



EPRI's Integrated Strategic System Planning (ISSP) Initiative

Lessons Learned for Implementing Integrated System Plans



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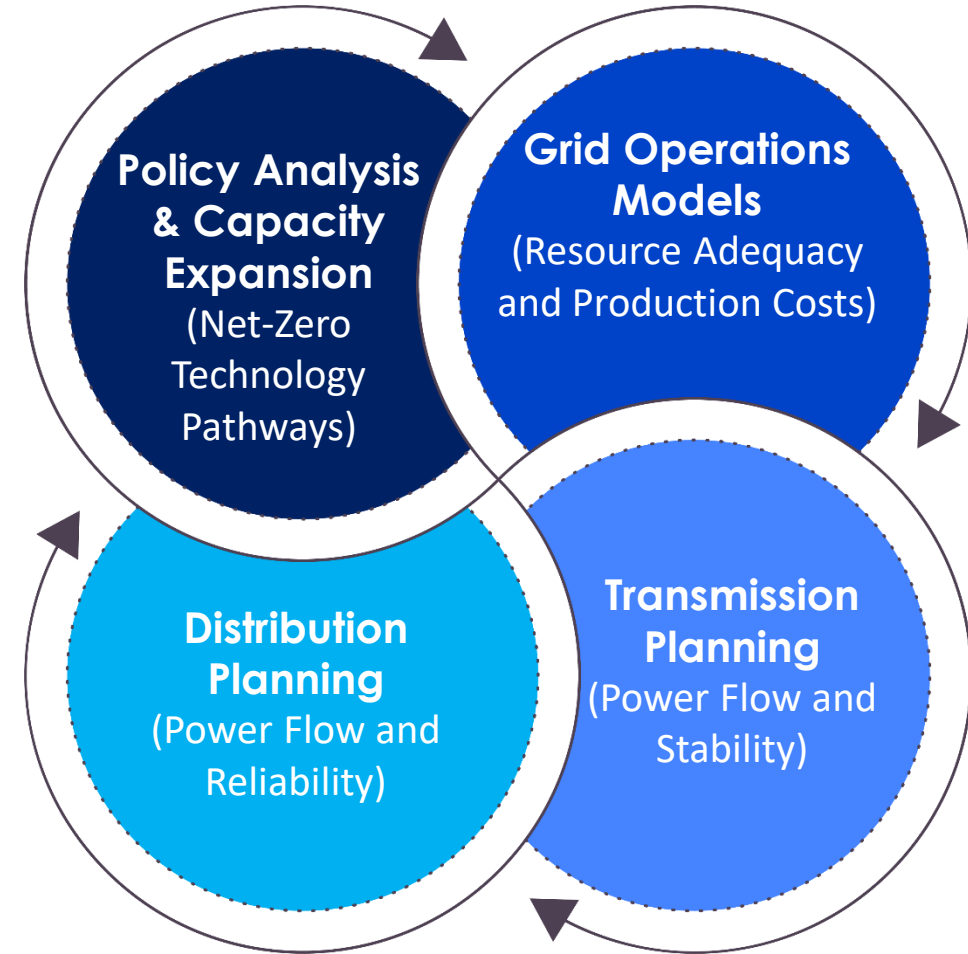


Integrated Planning for Strategic Questions

Least-cost pathway to electric sector decarbonization?

Sufficient capacity, energy, and flexibility to reliably balance supply and demand?

T&D investments for reliability/resilience for a more distributed, inverter-based supply mix?



Developed a generalizable analytical framework to assess future expansion plans across supply (G) and delivery (T&D) & ensures reliability

Integrated Strategic System Planning Initiative:

Modeling Framework, Demonstration Study Results, and Key Insights



Linking Capacity Expansion, Resource Adequacy, and Production Cost Modeling Tools for Integrated Strategic System Planning



Guidelines for Linking Power Flow Analysis with Production Cost Modeling Tools for Integrated Strategic System Planning: Needs, Screening Methods, and Best Practices



EPRl's Integrated Strategic System Planning (ISSP) Initiative developed a resource planning framework and supporting analytical toolbox. Using a series of soft-linked existing power system modeling tools, the framework is generalizable and may be used for more comprehensively planning reliable, low-carbon future resource portfolios across electric power system supply, delivery, and end-use. **This technical report series provides an overview of ISSP research and implementation guidance to the industry.**

