Resource Planning for the Next Generation

Developing a Framework for Integrated Energy Network Planning

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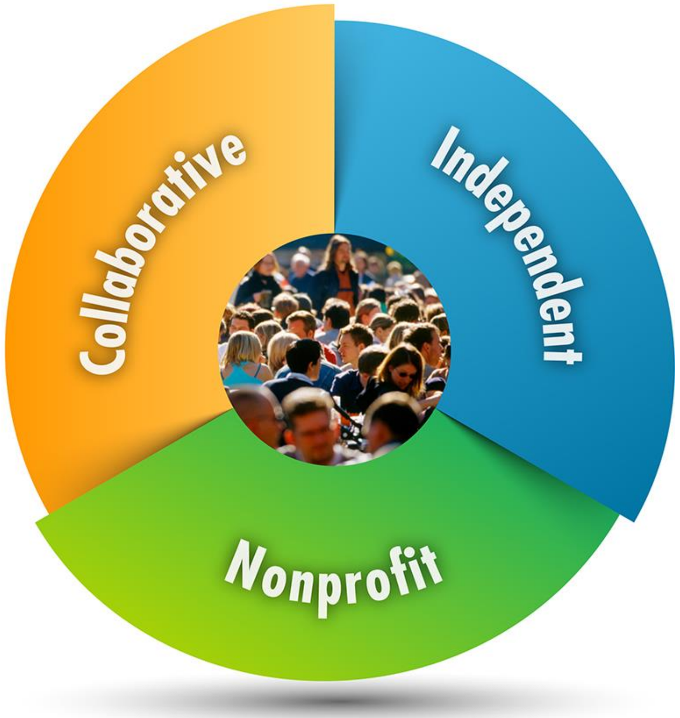
ESIG Webinar
November 21, 2019

www.epri.com

Electric Power Research Institute (EPRI)

- **Non-profit** — EPRI is a scientific research consortium founded in 1973 to perform objective research and development related to the generation, delivery and use of electricity for the benefit of the public.
- **Mission** — "Advancing ***safe*, *reliable*, *affordable* and *environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation."
- **Membership**:
  - Include IOUs, POUs, Coops, Munis, IPPs, ISO/RTOs…
  - EPRI participants generate >90% of electricity delivered in the US.
  - EPRI has 450+ participants in more than 30 countries.
- **Principal locations** — Palo Alto, CA, Charlotte, NC and Knoxville, TN.

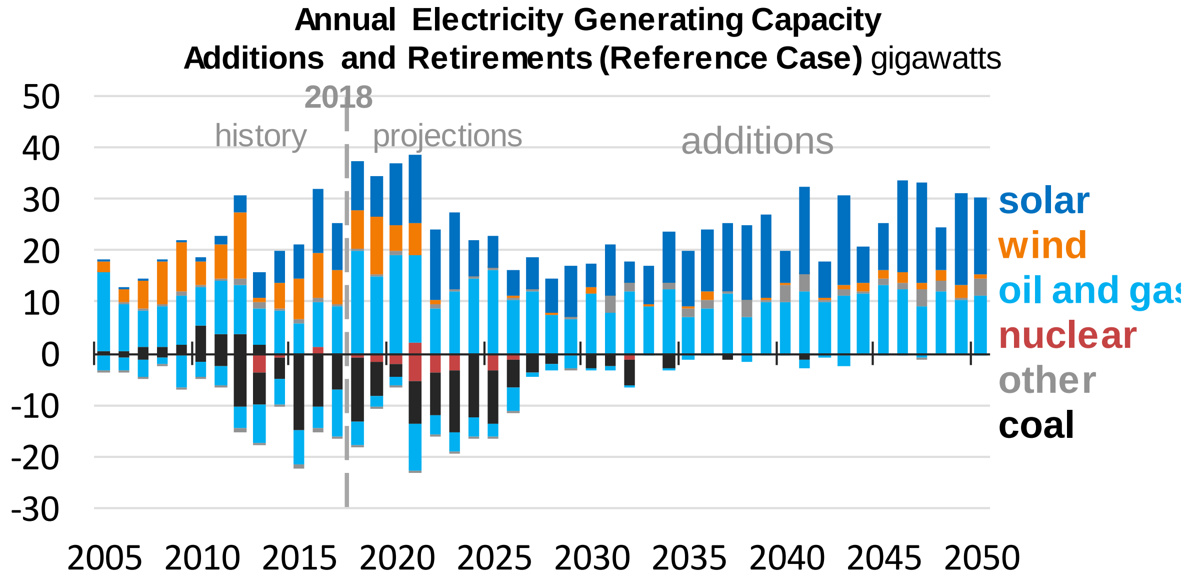
Three Key Aspects of EPRI



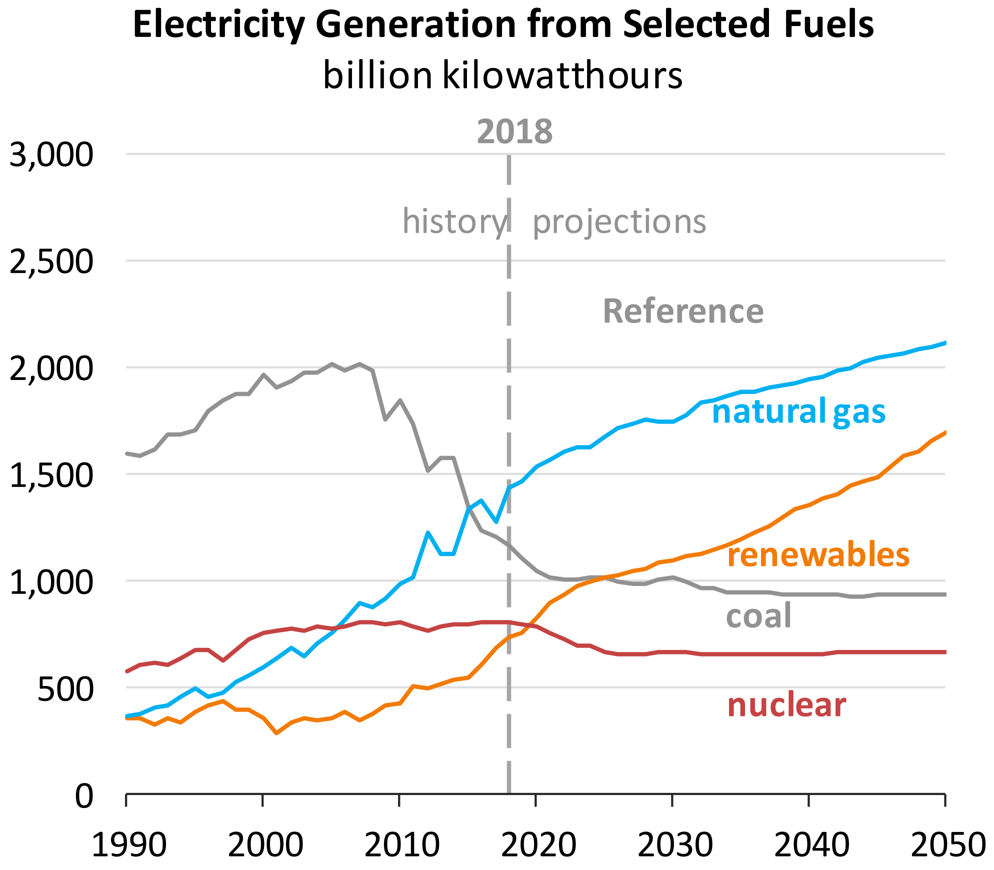
"Together…Shaping the Future of Electricity"

The Electric Industry is Undergoing a Profound Transformation

- Rapidly changing resource mix
- Different system characteristics
- Interaction of system resources



Source: U.S. Energy Information Agency, Annual Energy Outlook 2019



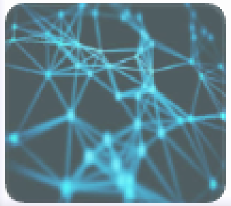
Source: U.S. Energy Information Agency, Annual Energy Outlook 2019

Ongoing transformation requires evolution of resource planning

New Complex Resource Planning Issues and Opportunities Require More Integrated Analyses to Answer Comprehensively

Energy Storage

What role could storage play in low carbon, high renewables power systems? How does it contribute value across G, T and D systems?



Distributed Energy Resources

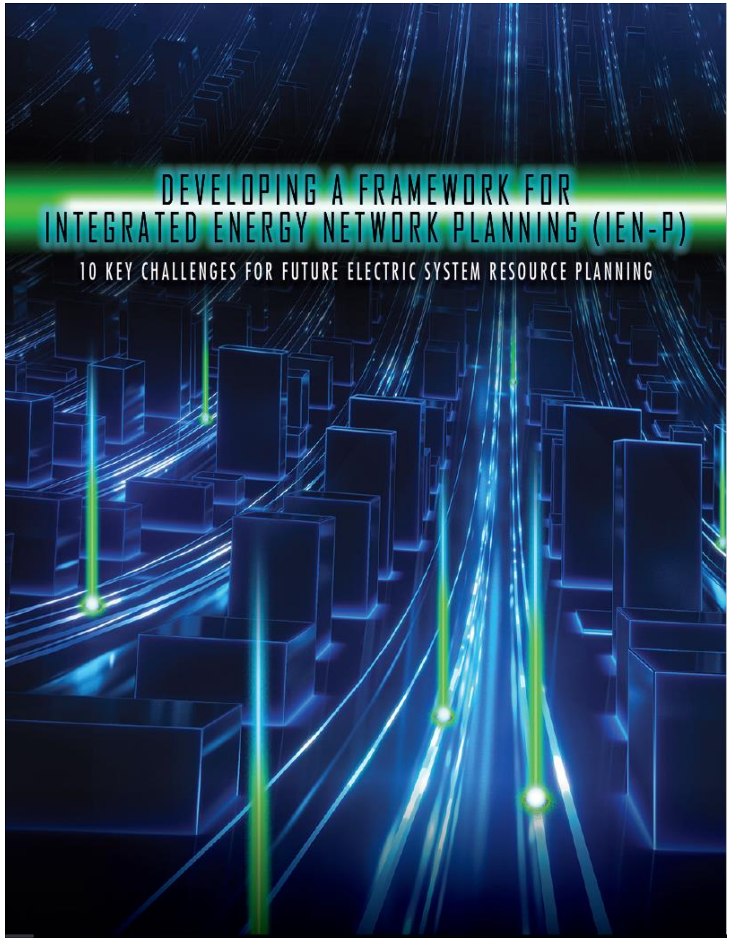
Can DERs support system reliability? Can the system support a network of aggregated DERs? How does it all work together? Can DERs substitute for G, T or D investments?

High Renewable Systems

How can cost-efficiency and environmental performance be balanced in high renewable systems? Do we have sufficient reliability?

We need to **improve existing analytical tools—and develop links between them**—to answer these new questions. Neither one tool, nor several isolated tools, will answer them!

