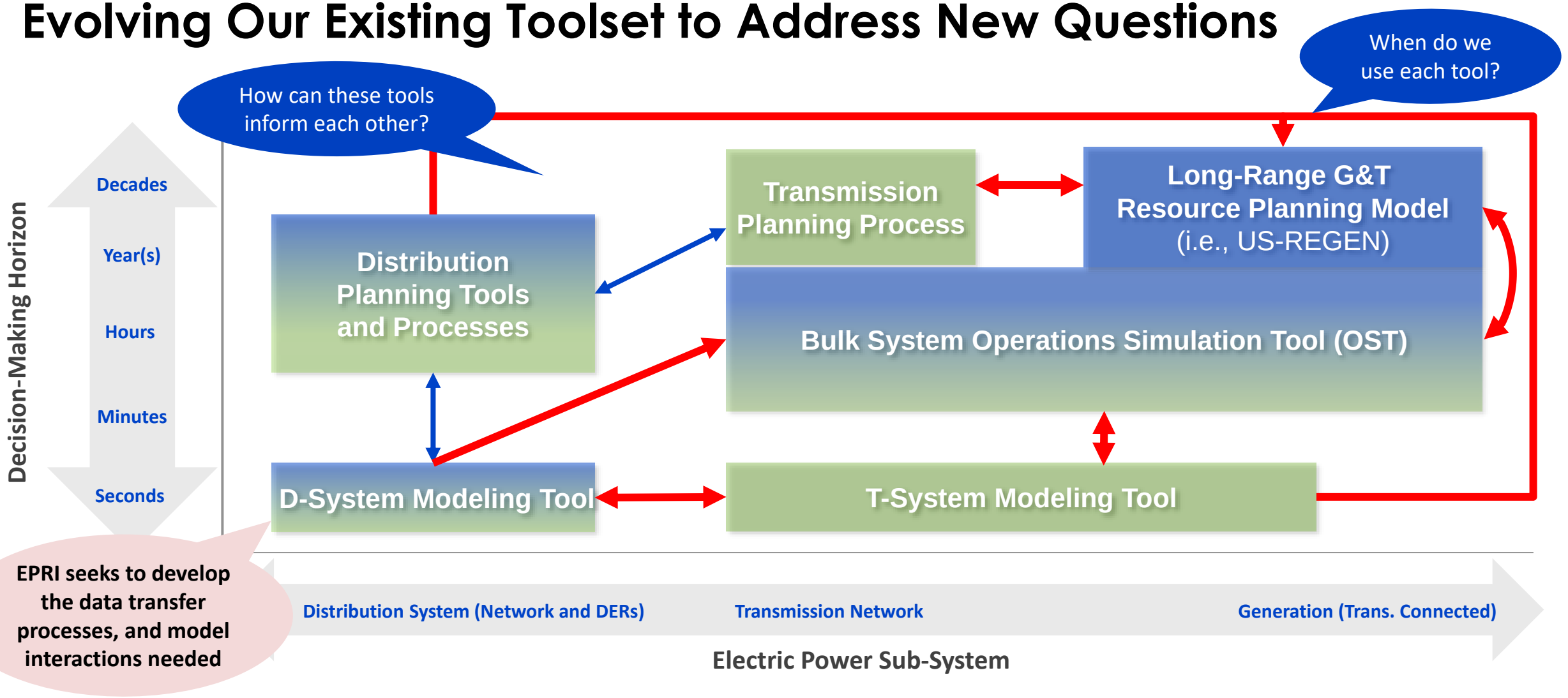
Deliverable: Tool and/or framework enhancements for EPRI and industry to conduct integrated, strategic planning studies.

Illustration: The Value of Energy Storage—A 'Simple' Question?