Wide-Area Distribution Assessments for Integrated Strategic System Planning



Current Modeling Capabilities and Practices for Integrated Planning: Review of Select Modeling Tools and Prominent Studies



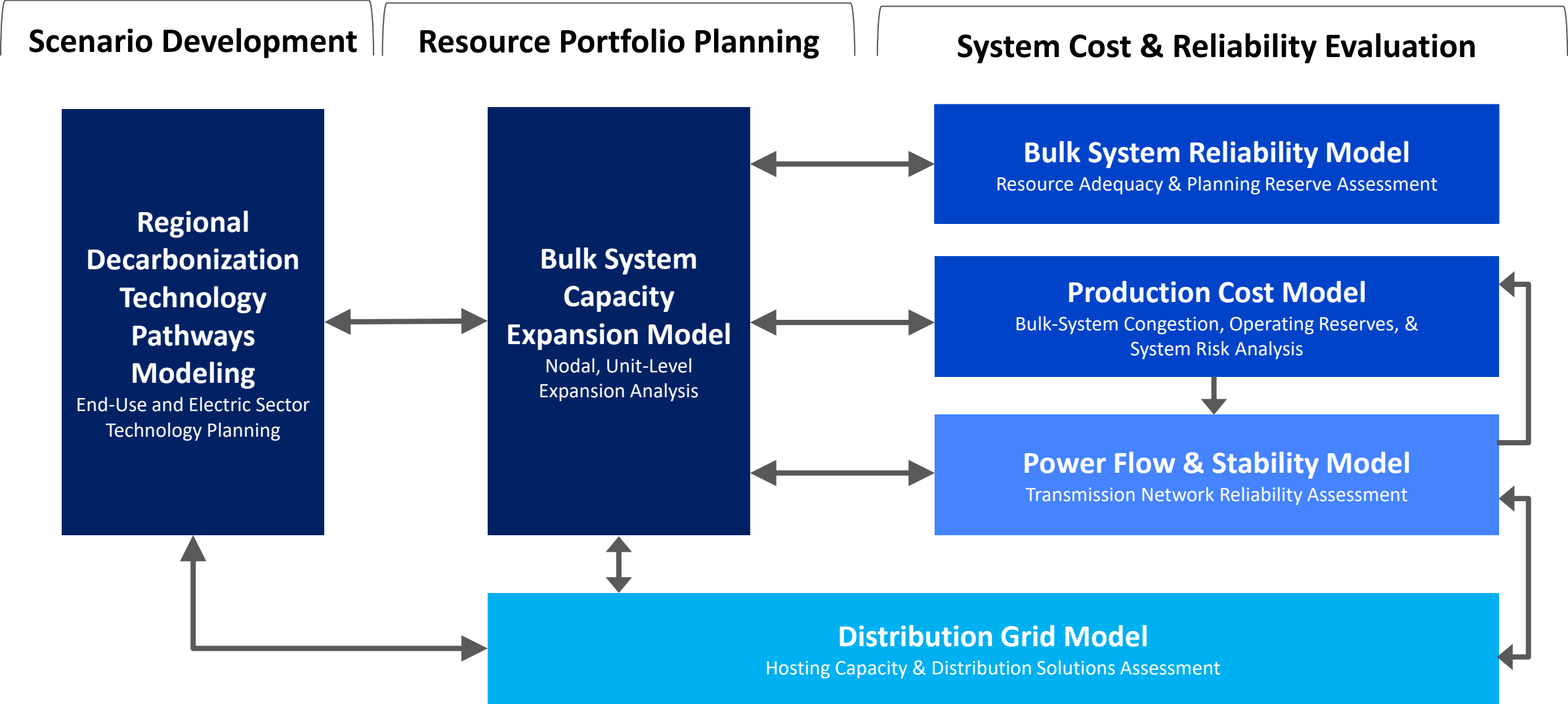
A Distribution Perspective of Process, Capabilities, and Data for Integrated Planning