Integrated Energy Network Planning (IEN-P)



EPRI Document #3002010821

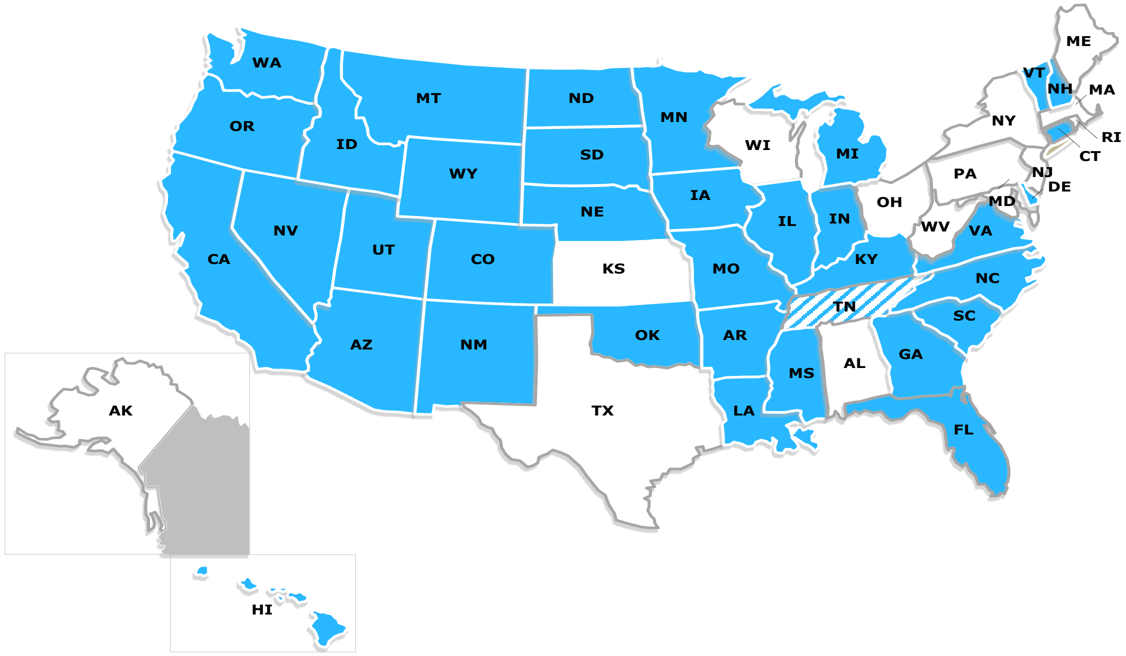
- New resource planning approaches and methods are needed to support the ongoing and rapid electric sector transformation.
- **Describes** 10 critical resource planning challenges
- **Communicates** the magnitude of these challenges to companies, regulators and stakeholders
- **Identifies** key research gaps

http://integratedenergynetwork.com/wp-content/uploads/2018/07/3002010821_IEN-P_White_Paper.pdf

IEN-P Goals

- To help stakeholders identify and respond to new planning challenges.
- To help electric companies and regulators to take actions to begin to implement the *Integrated Energy Network*. (http://ien.epri.com)

States that Required Integrated Resources Planning 2015.

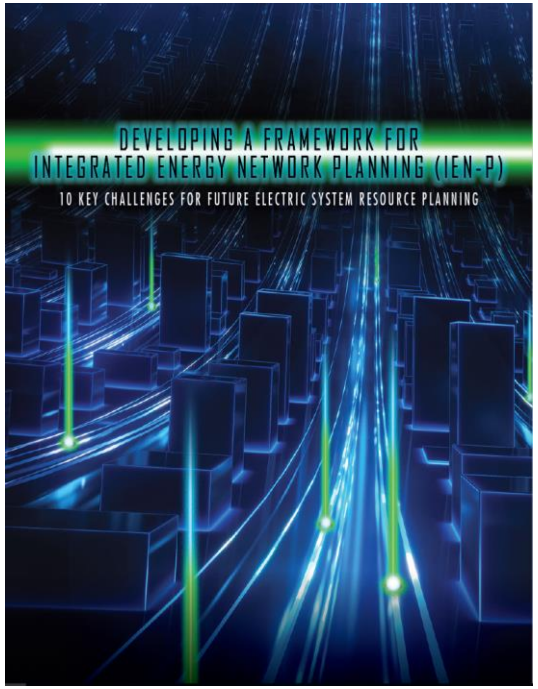


Source: Adapted from United States Environmental Protection Agency Energy and Environment Guide to Action 2015. Additional updates by EPRI.

The IEN-P white paper is critical to galvanizing the industry's thinking and bringing together all stakeholders to solve these challenges

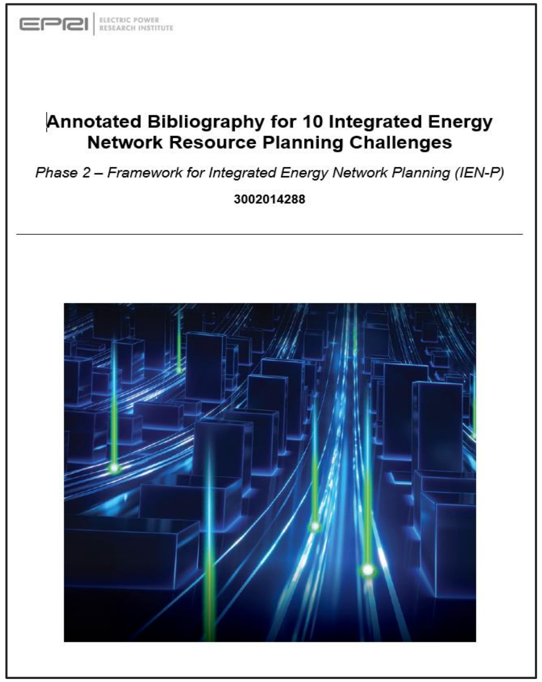
Integrated Energy Network Planning Resources

July 2018 → **Sept 2018** → **Feb 2019** → **Dec 2019**



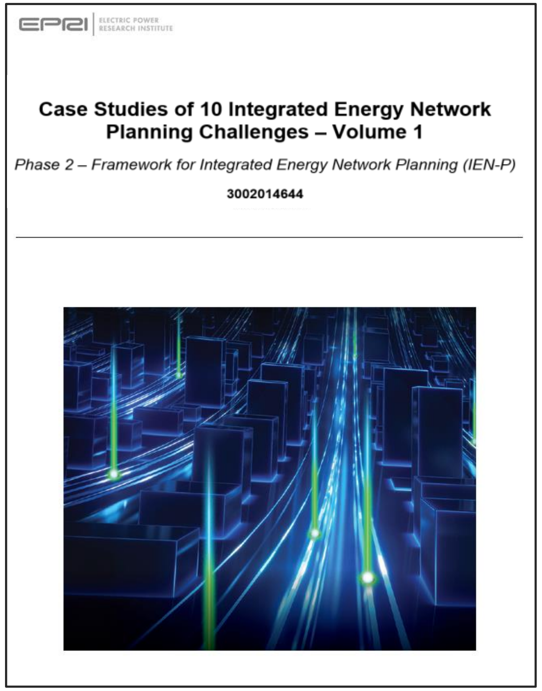
EPRI Product ID# 3002010821

Developing an Integrated Energy Network Planning (IEN-P) Framework



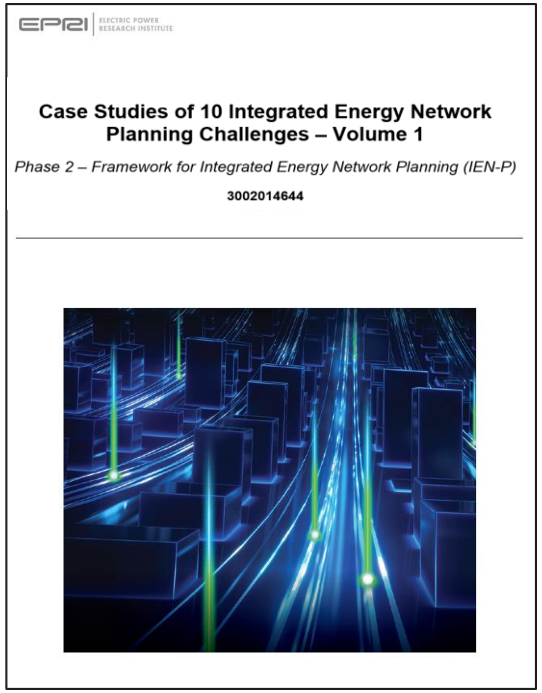
EPRI Product ID# 3002014288

IEN-P Annotated Bibliography



EPRI Product ID# 3002014644

IEN-P Case Studies Volume 1



EPRI Product ID# TBD

IEN-P Case Studies Volume 2

Value of the IEN-P White Paper

- **Internal – *Inside* an Electric Company**
  1. Provides a common vision to multiple company planning groups that may not routinely communicate and coordinate with one another.
  2. Identifies key resource planning challenges to focus future corporate action and resource planning efforts.
  3. Company leadership and staff can use the IEN-P to frame and discuss key planning issues with *internal* company stakeholders.
  4. Used by company leadership to identify and prioritize internal and external R&D
- **External – *Outside* an Electric Company**
  1. Used by company leadership and staff to frame and discuss key resource planning issues with state regulators and *external* stakeholders
  2. Communicates the drivers and needs for increased communication and coordination across the electricity supply chain, and with key related industries and resources.

Integrated Energy Network Planning (IEN-P)

- **Integrated**
  - Includes all electricity supply and demand-side resources, like traditional IRP
  - Also includes coordinated generation, transmission and distribution planning
  - Spans other resources & infrastructure (e.g., natural gas)
- **Energy**
  - Focused primarily on the electric sector, but also includes related fuels, energy resources and infrastructure
- **Network**
  - Includes the electric grid (i.e., transmission <u>and</u> distribution) and the broader energy network and associated infrastructure
- **Planning**
  - Strategic framework to enhance long-term electric sector investment planning

The Integrated Energy Network: Key Planning Issues

- Modeling the Changing Power System
- Integrating Forecasts
- Expanding Planning Boundaries

The Integrated Energy Network Planning: 10 Critical Challenges

Modeling the Changing Power System

1. Incorporating operational detail
2. Increasing modeling granularity
3. Integrating generation, transmission & distribution planning
4. Expanding analysis boundaries and interfaces
5. Addressing uncertainty and managing risk

Integrating Forecasts

6. Improving forecasting
7. Improving modeling of customer behavior and interaction

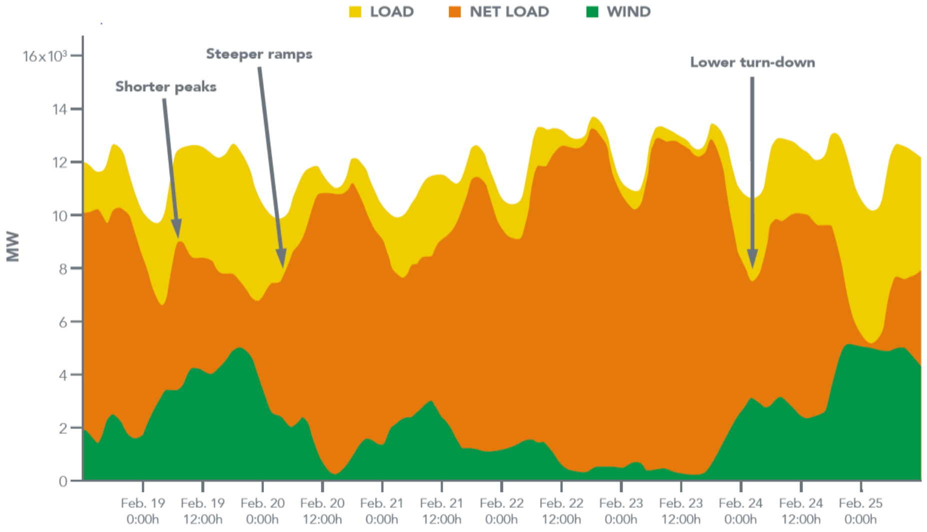
Expanding Planning Boundaries

8. Incorporating new planning objectives and constraints
9. Integrating wholesale power markets
10. Supporting expanded stakeholder engagement

IEN-P Report

Challenge #1. Incorporating Operational Detail

- Evaluate and address potential reliability response, voltage stability and short circuit considerations) associated with the changing resource mix.



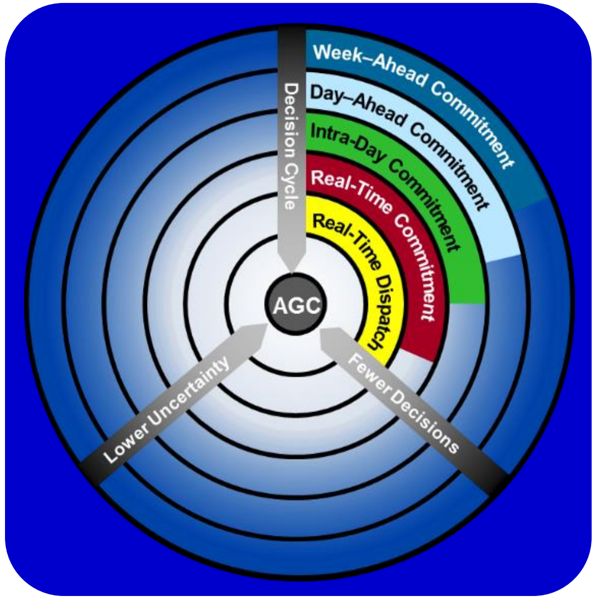
Wind and Solar Generation Can Increase Power System Flexibility Needs.
Source: Flexibility in 21st Century Power Systems, 21st Century Power Partnership.