Inter-dependent values in advanced energy systems require a more integrated planning approach

Evolving Our Existing Toolset to Address New Questions



A New Integrated Modeling Platform

EPRI Tool

Other Tool

New Links to Explore

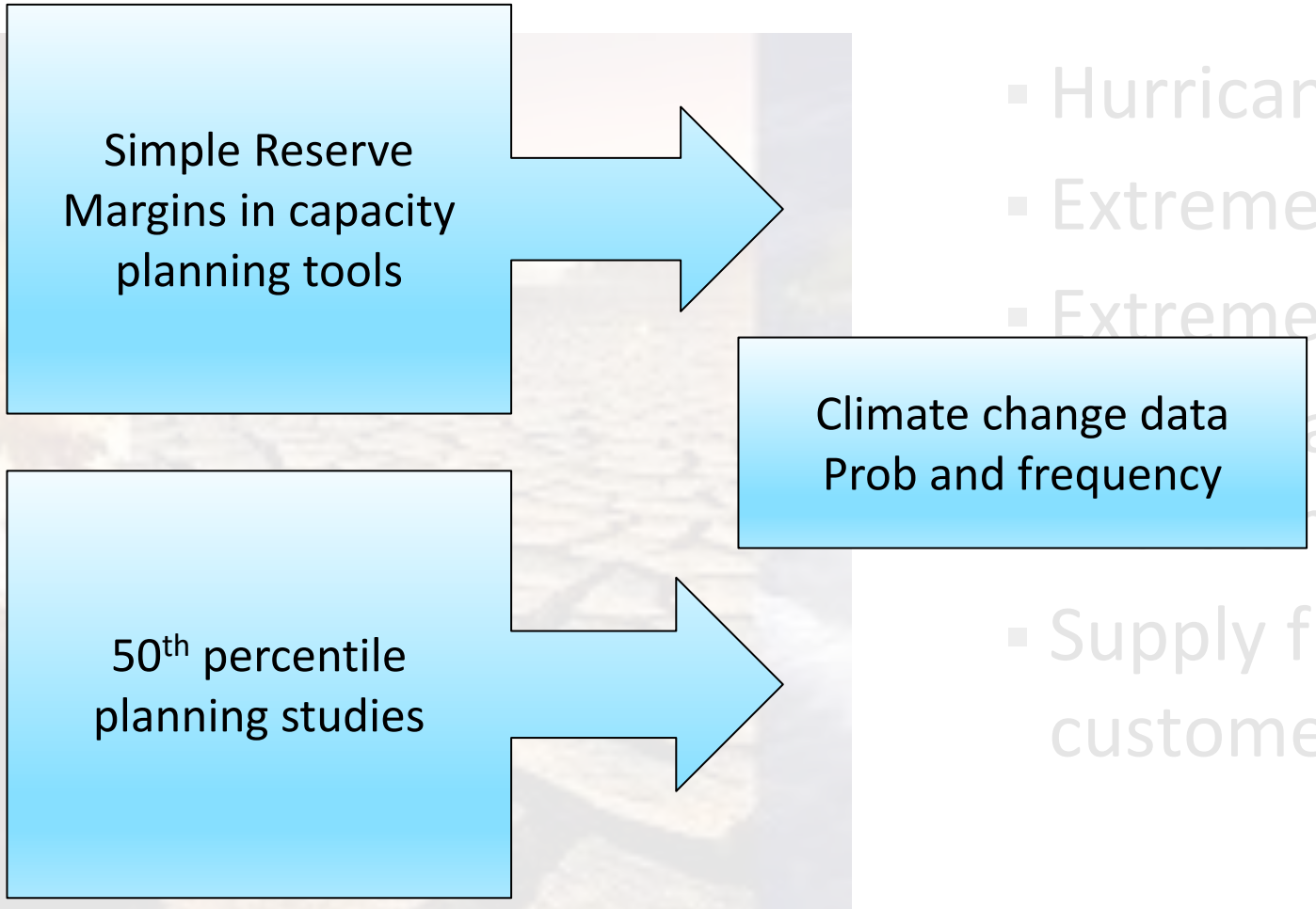
EPRI In-Development Links

Incorporating Extreme Events into Planning

- Hurricanes, wildfires, droughts
- Extreme Cold
- Extreme Heat
- Chronic and seasonal events
- T/D infrastructure to withstand
- Supply fleet to continue meet customer demands

Slide courtesy of Erik Ela

Incorporating Extreme Events into Planning



Slide courtesy of Erik Ela

Incorporating Customer Behavior into Planning

Demand no longer passive element

Forecasting customer behavior to understand residual planning decision needs

- Electrification
- Distributed Energy Resources and customer supply
- Price responsive demand