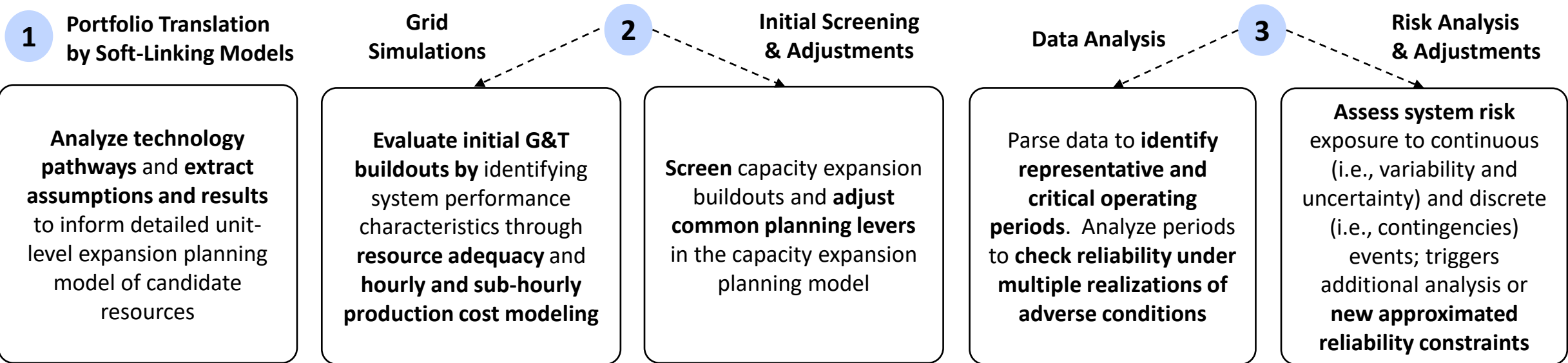
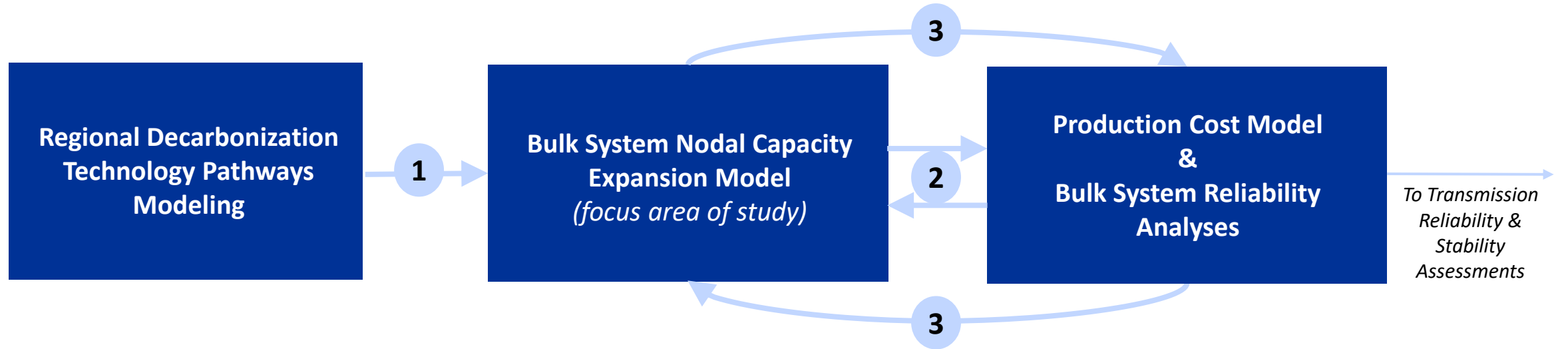
Emerging Integrated System Planning Methods: Utility Perspectives and Applications



ISSP Analytical Framework & Modeling Toolbox



Summary of Approach: Linking Capacity Expansion & Grid Operations Models to Identify Robust Portfolios



New York System Demonstration Study

Framing Question 1

Which technologies support meeting a decarbonized electricity sector in NY by 2035?

How does this compare to business as usual?

Framing Question 2

How reliable is that future decarbonized NY power system?









Framing Question 3

How may NY generation portfolios be modified to cost-effectively respond to potential reliability scarcity or excesses?

Can robust portfolios be identified?

A defined system of study (NY) and a stylized set of framing questions facilitated developing the needed links between tools to perform more integrated planning studies.