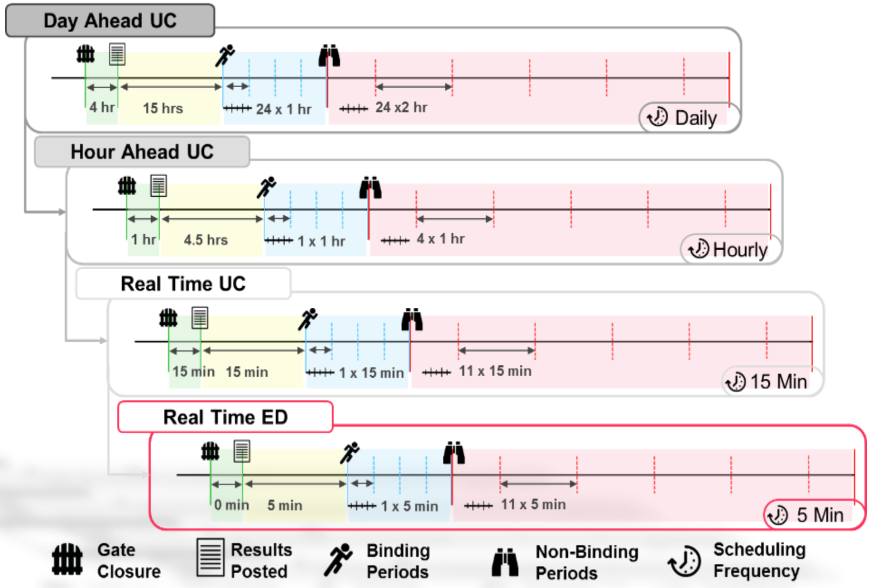
- It is becoming more important to incorporate operational reliability capabilities (e.g., ramping rates, minimum generation levels), and adverse interactions (e.g., variability, uncertainty, active and reactive control capabilities) into resource planning.

- Existing resource adequacy metrics (e.g., LOLE) may not be the "best" or only metric to use to measure electric reliability.

Production Cost / Operations Simulation Models: State of the Art

- Simulate at least two-stages of scheduling process
  - Day-ahead and
  - Real-time
- Include network security constraints
- Detailed generating unit constraints
  - Ramp rate, min on/off time, start-up time
  - Advanced: Hydro reservoir and cascade constraints, combined cycle modes, energy storage optimization
- Annual simulations, hourly or down to five-minutes
- Outputs: Production costs, marginal costs, power flows, generation production, load shed or reserve shortage violations





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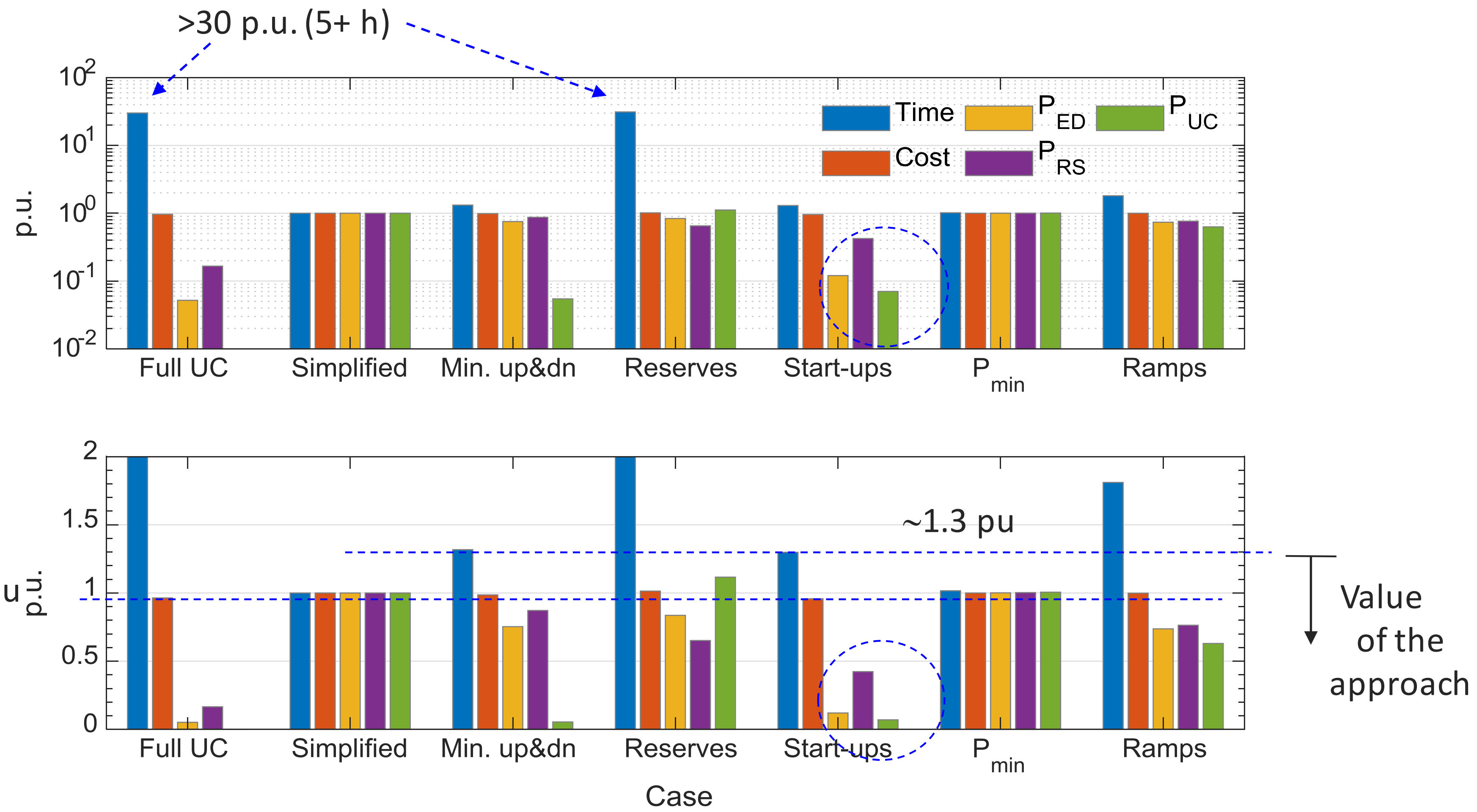
What Level of Detail is Suitable in a PCM?

- Results are normalized with respect to the simplified UC

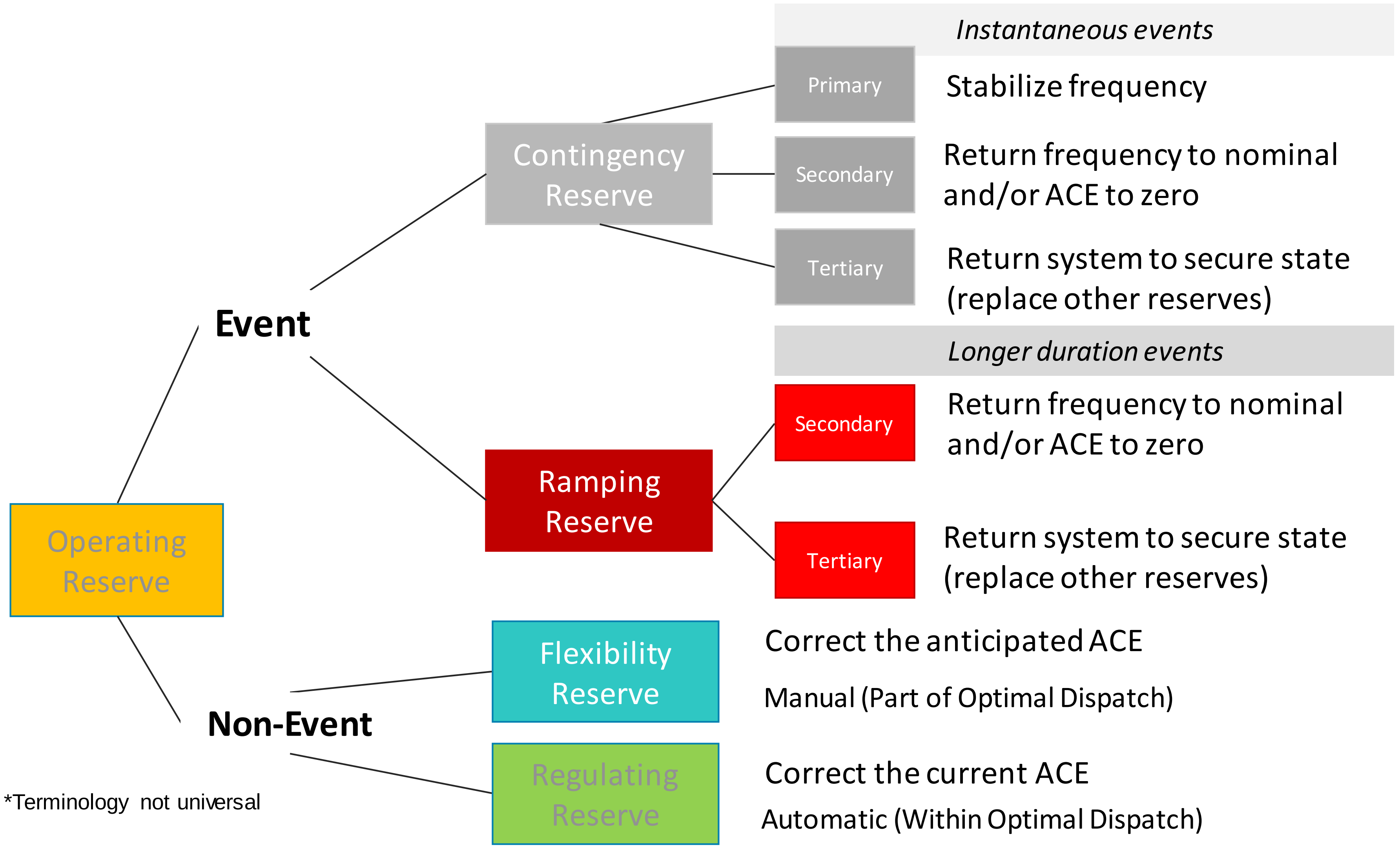
Simplified UC:
Solve time: 613.4 s (>10 min)
Cost: M$ 548.22
UC penalties: M$ 6,371.83
ED penalties: M$ 2,949.75
RS penalties: M$ 429.39

Gap: 1×10^{-3} (0.1%)

Intel Xeon CPU E5-2643
@3.40 GHz (2 processors)
96 GB RAM



Short-term Operational Needs – Impact on Operating Reserve

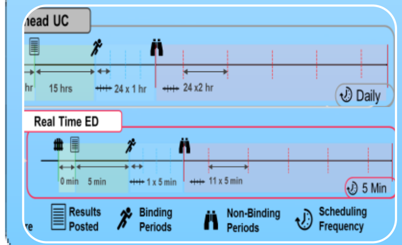


*Terminology not universal

EPRI Dynamic Reserve Method

Scheduling Procedures

- When reserve is held and when released
- Scheduling interval length, horizons



Historical Forecast and Actual Data

- Wind, solar, load
- Forecast error

Current and Anticipated Conditions

- Known data about current or future conditions
- Forecasts, time of day, probabilistic data

- Multiple utility case studies have shown benefits to dynamically setting reserve requirements
- Both economic (several $m) and reliability benefits (area control error) can be observed
- Recent improvements to the tool include addition of neural network to forecast reserve requirements