Slide courtesy of Erik Ela

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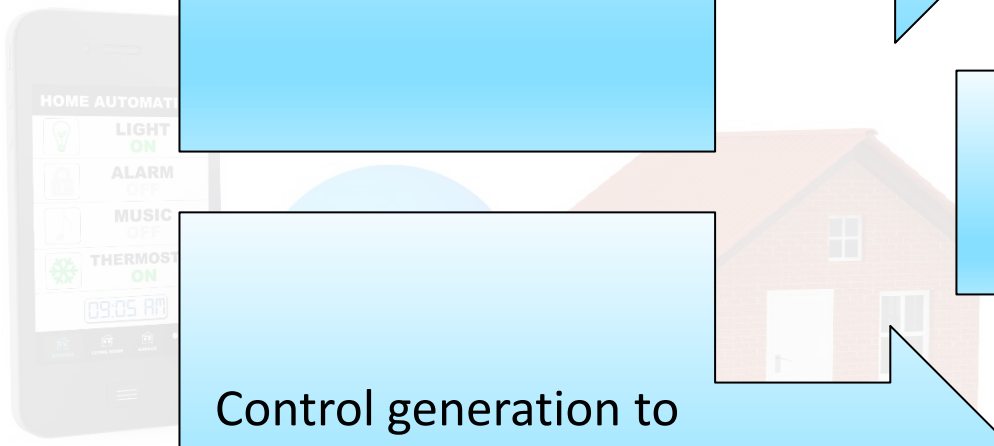


Plan to meet the peak load

Control generation to follow the demand

DER Adoption
Customer Response
Analytics

Plan for the supply curve to meet the demand curve

Decentralized control
Supply and demand follow each other

Slide courtesy of Erik Ela

Existing Tools Gap Assessment

Holistic resource investment planning across G, T, & D with high renewables, storage, and DER requires a more comprehensive, less piecemeal approach.

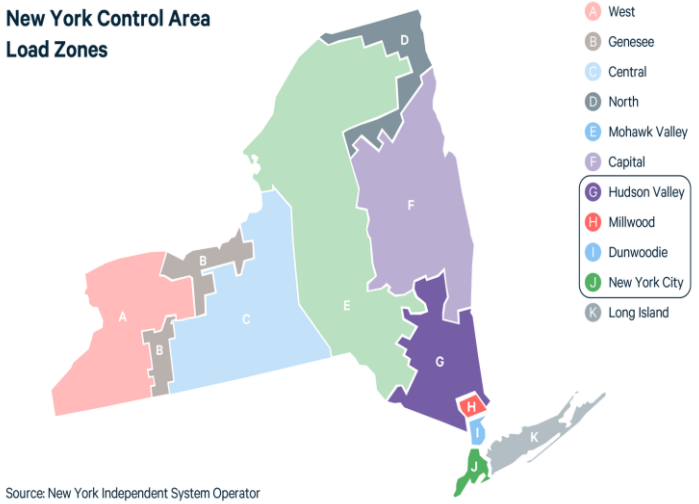
Resource Expansion & Planning	Grid Operations & Planning
Inability to scale with operational detail needed (data, computation)	Lack coordination between T&D models limits planning for non-wires alternatives (NWA)
Lack feedback between operations, risk, and investment decisions	Inconsistent modeling techniques and terminology
Inflexibility to adapt to different user-owned data structures/ inputs	Inadequate data availability

Both lack an adequate consideration of (1) potential climate impacts and (2) load flexibility and reliability impacts from customer resources.

Bridging Resource Expansion & Planning and Grid Operations & Planning

NY Test Case Objectives

- Demonstrate enhancing capacity expansion tool decisions with more granular tools
  - validate a chosen G&T resource from a less granular tool
  - update expansion decisions when granular tool results show inefficient or unreliable portfolio
- Begin process of evaluating integrating tools
  - catalogue challenges of tools that use different data sets
  - brainstorm mitigation through model enhancements, data sources and/or manipulation, and other efforts



NY Case Study Framing Questions

What types of questions can we now begin to explore with the new integrated tool?

1. How much does it cost to build and operate a decarbonized electricity sector in NY? How does this total cost compare to a future without a carbon constraint?
2. How reliable is a decarbonized NY power system? What aspects of reliability may be degraded most?
3. How can the resource mix be modified to cost-effectively respond to reliability scarcity/excess, while still meeting the original decarbonization goals?

Initial Modeling Framework

Aggregated CAP-EX

EPRI's US-REGEN model is used to construct electric loads and aggregated capacity expansion scenarios across a range of policy, technology & climate futures.