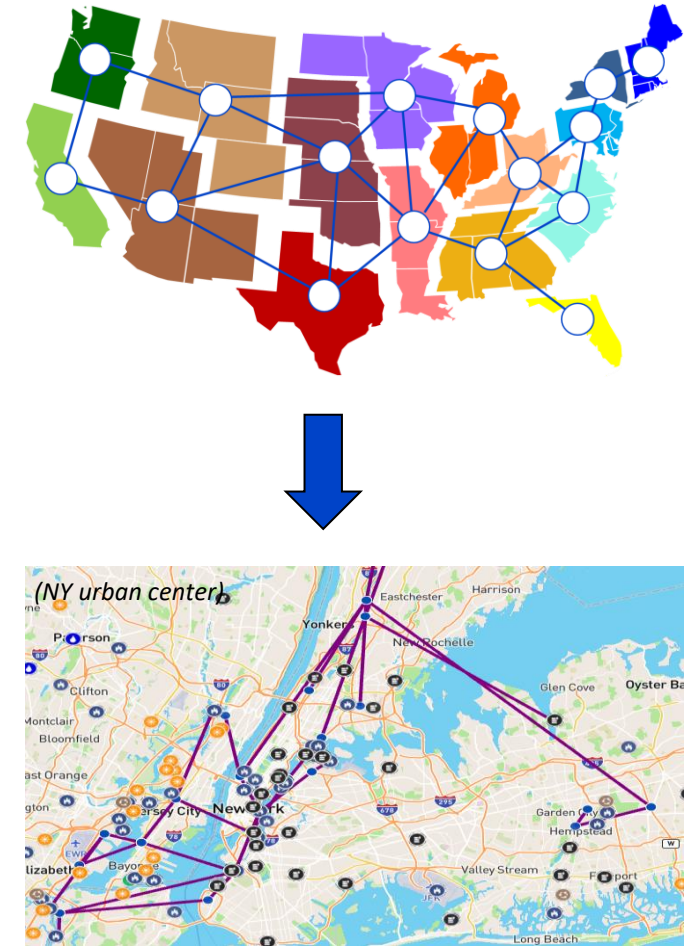
One Toolbox* & a Range of Coordinated Modeling Tools

Model Type	Tool	Primary Objective(s) in ISSP Demonstration Study	Generation Scope	Transmission Scope	Distribution & DER Scope	Temporal Resolution
Regional Technology Pathways Model		Regional End-Use and Electric Sector Technology Planning	Aggregate resources	Zonal “pipe and bubble network”	Aggregated end-use technologies & DERs explicitly modeled	120 representative time slices per year
Power System Capacity Expansion Planning Tool		System-specific G&T Expansion Analysis	Individual existing and new generators	Nodal	End-Use & DERs modeled via load adjustments	48 time slices per year, using statistical fitting to the load duration curve
System Reliability Assessment Tool		Resource Adequacy & Planning Reserve Assessment	Individual existing and new generators	Zonal	End-Use & DERs modeled via load adjustments	1 year, 8760 hours
Production Costing Tool	 + EPRI Scheduling & Dispatch Tool	Bulk-System Network Congestion, Operating Reserve, & System Risk Analysis	Individual existing and new generators	Nodal	End-Use & DERs modeled via load adjustments	1 year, 8760 hours & snapshots
Power Flow Model		Transmission Network Reliability Assessment	Individual existing and new generators	Nodal	DERs modeled via load adjustments	1 year, snapshots
Distribution Grid Model		Hosting Capacity & Distribution Solutions Assessment	No bulk-system	124 feeders 11 substations	End-use technologies and DERs explicitly modeled	1 year, 8760 hours

* This toolbox shows specific named tools used for the ISSP demonstration study; the actual ISSP framework is tool agnostic and can accommodate many different available named tools within each of the overall model types

ISSP Nodal Resource Portfolio Planning

- Detailed power system reliability studies benefit from each generating unit in a system being represented by its physical location and engineering/operating characteristics, and the transmission network lines between them and localized loads.
- We use Energy Exemplar's long-term capacity expansion planning model (PLEXOS-LT Plan) and inform it with EPRI's US-REGEN model scenarios to develop a power system model with the unit-level detail, loads, and system topology required for the system cost and reliability evaluations in this study.
- For this study, PLEXOS-LT Plan is configured as a nodal model, optimizing the generating and transmission capacity portfolio as a mixed integer program to site discrete units and lines across nodes.