Dynamic Operating Reserve Assessment and Determination (Dynador) Tool

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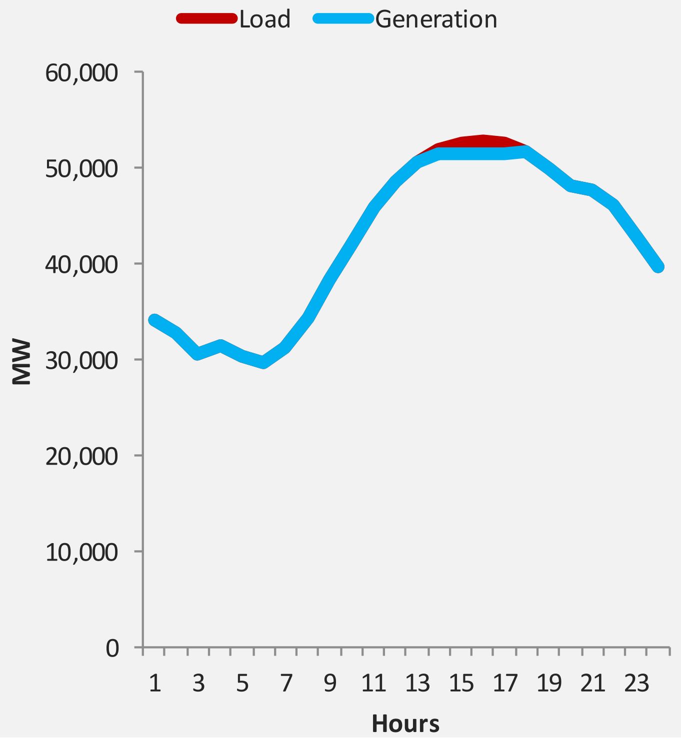
Long-Term Planning Needs – What "Type" of Capacity is Needed?

Traditional "Generic Capacity" Metrics

$LOLE_{GENERIC\text{-}CAPACITY}$

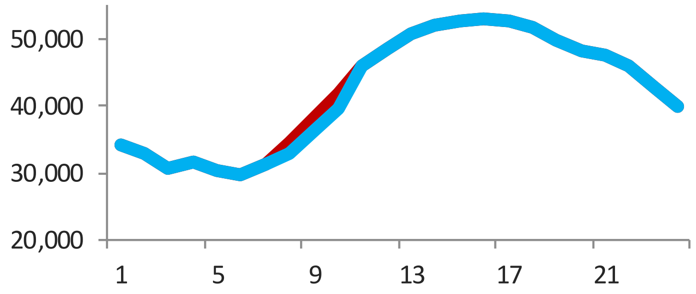
Traditional metric to capture events that occur due to capacity shortfalls in peak conditions



New "Flexible Capacity" Metrics

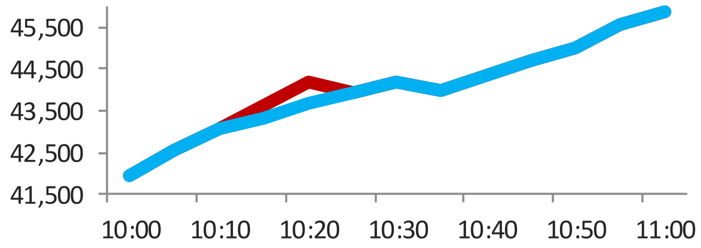
$LOLE_{MULTI\text{-}HOUR}$

New metric to capture events due to system ramping deficiencies of longer than one hour in duration



$LOLE_{INTRA\text{-}HOUR}$

New metric to capture events due to system ramping deficiencies inside a single hour

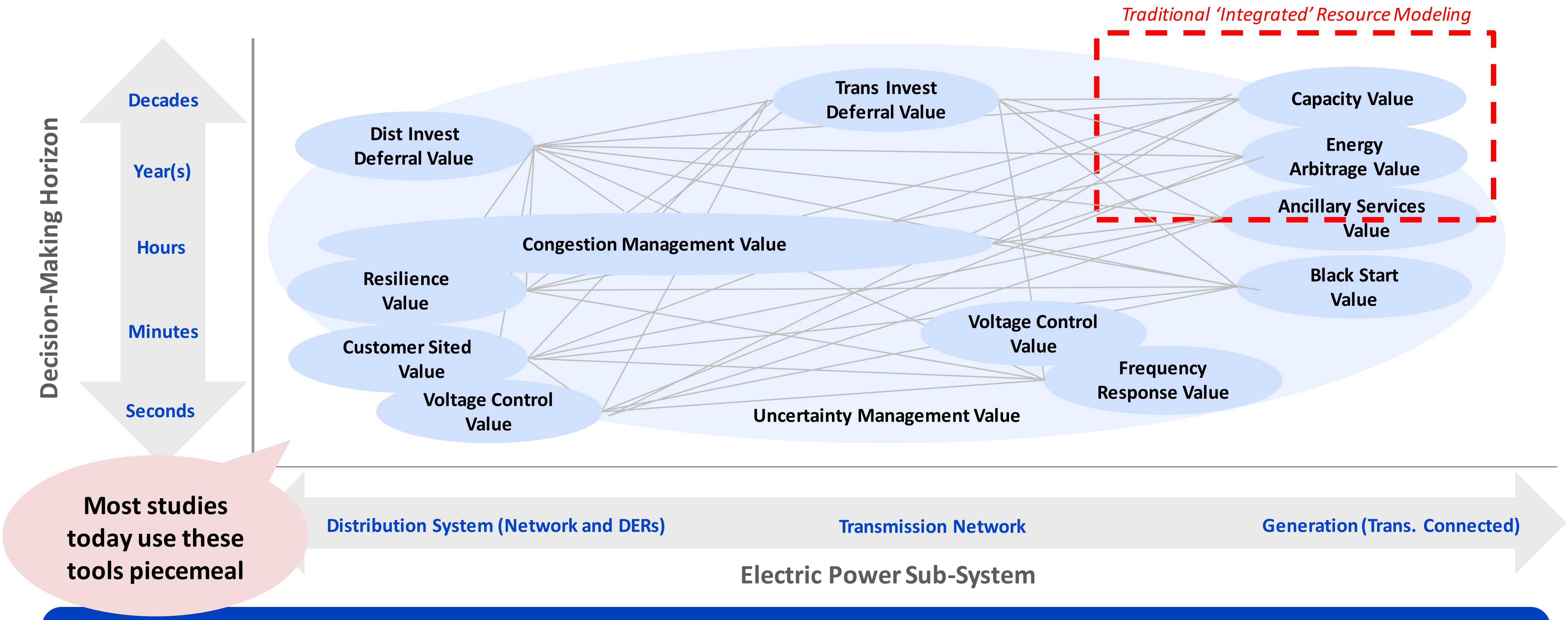


More Information:

California Energy Systems for the 21st Century Flexibility Metrics Project (2017)

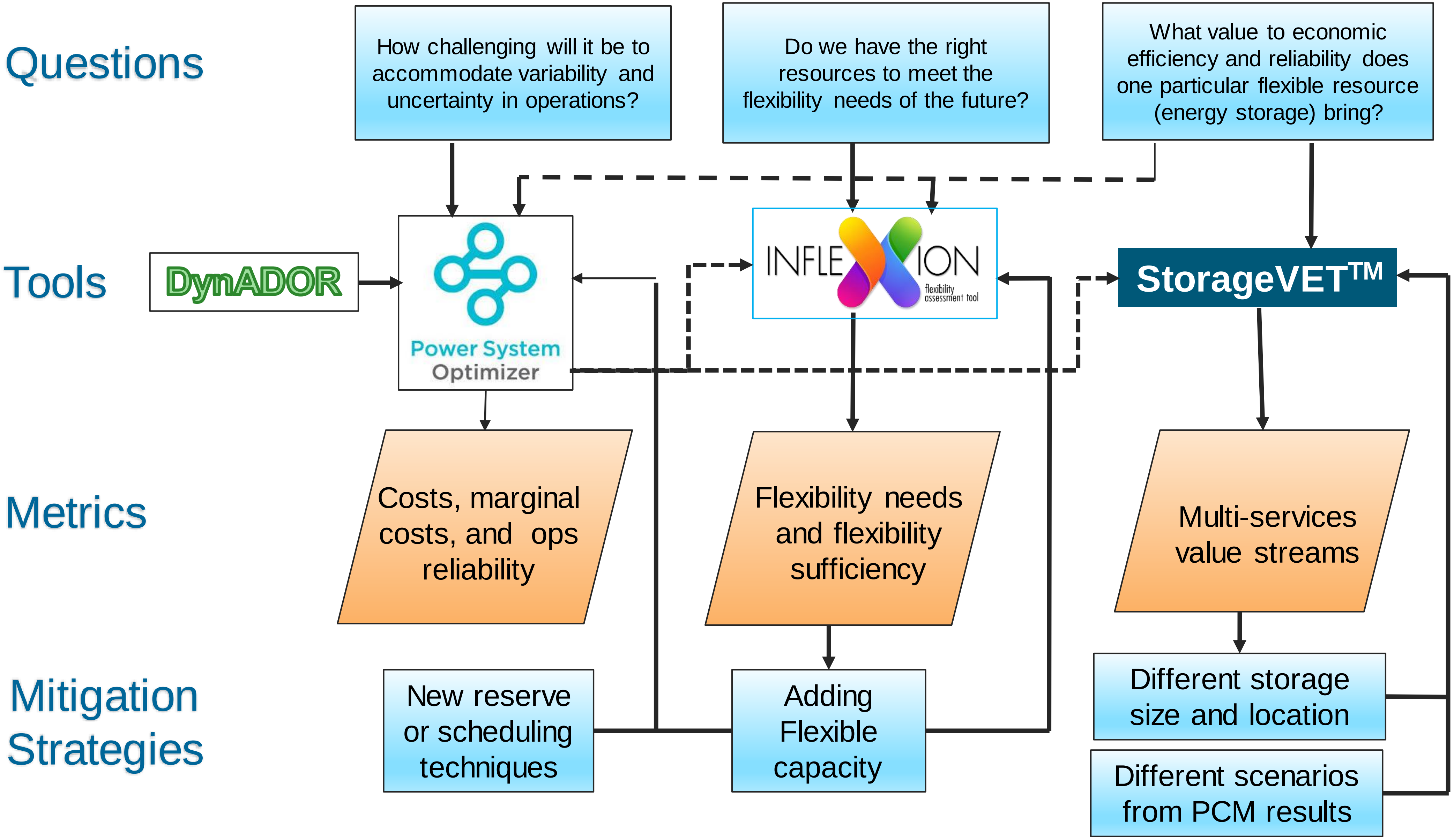
New need to ensure flexibility adequacy in long-term planning?