Unit-level CAP-EX

A commercial capacity expansion model is used for unit-level generation expansion across NYISO at the zonal and nodal levels. Candidate generator choices, electric loads, load duration curve time slices, and inter-regional electricity trade are informed by US-REGEN.

Operations Simulation Tool

A commercial operations simulation tool is used for detailed hourly operations modeling on the resulting resource mixes from above. Results are used to validate minimum levels of reliability, assess resource adequacy, and investigate potential constraints that can be fed back to the cap-ex planning problem.

EPRI DynADOR Model

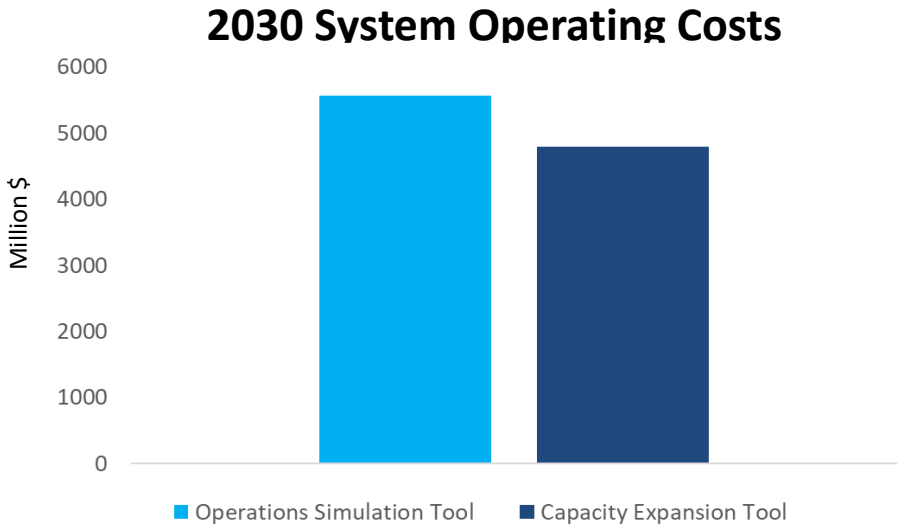
Determining Operating Reserve Requirements

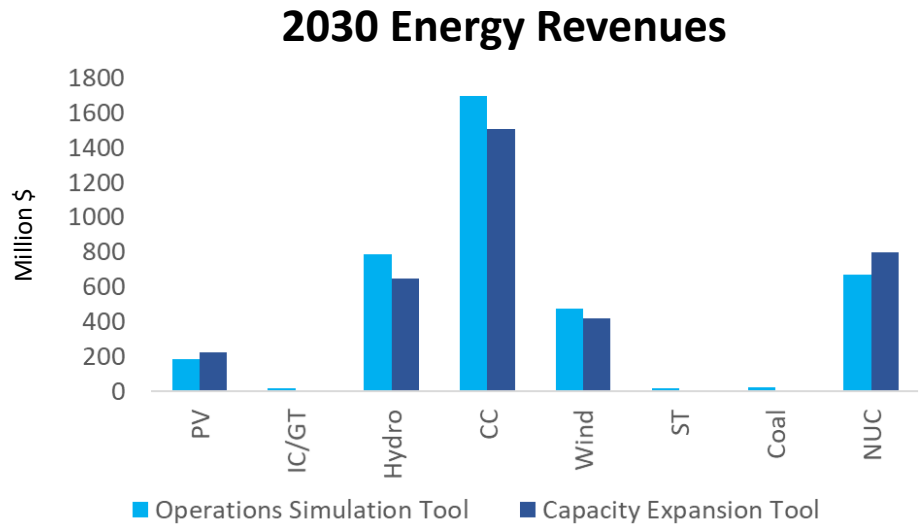
What Features Do 'Electric Sector' Models Include?