Regional technology planning models provide a critical starting point for detailed unit-level capacity expansion and operations analyses

ISSP Cost & Reliability Evaluation Feedbacks: Planning Analysis

Recommendations for an **Example Reference Scenario**

Evaluation	Description	Key NY Study Finding(s)	Recommended Planning Actions
1	Resource Adequacy— Planning Reserve Assessment	<ul style="list-style-type: none"> Resource portfolio failed minimum LOLE target of 0.1 days/year High risk periods of unserved energy (e.g., high load, low wind during summer peaks) 	<ul style="list-style-type: none"> Increase minimum required planning reserve margin in CapEx from 8% to 16%
2	Resource Adequacy— Storage Assessment	<ul style="list-style-type: none"> Significant LOLE benefits of longer duration storage 	<ul style="list-style-type: none"> Increase duration of candidate batteries available in CapEx (4x)
3	PCM—Transmission Network Congestion Assessment	<ul style="list-style-type: none"> Notable lines with significant congestion and overloading High variation in system wide prices 	<ul style="list-style-type: none"> Allow CapEx model to consider economic transmission upgrades for all congested lines (22 new line candidates)
4	Operations Reserves & Risk Assessment	<ul style="list-style-type: none"> Reference scenario passed key flexibility and contingency requirement tests 	<ul style="list-style-type: none"> None (Note, performed a sensitivity analysis to show a case where the CapEx would need to be re-run)
5	Transmission Network Reliability Assessment	<ul style="list-style-type: none"> 20 lines and 3 transformers need upgrades to make the system N-1 secure (plus 24 lines and 2 trans. For N-0) 	<ul style="list-style-type: none"> Reliability-driven candidate transmission reinforcements are recommended for CapEx

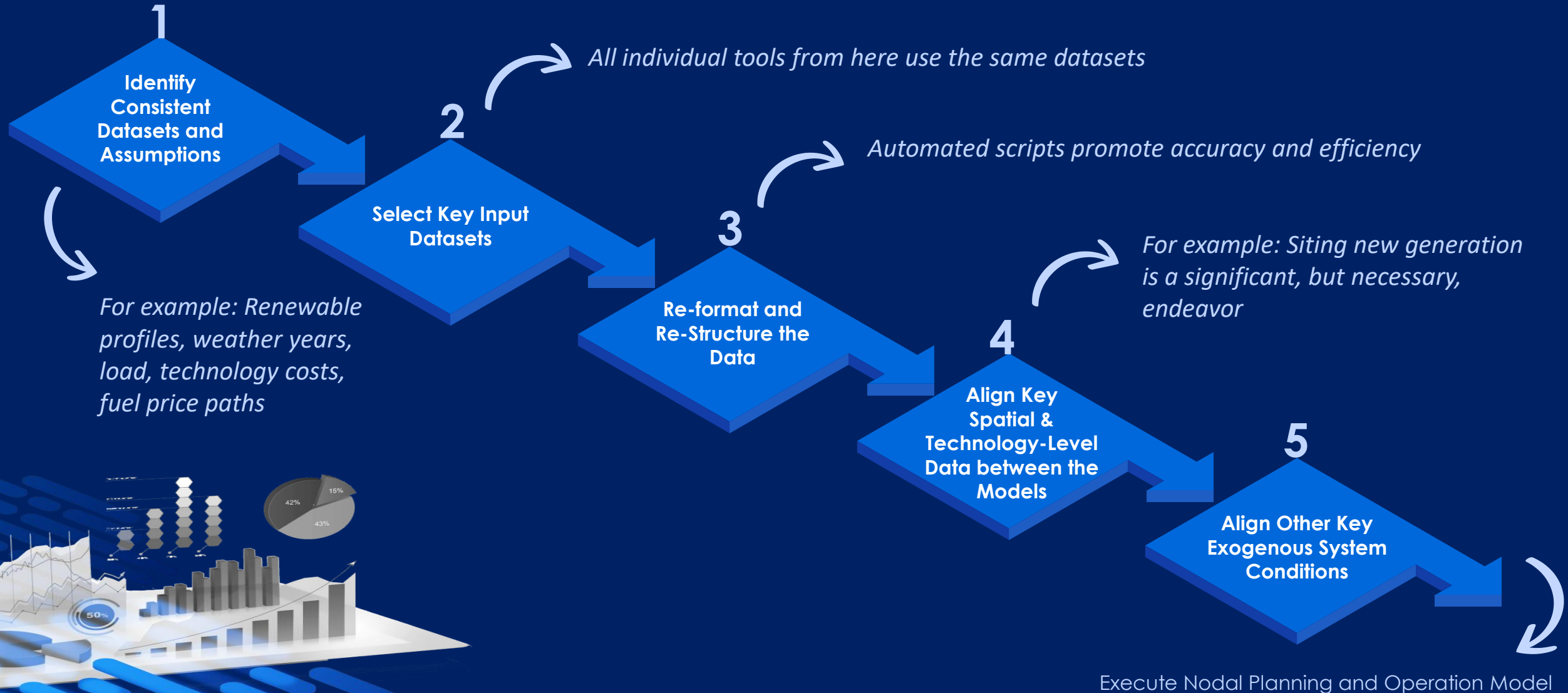
ISSP Cost & Reliability Evaluation Feedbacks: Planning Analysis