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



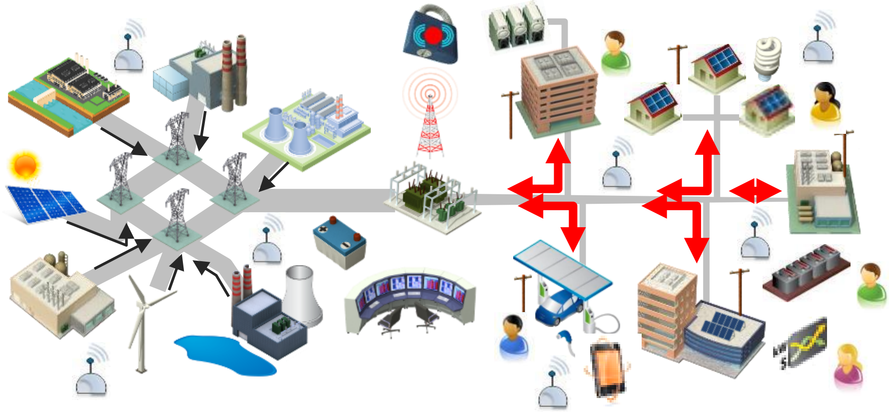
Inter-dependent values in advanced energy systems require a more integrated planning approach

Linking Different Tools to Study Storage Value



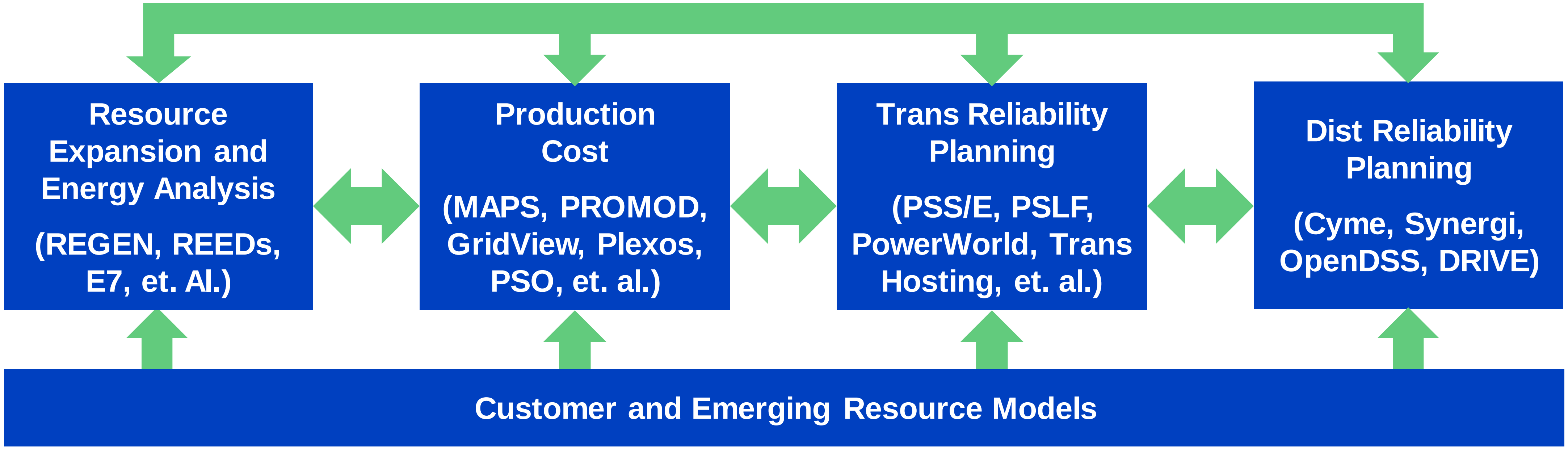
Challenge #3: Integrating G, T, and D Planning

- TSO/DSO interaction increasingly is important, particularly as the distribution system provides more services



- Allows for evaluation of “non-wires alternatives” (NWA) to new G, T and/or D investments
- DER valuation and targeting, including locational attributes
- Improve communications and “hand shakes” between planning functions
- Connections to other critical infrastructure (e.g., natural gas, H2O, EVs)

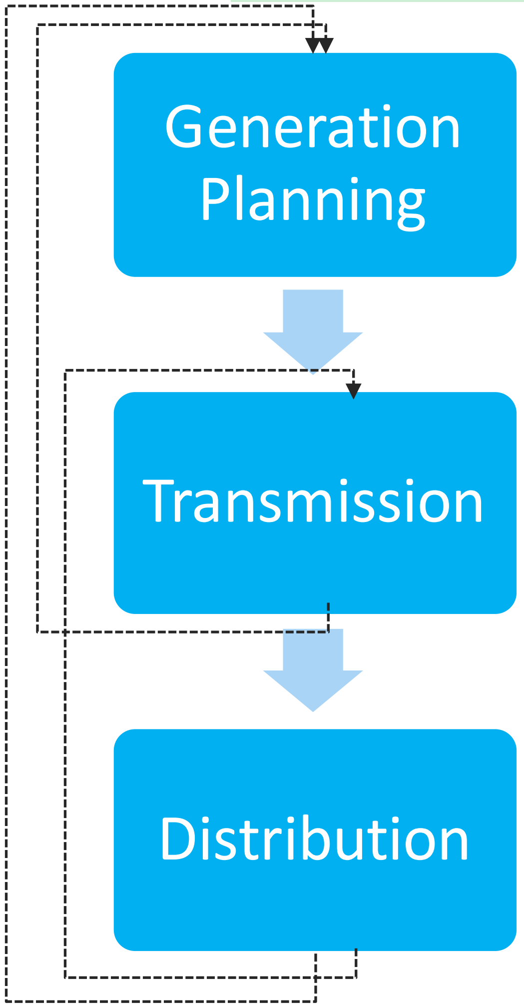
Integrated Planning (G/T/D) Needed



Operational realities of emerging resource mix and potential benefits of DER necessitates new and more integrated planning analytics.

What Extent of Integration is Needed/Possible?

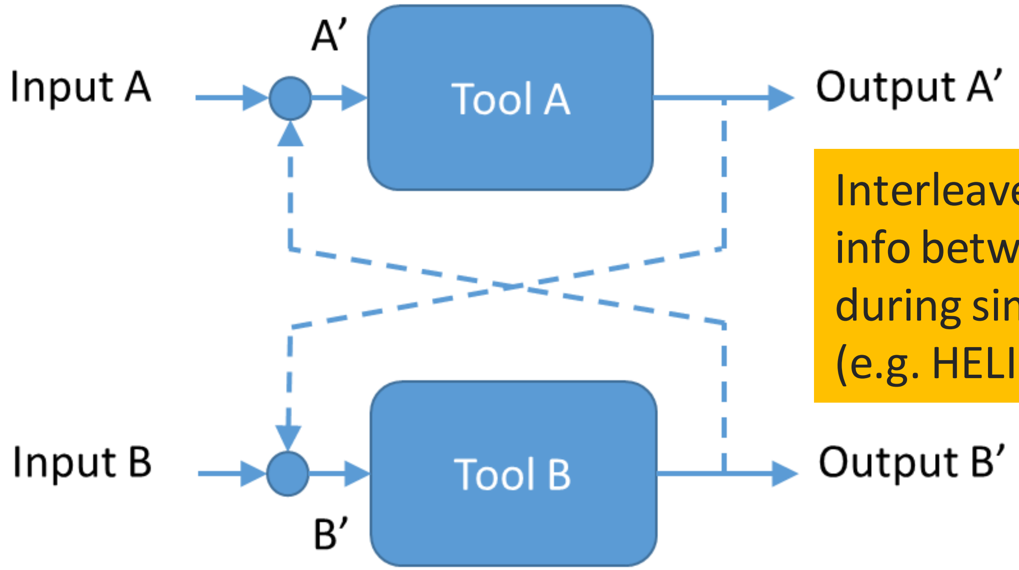
Iterative data exchange between models



Iterate passing results between models for holistic solution.

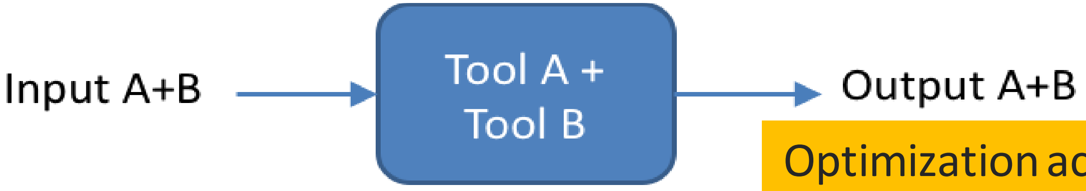
Computationally possible, but R&D needed to specify process flow (e.g., sequencing and I/O between models)

Co-simulation of Models



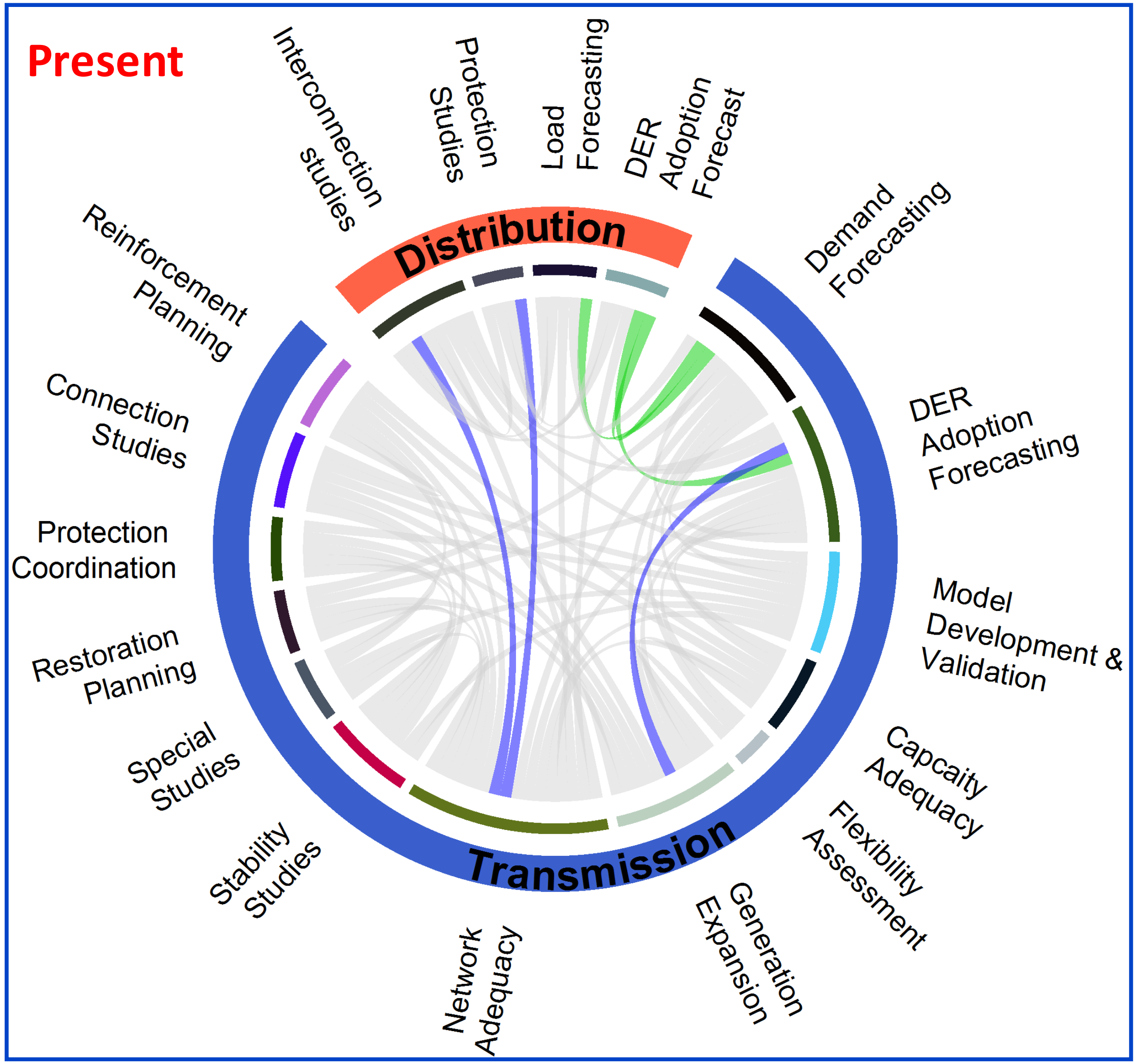
Interleaved models pass info between models during simulation (e.g. HELICS)