Cost	Typical CEM	Typical PCM
Investment costs from existing infrastructure (still being paid off)	–	–
Investment costs for new generation capacity	✓	–
Investment costs for new transmission	✓	–
Distribution costs	–	–
Fuel and operating costs	✓	✓
Unit commitment/Ramping costs	–	✓
Network Congestion	Transport flow	Nodal, n-1
Reserve requirements	Approximated	✓
Chronology	Annual or greater	Sub-hourly
Short-term (Day-Ahead) forecast error	–	✓
Technology-specific operating parameter (e.g., storage SOC	–	✓
Extreme event scenarios	–	✓

Motivation #1: Models "see" and base decisions on different costs

- Capacity expansion models use capital costs and dispatch costs for the system to choose a least-cost resource mix
- Operations simulation tools mimic actual system operations, integrating costs at hourly and sub-hourly levels on a nodal transmission network basis, inclusive of congestion and losses.
- This allows identifying safe & unsafe operating margins for a given resource mix.



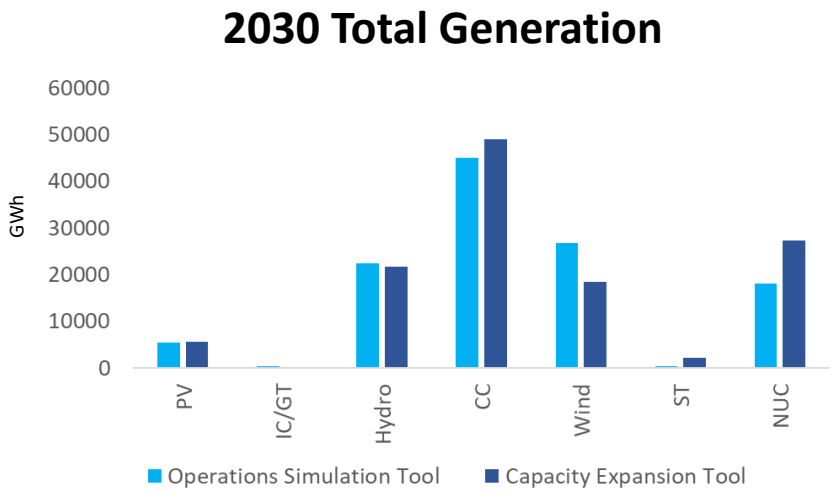


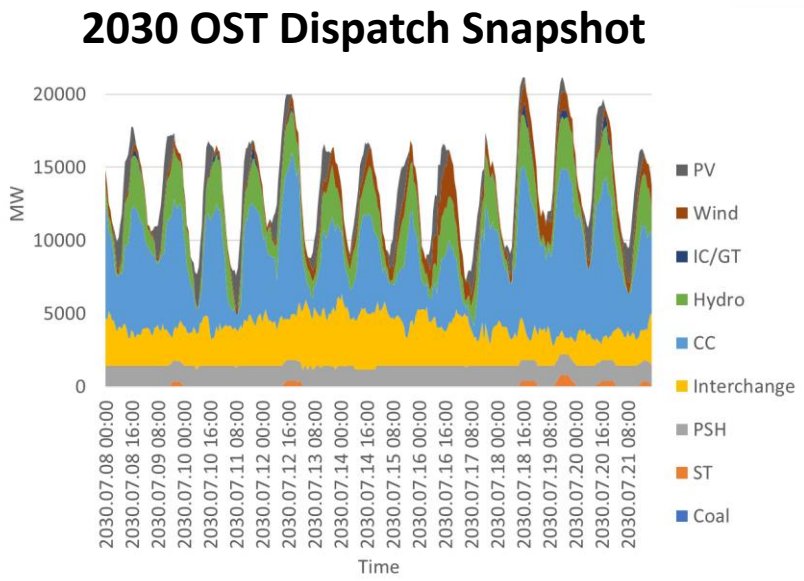
Our work will focus on allowing the capacity expansion model to consider these additional costs

Results are shown from a "Pre-CO_2 Policy Case"

Motivation #2: Model granularity affects generation dispatch

- Typical capex models do not consider inter-period transitions or detailed system reliability needs
- Operations simulation models choose detailed hourly and sub-hourly dispatch by unit throughout the year
  - Can highlight periods of system stress and scarcity
  - Can show how dispatch patterns change with different buildouts
- Higher renewables, DERs, and energy storage will significantly alter traditional dispatch patterns, increase cycling, and utilization factors.