Recommendations for an **Example Zero CO₂ Scenario**

Green text highlights key differences from Reference

Evaluation	Description	Key NY Study Finding(s)	Recommended Planning Actions
1	Resource Adequacy— Planning Reserve Assessment	<ul style="list-style-type: none"> Resource portfolio failed minimum LOLE target of 0.1 days/year High risk periods of unserved energy (e.g., high load due to heating on winter nights) 	<ul style="list-style-type: none"> Start with higher (16%) PRM from Reference Scenario final portfolio and check sufficiency; explore other solutions (e.g., storage) to complement PRM needs
2	Resource Adequacy— Storage Assessment	<ul style="list-style-type: none"> Significant LOLE benefits of longer duration storage 	<ul style="list-style-type: none"> Increase duration of candidate batteries available in CapEx by 30%
3	PCM—Transmission Network Congestion Assessment	<ul style="list-style-type: none"> Notable lines with significant congestion and overloading High variation in system wide prices 	<ul style="list-style-type: none"> Allow CapEx model to consider economic transmission upgrades for all congested lines (37 new line candidates)
4	Operations Reserves & Risk Assessment	<ul style="list-style-type: none"> Reference scenario passed key flexibility and contingency requirement tests 	<ul style="list-style-type: none"> None (Note, performed a sensitivity analysis to show a case where the CapEx would need to be re-run)
5	Transmission Network Reliability Assessment	<ul style="list-style-type: none"> 17 extra circuits in addition to those required under Reference for N-1 required to secure the Decarbonization portfolio 	<ul style="list-style-type: none"> Reliability-driven candidate transmission reinforcements are recommended for CapEx

The ISSP Initiative Delivers a Framework for Efficiently Linking Technology Pathways and Resource Portfolio Planning Models



ISSP Results — Key Insights for Implementing the Framework



Use a regional technology planning model with a comprehensive representation of emerging technologies, inter-related regions, and potential policy requirements to help narrow the initial set of critical candidate technologies for a given scenario.



Facilitate early collaboration between generation planning & transmission planning teams when developing candidate portfolios. Starting with an informed siting strategy provides an efficient way to identify storage and other locational resource options for reliability support.



Continue to apply traditional RA and hourly PCM analysis methods. These methods are well understood for both capabilities and limitations, often require relatively minimal resources, and can effectively screen the set of scenarios to study further using evolving RA and PCM techniques.



Engage wide area distribution analysis (WADA) methods; they can provide a useful perspective in an integrated planning environment with cost-effectiveness objectives.



Employ automated processes for data adjustments and transfer between models. This will reduce errors and provide a more efficient means for scenario analysis.

Balancing Integrated Planning Dimensions

Computational tractability —
Can we solve our models in a reasonable amount of time and is the complexity of inputs and outputs manageable by users

Practical Considerations — Are the frameworks, tools, and processes sufficiently transparent and designed for being adopted by the industry at large

Analytical fidelity — Are we representing the power system and important interactions with the highest degree of accuracy and realism

Challenges and Looking Forward

5 High Priority ISSP Research Actions for EPRI

EPRI's ISSP research prompts several future research needs.

Highest priority items accelerate full-scale industry implementation of electric sector integrated system planning.

03

Identify the conditions and planning phases where **higher temporal and/or spatial granularity** and formal **co-optimization** is most useful—and supporting **data needs** (e.g., nodal vs. zonal capex)

01

“Close” the bulk-system + distribution system planning gap to enable identifying the most cost-effective resource options

05

Communication of ISSP value & need (ongoing) and industry workforce training to implement methods

04

Evaluate **application of the ISSP framework to a wide-range of electric sector entities** (e.g., wires-only, G&T only)

02

Apply emerging algorithms and newer AI-based methods (e.g., intelligent sampling, scenario generation + reduction techniques) to **improve computational tractability and support scalability.**