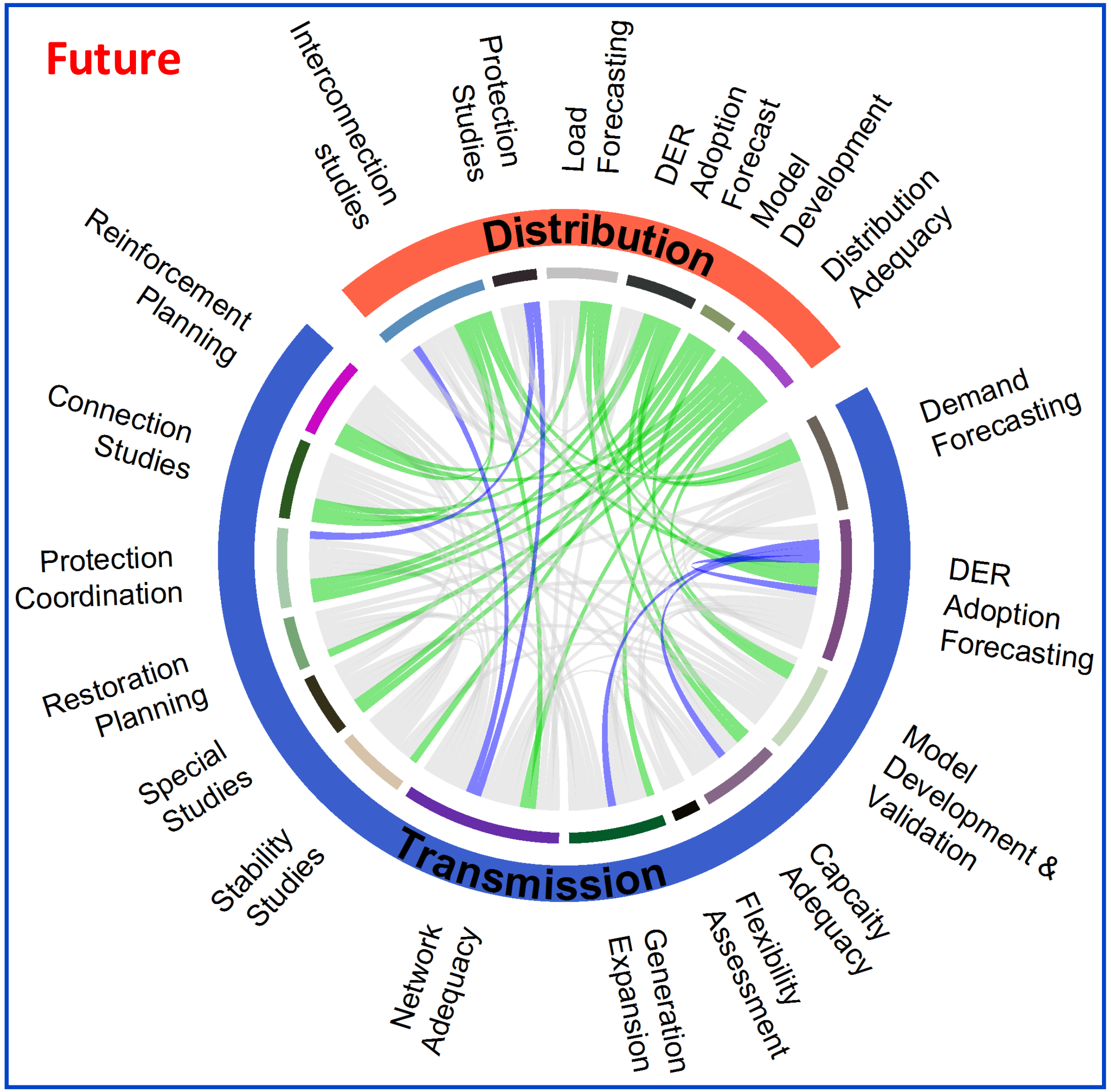
Co-Optimization/Co-Modeling



Optimization across levels in single model. Computationally possible?

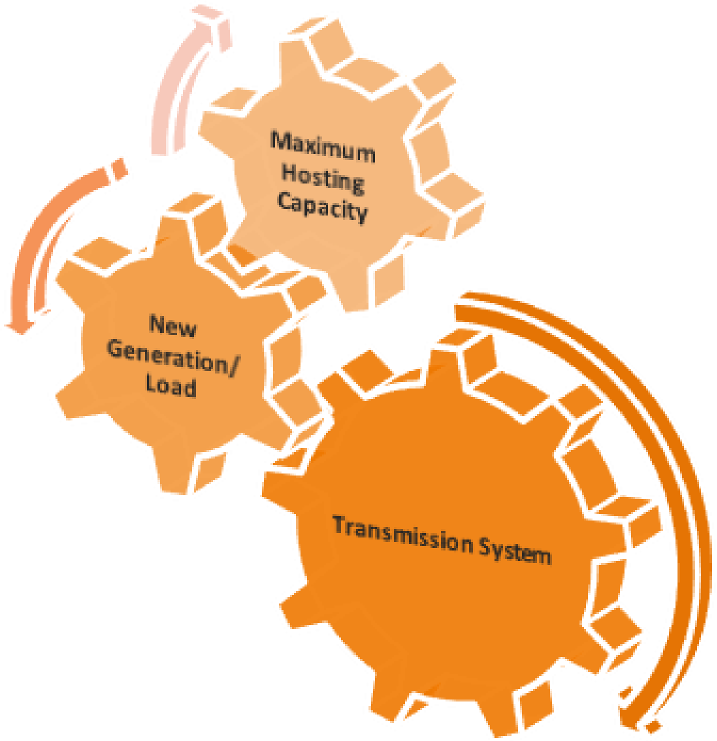
Coordination in Long Term Planning





New Generation and Load Hosting Capacity Tool for a Transmission Network

- **Inspiration** : Distributed PV Hosting Capacity Tool for a distribution system
  - A screening tool which provides maximum potential PV deployments across a distribution system
  - "As-is" without any system upgrades
- **Goal** : Develop a similar automated tool/engine for transmission system
  - Provides maximum new generation and load a transmission region can host without any network upgrades
  - High-level screening tool
- Disclaimer
  - The tool is not intended to replace detail feasibility and system impact studies which are imperative to make to any investment decisions

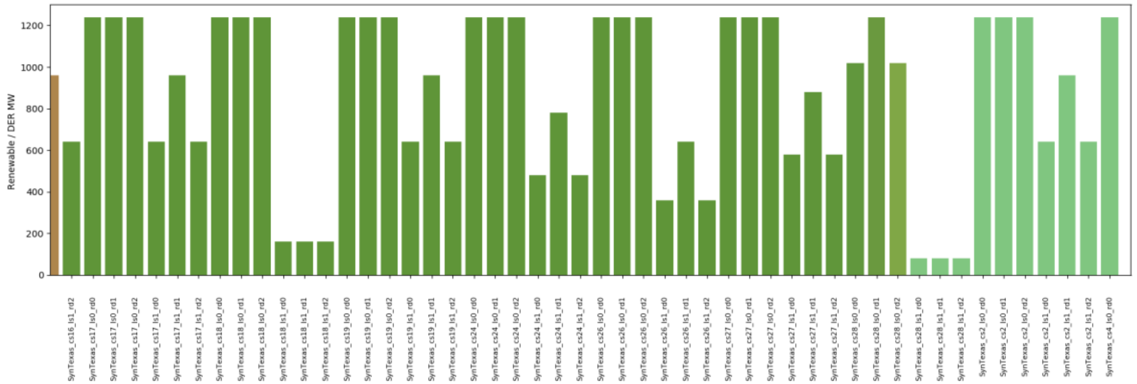


The tool will help planners :

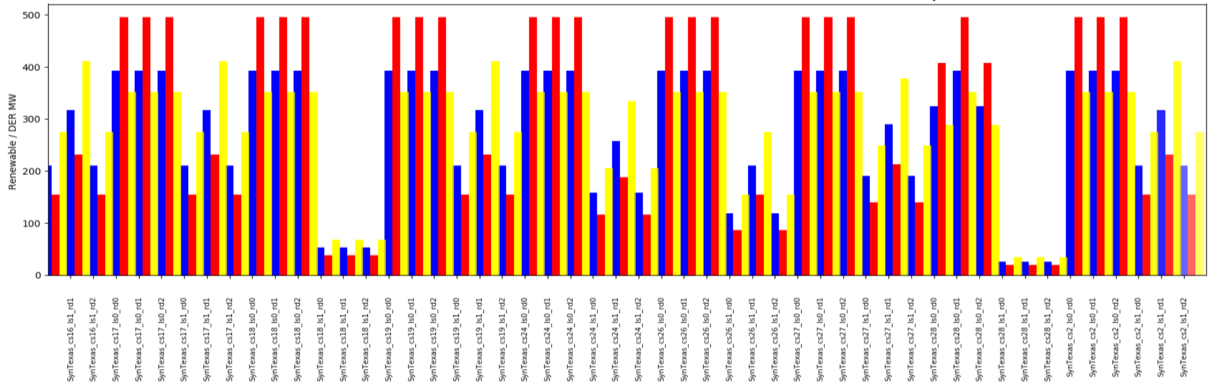
- **To screen through multiple interconnection requests allowing for a better understanding of where and how much new generation resources would impact the system**
- **To identify optimal versus non-optimal locations of future new generation and load deployments such that grid updates can be minimized**

Tool Output : Sample Results – 2000 bus system

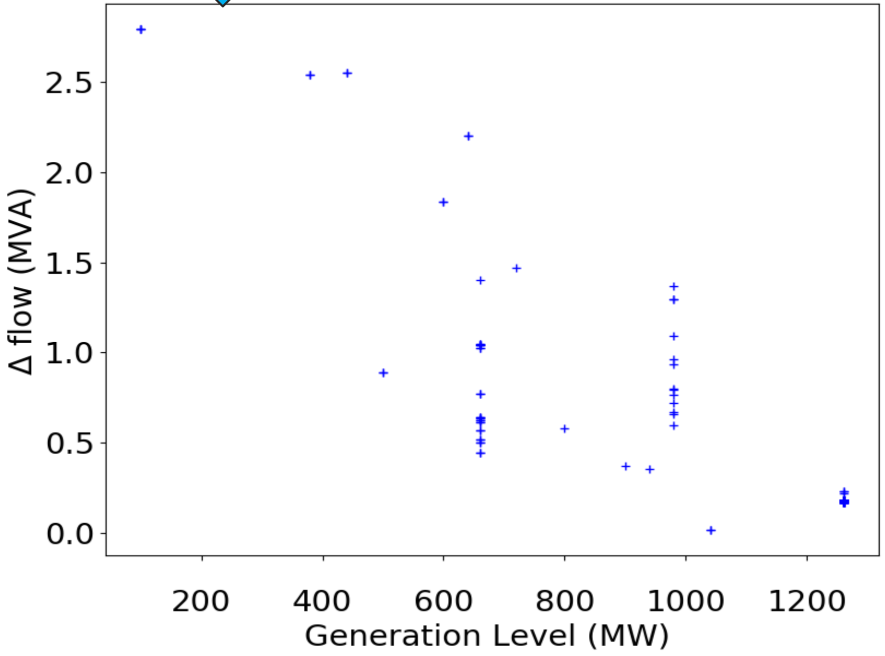
Maximum Penetration Level across Multiple Contingency Cases



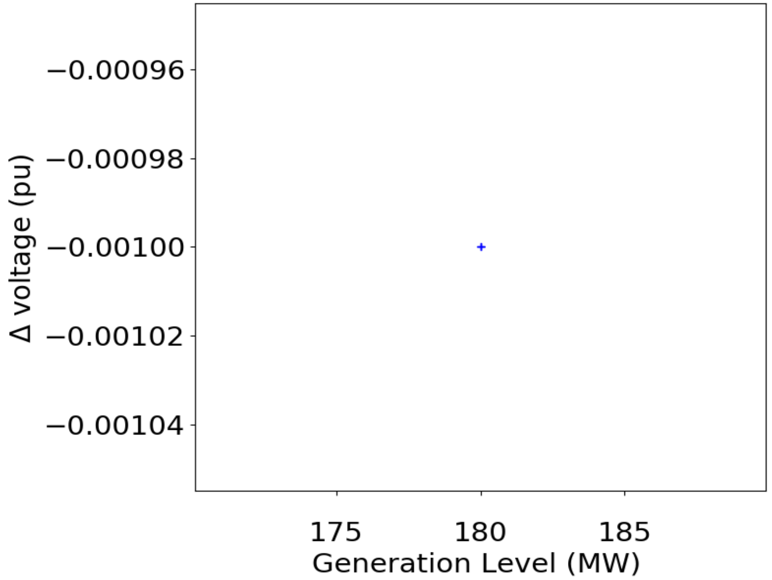
Maximum Penetration Level Split up by Type of Generation Resource