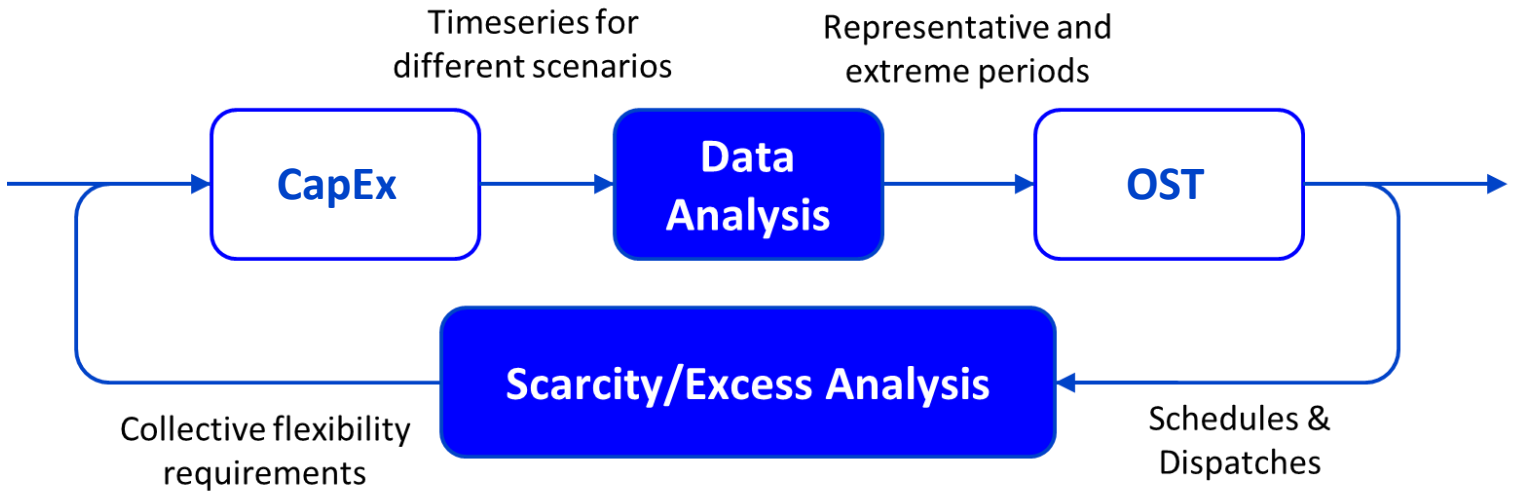




Cost-effective, robust capacity planning will require more information upfront about expected detailed system dispatch

Results are shown from the "Pre-Policy Case"

Capacity Expansion & Operations Simulation Tool (OST) Integration Method



- Data Analysis: Determine representative and extreme periods to estimate expected operating costs and choosing supply resources to ensure reliability and flexibility
- Scarcity/Excess Analysis: Perform detailed operations simulation on representative & extreme days to reveal scarcity (or potentially excess) on system adequacy and flexibility
- Estimate incremental collective flexibility requirements to be enforced in the CapEx tool

See also: Program on Technology Innovation: "Coordinated Expansion Planning with Increased Temporal Resolution: Embedding Production Simulation Models," EPRI, Palo Alto, CA, Rep. No. 3002018763, Dec. 2020.

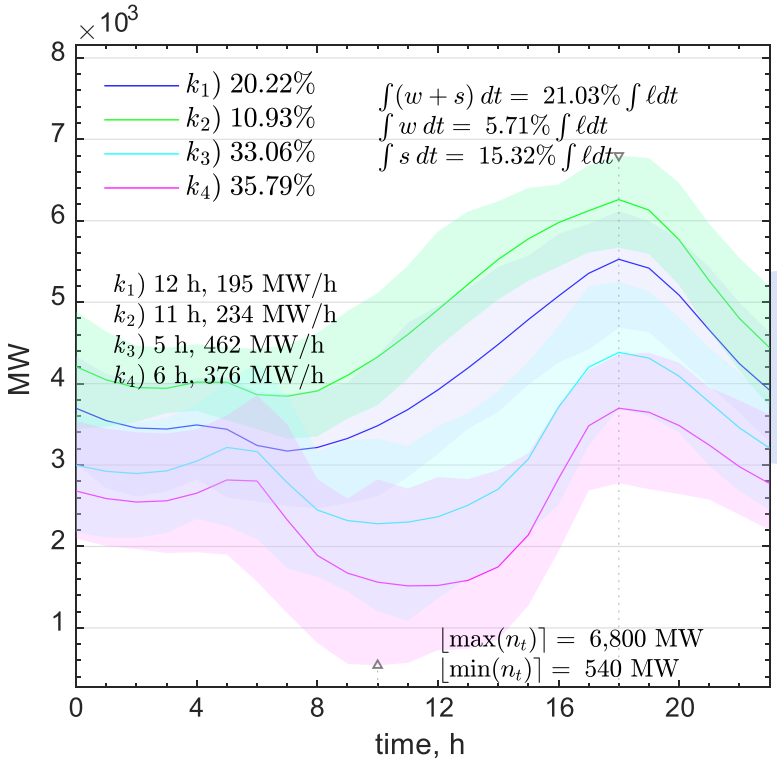
How can we improve expansion decisions based on the information we learn from more granular tools?