Branch Flow Violations v/s Generation Level



Voltage magnitude Violations v/s Generation Level



Maximum Penetration Level Split by bus number

Bus No	Gen (MW)	Bus No	Gen (MW)
7027	4.3956	7261	2.63736
7085	0.87912	7291	5.27473
7131	11.4286	7319	7.91209
7173	1.75824	7387	7.03297
7181	8.79121	7390	9.67033
7200	6.15385	7431	3.51648
7222	10.5495		

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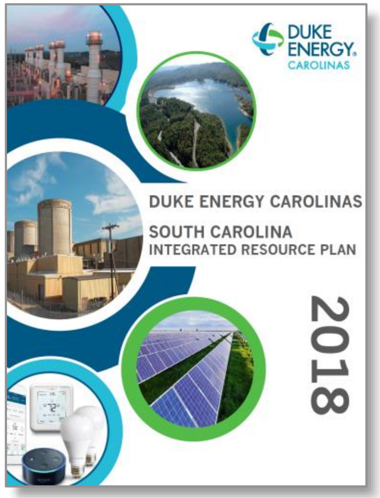
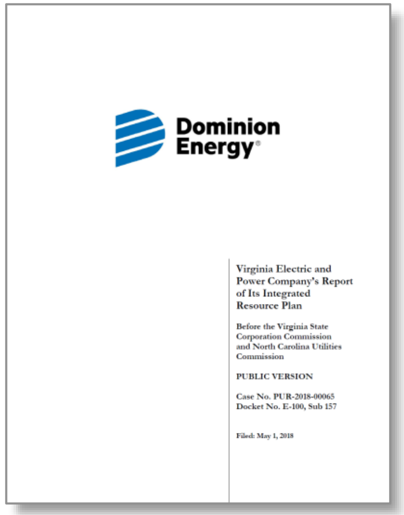
Truly Integrated Resource Planning: An Emerging Industry Movement?



Duke Energy
Resource Planning & Integrated System Operations Planning (ISOP) Initiative

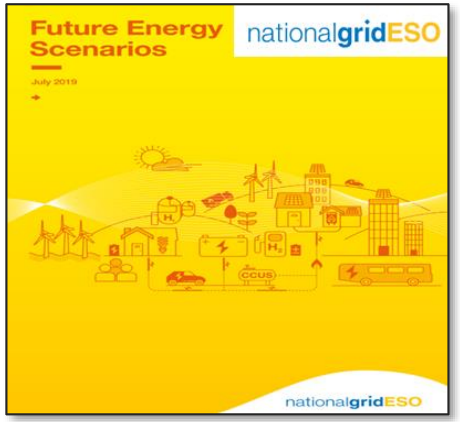


Dominion Energy
Resource Planning & Integrated GT&D Planning Initiative

Great River Energy
Resource Planning & Coordinated Grid Modernization Initiative

Traditional IRP has existed since the 1980s…

CPUC IRP Process to meet state goals



National Grid UK
Pathways for the future grid

Bottom-up? (D, then G&T)
Top-down? (G, then T&D)
Sideways?

Emerging resource mix necessitates evolution to more integrated planning process

NARUC-NASEO Task Force on Comprehensive Electricity Planning www.naruc.org/taskforce

Announced
Nov. 2018

Purpose: Develop new pathways for aligned electricity planning

1. **Innovation**: Pioneer new tools and roadmaps for aligning planning to meet state needs
   - Participants are convening in multi-state cohorts with others operating in similar market, regulatory, and policy environments

2. **Action**: Apply insights to directly benefit state action
   - Each state will develop concrete steps / an action plan at the end of the initiative

3. **Replication**: NARUC and NASEO will publish templates and resources to support all members

NARUC National Association of Regulatory Utility Commissioners
NARUC-NASEO TASK FORCE ON COMPREHENSIVE ELECTRICITY PLANNING
NASEO National Association of State Energy Officials

Source: Presentation by Danielle Sass Byrnett, NARUC at the 2019 EPRI Seminar on Fuels, Power Markets and Resource Planning, Nov. 13, 2019.

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NARUC-NASEO Task Force Leadership

Task Force Co-Chairs

Hon. Jeff Ackermann
Chairman

Colorado Utilities Commission

Dr. Laura Nelson
Executive Director

Utah Office of Energy Development

Task Force Co-Vice-Chairs

Hon. Beth Trombold
Commissioner

Public Utilities Commission of Ohio

Dr. Andrew McAllister
Commissioner

California Energy Commission

NARUC National Association of Regulatory Utility Commissioners

NARUC-NASEO TASK FORCE ON COMPREHENSIVE ELECTRICITY PLANNING

NASEO National Association of State Energy Officials

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EPRI Research Programs Explore Many Aspects of the IEN-P

Modeling the Changing Resource Mix

18. Electric Transportation
39. Grid Operations
55. Water Availability and Resource Risk Management
94. Energy Storage and Distributed Generation
170. End-use Energy Efficiency and Demand Response
173. Bulk System Integration of Variable Renewable Resources
174. Integration of Distributed Energy Resources
200. Distribution System Operations and Planning
201. Energy, Environmental and Climate Analysis

Ensuring Adequate System Attributes

40. Grid Planning

41.11.01. Flexible Nuclear Operations

66. Fossil Fleet for Tomorrow

178. Integrated Energy Systems Planning, Market Analysis and Technology Assessment*

193. Renewable Generation

New Inputs for Resource Planning

182. Understanding Electric Utility Customers
198. Strategic Sustainability Science
199. Electrification for Customer Productivity

Thought Leadership

Technology Innovation (TI) Program

* EPRI research program 178 is leading EPRI's research efforts in this area.

Together…Shaping the Future of Electricity

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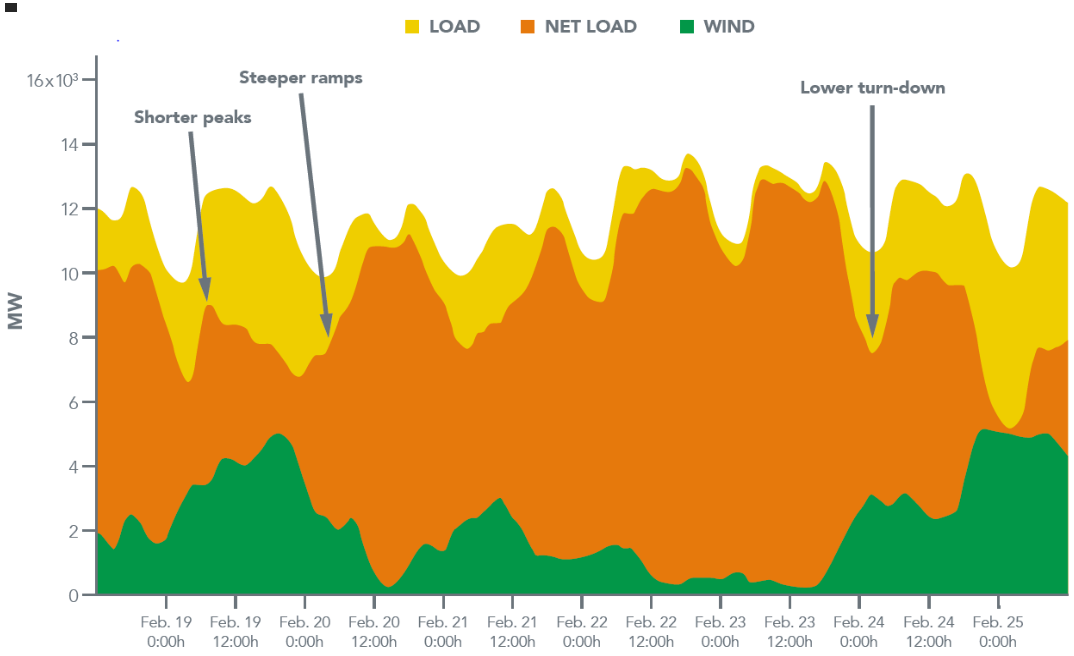
Appendix
EPRI’s 10 IEN-P Challenges

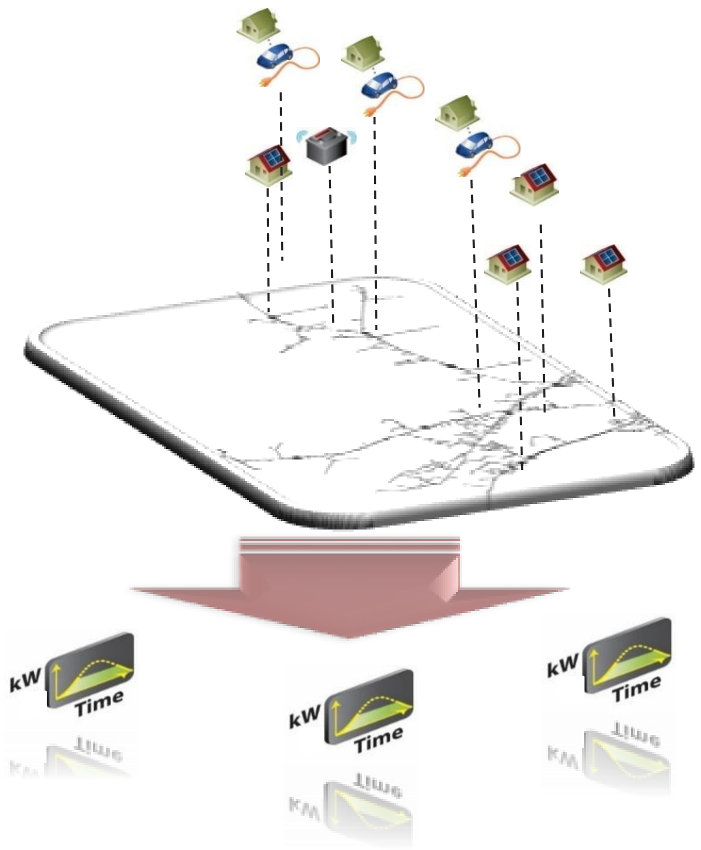
1. Incorporating Operational Detai

- Evaluate and address potential reliability impacts (e.g., frequency response, voltage stability and short circuit considerations) associated with the changing resource mix.
- It is becoming more important to incorporate operational reliability capabilities (e.g., ramping rates, minimum generation levels), and adverse interactions (e.g., variability, uncertainty, active and reactive control capabilities) into resource planning.
- Existing resource adequacy metrics (e.g., LOLE) may not be the "best" or only metric to use to measure electric reliability.



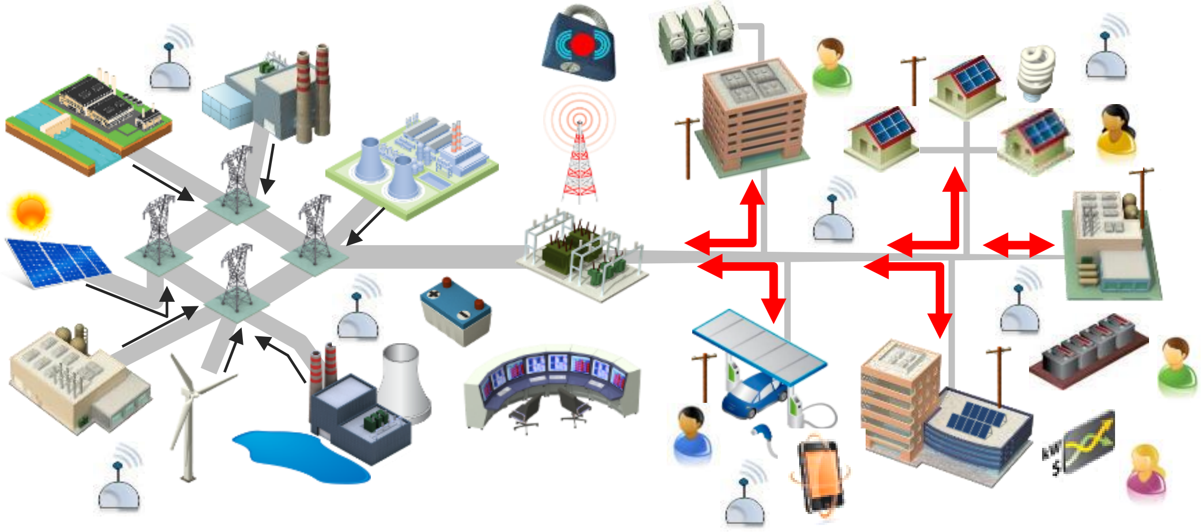
Wind and Solar Generation Can Increase Power System Flexibility Needs.
Source: Flexibility in 21st Century Power Systems, 21st Century Power Partnership.