- Capacity expansion problems must assess various alternatives over many scenarios
- Even being able to produce hourly chronological operations simulations for every single year of the planning horizon is insufficient
- Operations simulations need to identify periods of interest that:
  - Are representative of system conditions for each of the capacity expansion scenarios.
  - Include the potential extreme operating conditions in which resources are operated close to their limits

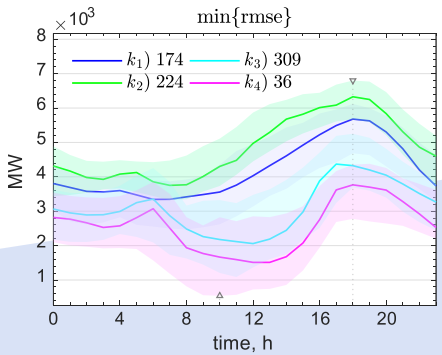
Finding Representative & Extreme Days

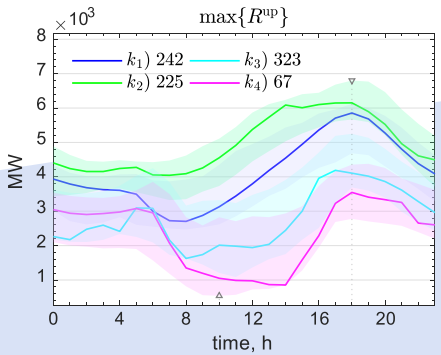
- Use of appropriate distance metrics and clustering algorithms for trend identification