2. Increasing Modeling Granularity



- *Temporal* Resolution
  - Hourly / sub-hourly time steps and multiple timeframes
  - Evaluation of energy storage systems and variable renewable resources require inter-temporal constraints and opportunities to be more fully recognized.
  - Understand potential net load impacts from utility renewable generation, customer choice, storage, DER deployment, and increased electrification.
- *Geographic* Resolution
  - "Birds of a feather flock together" – EVs and rooftop PV typically are adopted in neighborhoods, so disproportionally impact circuits. Traditional deterministic and stochastic modeling do not capture the geographic nature of customer preferences.
  - DER targeting and location have a direct impact on transmission and generation investment decisions and depend on customer preferences.

3. Integrating G, T, and D Planning



- TSO/DSO interaction increasingly is important, particularly as the distribution system provides more services
- Allows for evaluation of “non-wires alternatives” (NWA) to new G, T and/or D investments
- DER valuation and targeting, including locational attributes
- Improve communications and “hand shakes” between planning functions
- Connections to other critical infrastructure (e.g., natural gas, H_2O, EVs)

4. Expanding Analysis Boundaries

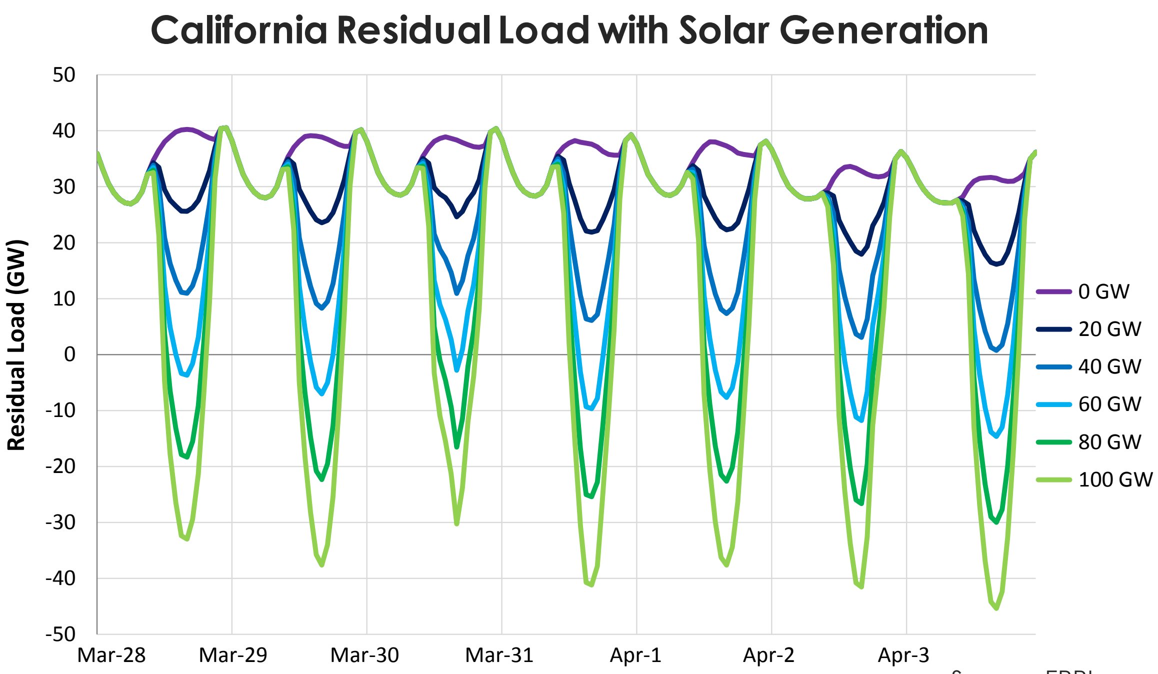
- Interactions with other sectors of the economy to achieve least-cost GHG emissions reductions (e.g., CA SB-350)
- "Gas-electric" coordination to better optimize planning and operations of natural gas fuels with electric operations
- Energy-water nexus – Planning to address both consumption and use of water in power generation and potential impacts of power generation on water resources is becoming more prominent.
- Multi-jurisdictional planning – Some companies are now facing conducting resource planning across multiple jurisdictions in an integrated manner. Examples include PacifiCorp in the western US and Duke in the eastern U.S.

5. Addressing Uncertainty and Managing Risk

- **Risk**
  - Deterministic v. stochastic modeling – Deterministic modeling and scenario analysis may not be adequate. Planners may need to do more stochastic modeling to capture the inherent uncertainty in the electric system.
  - Non-market risks – Growing need to develop methods and approaches to evaluate "non-market" risks, such as a perceived lack of "fuel diversity," and the ability to respond to changes in the external operating, policy and regulatory environments.
- **Uncertainty** – Becoming increasingly important to incorporate forecast uncertainty and variability in future loads, VER production, and DER adoption and use.
  - Production profiles for VERs are uncertain over time horizons from minutes to years, with each different time horizon causing their own challenges
  - Capacity values for variable generation are uncertain
  - VERs can increase variability and volatility of energy prices
  - Increasing DR capabilities may make it more difficult to forecast load

6. Improving Forecasting

- Key areas of forecasting are critical for robust long-term resource planning.
  - Electric load
  - DER adoption
  - Natural gas prices
  - Weather



Source: EPRI

- Need to better characterize natural <u>uncertainty</u> inherent in these key factors, and gain insights using computationally tractable methods.

- The ability to analyze “big data” related to DER, customer behavior, operations and other aspects of the future electric system may require new analysis capabilities and computational power.

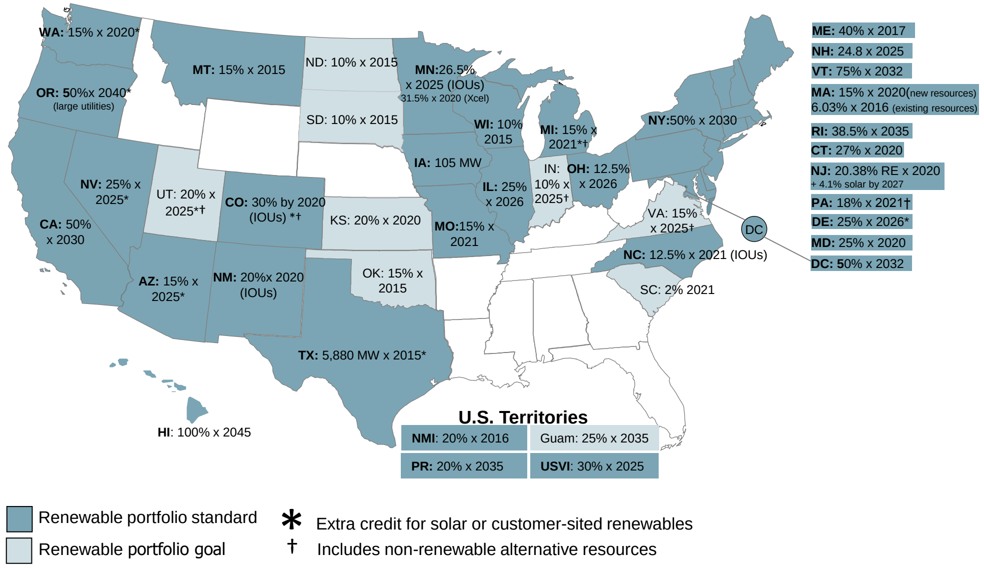
7. Customer Behavior and Interaction

- Customer behavior is expected to have a direct and tangible impact on resource planning in the future.
- Some ways customer behavior and resource planning may interact include:
  - Behind the meter generation (e.g., solar PV)
  - DER approaches, such as EE and DR
  - Electric transportation, electrification, and smart devices
  - Electric rates and rate structures may impact consumer behavior, electric demand, and planning

8. New Planning Objectives and Constraints

- GHG emissions and RPS – CA requires IRPs to achieve least-cost GHG emissions reductions and aggressive RPS targets.

- Water resources – Some electric companies are being asked to consider impacts on local water resources.

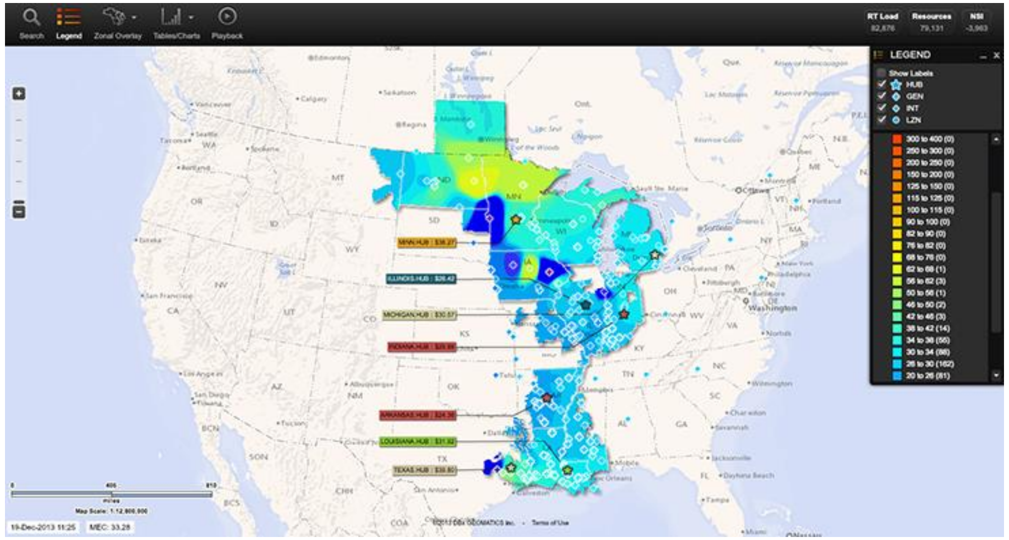


29 States + Washington DC + 3 territories have a Renewable Portfolio Standard
Source: www.dsireusa.org / February 2017

- Resiliency – Electric companies are being asked to more fully address system resiliency in resource planning. This includes two facets:
  - *Physical* – Protect the system from extreme weather events and restore it
  - *Cyber* – Protect the electric system from cybersecurity threats and restore it

9. Wholesale Power Market Interactions

- Interactions between companies and ISO/RTOs markets are starting to create new challenges for resource planners.
- Planners are challenged by considering buying and selling energy, capacity, and ancillary services (A/S) rather than building new resources or procuring "own" resources.



- Growing need to project uncertain potential future wholesale power prices, and incorporate them into modeling tools.
- Growing need to better understand how A/S and capacity markets may evolve, and impacts on future value of power resources.
- Planning methods will have to consider how ISOs/RTO markets will value different resource capabilities in the future.

10. Expanding Stakeholder Engagement

- The primary audience for company IRPs traditionally has been state PUCs and other regulators. Additional important audiences have included business associations, environmental and consumer advocates, and local non-governmental organizations (NGOs).
- In recent years, public expectations regarding involvement in company resource planning have changed dramatically
  - New stakeholders are engaged and participating in the planning process
  - Stakeholders want to address a broader array of issues than have been addressed in company resource planning in the past (e.g., rate design, rate setting, others…)
  - Stakeholders are becoming engaged in the entire resource planning process
- More companies now are engaged in designing and managing extensive stakeholder engagement processes related to resource planning activities.