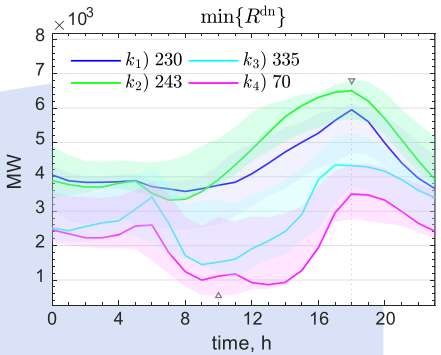
Representative Days

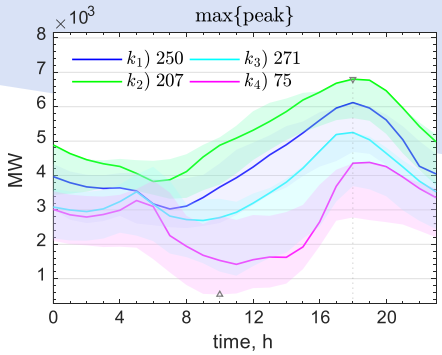


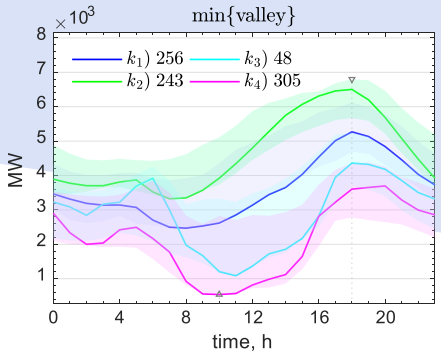
Extreme Days

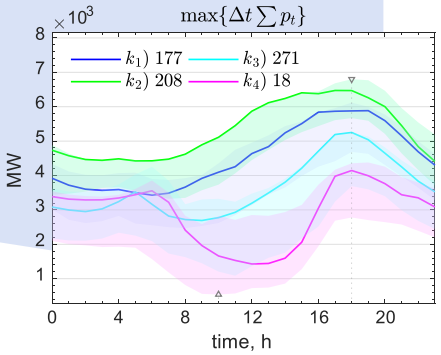








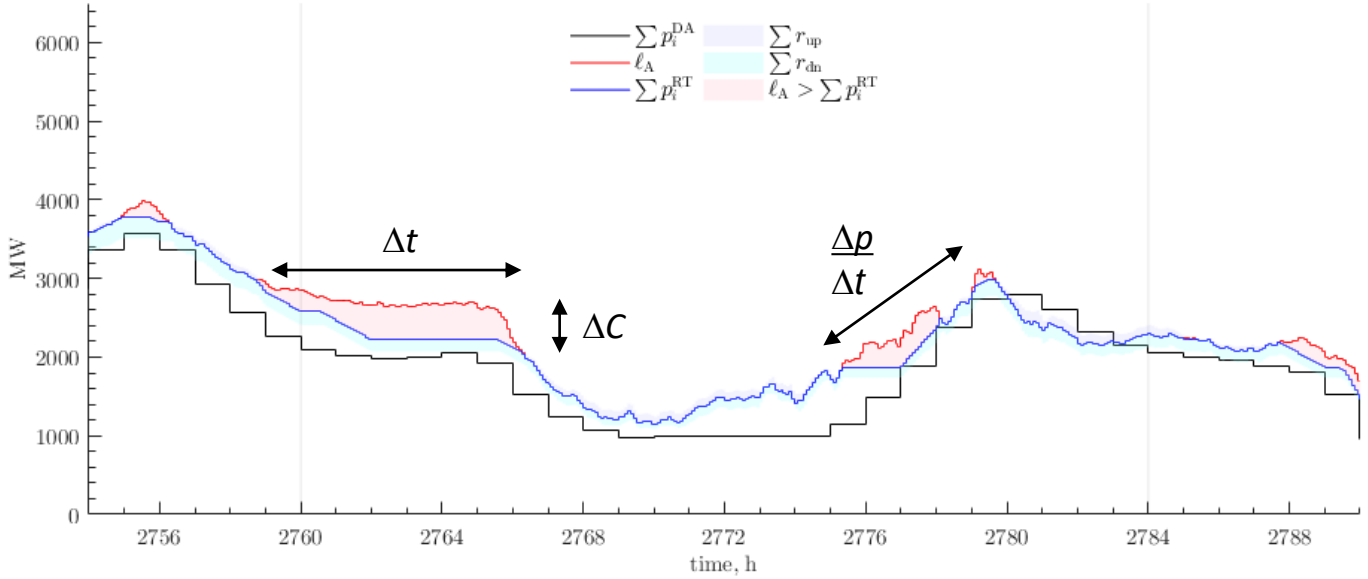




Slide courtesy of Miguel Ortega-Vazquez

Operations Simulation Solution Assessment

- Representative days and extreme days are used to assess the performance of the operations simulation solution
  - Representative days: expected operating costs
  - Extreme days: ensure system reliability
- Over many trials, we are generating **statistically sufficient data** to assess costs and reliability against worst possible materializations



Characteristics of the Violations:

- Capacity
- Duration
- Energy
- Ramps
- Mileage

Slide courtesy of Miguel Ortega-Vazquez

Additional Steps for Coordination Across EPRI

- Identify future network constraints and site new candidate generators for nodal capacity-expansion.
- Identify transmission build-out scenarios for the NYISO grid between 2020-2040.
  - Test Enelytix coordinated G&T expansion modeling capabilities.
- Quantify DER impact on end-use loads to begin integrating initial distribution system aspects into this work.
- Develop a fuller set of renewables profiles that can be used to model different future climate scenarios including potential extreme events.

Additional Slides

EPRI's US-REGEN Model

Energy End-use

- Detailed representation of building, transportation, and industrial sectors
- Multiple end-use technologies modeled
- Technology choice

SYNCHRONIZED

Hourly Load, Prices & Renewable Profiles

Model Outputs:

Economic equilibrium for generation, capacity, and end-use mix

Emissions and environmental outcomes

Electric Generation

- Investment and dispatch
- Intermittent renewables
- Transmission
- Energy and capacity requirements
- State-level policies and constraints

US-REGEN
Regional Economy, GHG, and Energy

EPRI's State-of-the-Art Modeling System Enables Comprehensive Energy System Analysis

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